A COMPARISON OF ACOUSTIC FEATURES IN LVPPA BEFORE AND AFTER TREATMENT PROGRAMMES

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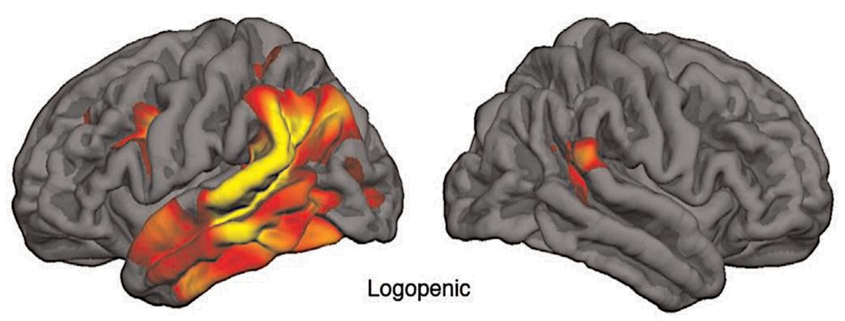
INTRODUCTION

LOGOPENIC PRIMARY PROGRESSIVE APHASIA (lvPPA)



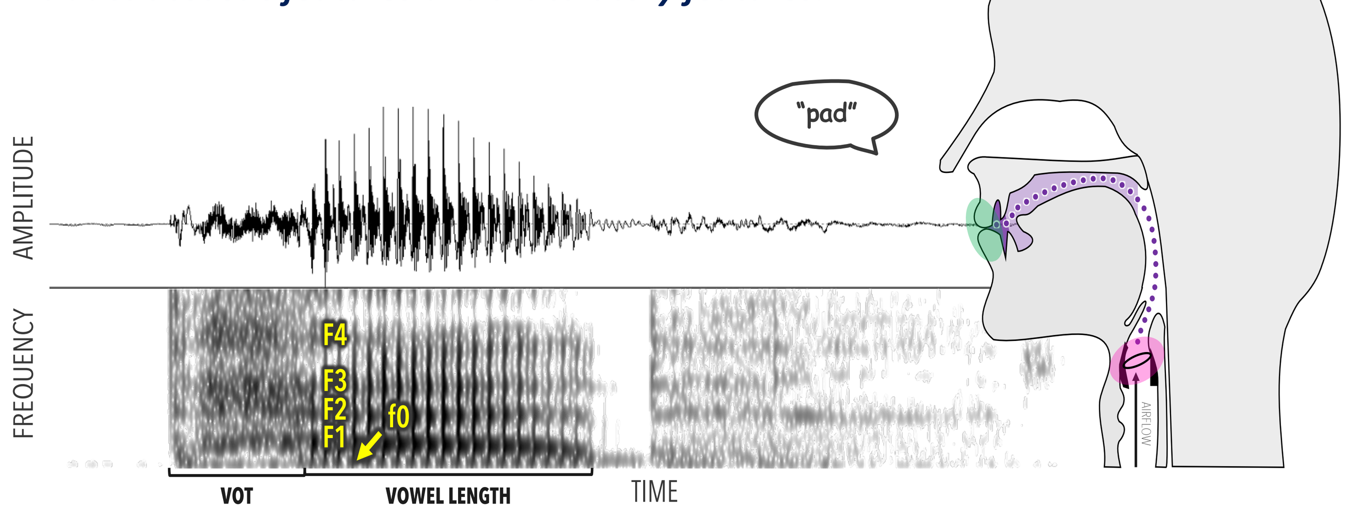
Mack et al. (2015)[1]

The ***logopenic variant of primary progressive aphasia (lvPPA)*** is an age-related neurodegenerative syndrome with isolated language (2). It often co-occurs with underlying Alzheimer Disease (AD) (2).

lvPPA	
Core features	▪ Impaired single-word retrieval in spontaneous speech and naming
	▪ Impaired sentences and phrases repetition
Other features	▪ Phonological speech errors (impaired phonological loop)
	▪ Spared single-word comprehension and object naming
	▪ Spared motor speech
	▪ Absence of frank agrammaticism
Atrophy	▪ Left posterior perisylvian or parietal regions

PHONOLOGICAL FEATURES, ERRORS, AND PROCESSES

Phonological features describe the differences between perceptually distinct speech sounds in a language. This includes ***acoustic features*** and ***articulatory features.***



Phonological paraphasias (