Testing the Effectiveness of Dynamic Adaptive Speech Reconstruction (DASR) in Eliciting Brain Activation in the Right Ventrolateral Prefrontal Cortex

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Introduction

Background:

- >1 million people in the U.S. have the language disorder aphasia
- **Broca's aphasia**, the most common type of nonfluent aphasia, often results from injury to the brain's principal language expression center (Broca's area) in the **left ventrolateral prefrontal cortex** (VLPFC) region
- **Melodic Intonation Therapy (MIT):** treatment for patients with this disorder - combines speaking, singing, and tapping to activate Broca's area + right hemisphere homologue
- **Dynamic Adaptive Speech Reconstruction (DASR):** builds on MIT by incorporating systematic progression of increasingly complex speech/song/rhythm production + **functional Near-Infrared Spectroscopy** (fNIRS) to visualize and measure brain activity

Purpose:

- To determine the effectiveness of DASR in eliciting brain activation in the right VLPFC

Figure 1. fNIRS headband

Methods

DASR Paradigm

- Artificial intelligence algorithm – analyzes patient's response, associated brain activation, and suggests next request the therapist should ask of the patient

Study Design

- fNIRS continuously recorded **frontal lobe brain activity** while participants performed a series of 21 tasks (to deconstruct and then reconstruct the phrase "happy birthday to you")
- Brain activity was measured by fNIRS in terms of the **Blood Oxygen Level Dependent (BOLD) signal** - changes in oxygenated and deoxygenated hemoglobin levels

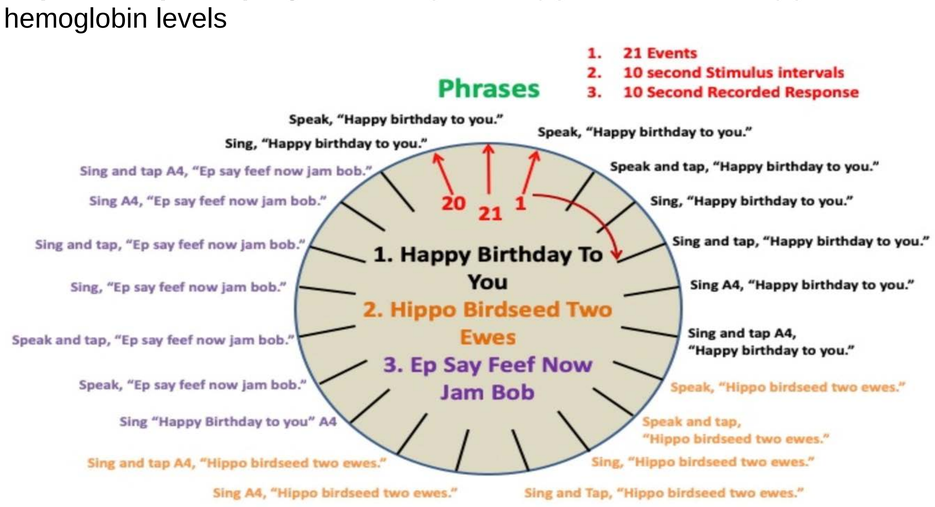


Figure 3. DASR experimental design schematic for fNIRS

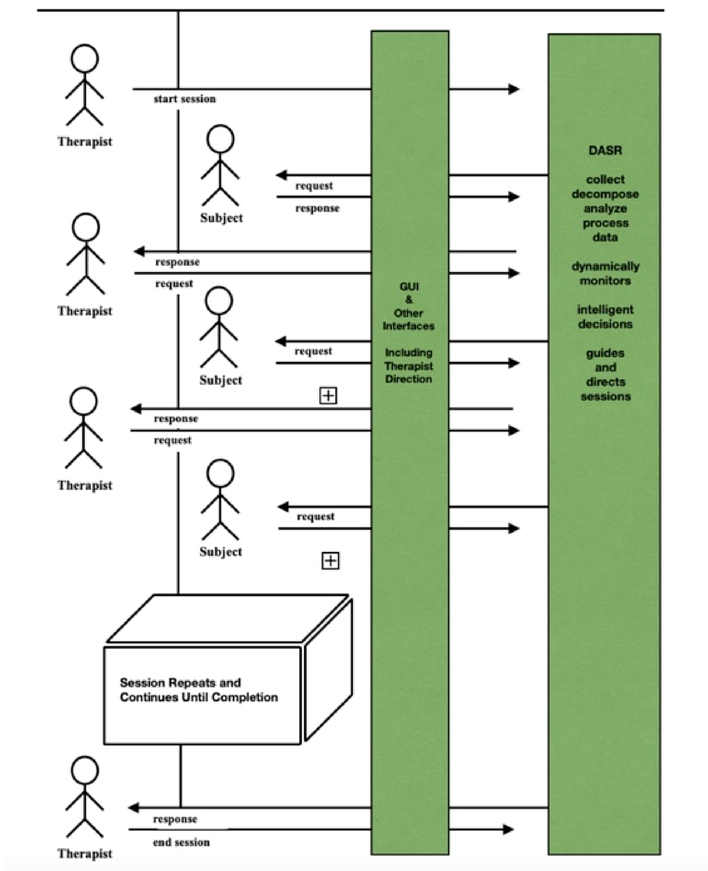


Figure 2. Swimlane diagram workflow of DASR

Results

- Participant brain activity was analyzed for all three speaking tasks (Task 1 – speak "Happy birthday to you"; Task 7 – speak "Hippo birdseed two ewes"; Task 14 – speak "Ep say feef now jam bob")

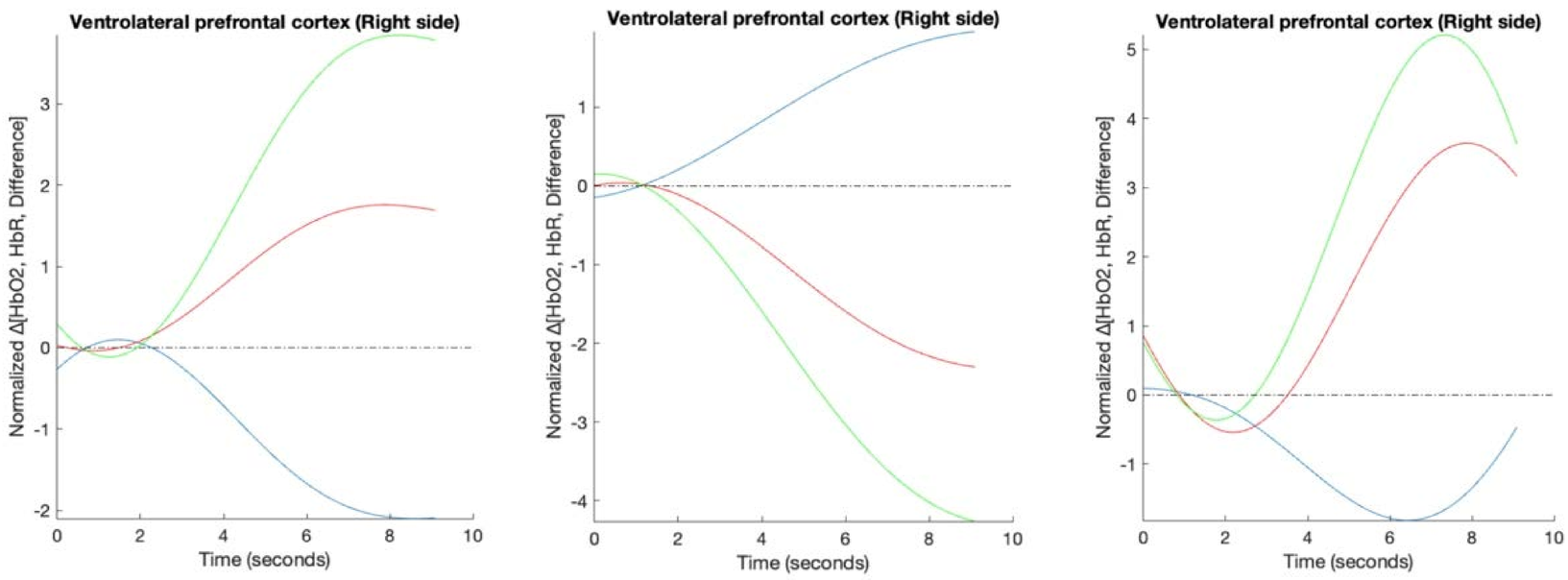
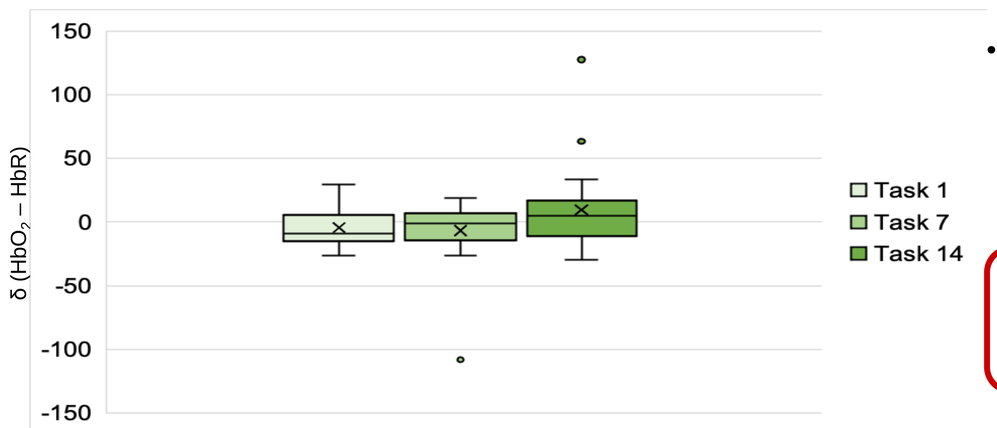


Figure 4. Analysis of speaking tasks (Task 1, 7, and 14, respectively) from participant 6
HbR (blue) is deoxygenated hemologlobin and HbO_2 (red) is oxygenated hemoglobin. δ (green) is the difference between oxygenated and deoxygenated hemoglobin (HbO_2 – HbR).

Changes in HbO_2 and HbR across 10 second interval indicate **activation in the right VLPFC** during all three speaking tasks (continuous blood flow/delivery and consumption)



- **Two-sample t-test assuming unequal variances** was performed between fNIRS data for VLPFC brain activity for each of the three speaking tasks (Task 1, 7, and 14)

No statistically significant difference was found between brain activation (mean δ [HbO_2 – HbR]) in any of the three speaking tasks

Figure 5. Comparison of VLPFC activity between speaking tasks, p>0.0167

Conclusions

- Consistent activation in the right VLPFC while participants were performing all three speaking tasks demonstrated that the **DASR protocol was successful in prompting brain activation in the right VLPFC** (and inducing brain plasticity in the process)
- No statistically significant difference found between VLPFC brain activation in any of three speaking tasks → likely that while the DASR speaking portion did not elicit the change in right VLPFC brain activity, the singing and tapping portions of the protocol did
- As determined through fNIRS, this finding shows that **speaking alone is not sufficient to induce right hemisphere brain activity**, a notion consistent with the reasoning behind MIT
- Collectively, these findings demonstrate the potential **validity of DASR as a form of speech-language therapy for Broca's aphasia**

References

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Acknowledgements

My deepest gratitude is extended to Dr. Jonathan Wisco for the invaluable guidance and support he has offered me throughout the course of this project. I would also like to thank my wonderful lab partners, Lauren and Sarayu, for their hard work, as well as the RISE program for this incredible opportunity to be a part of novel, ground-breaking research.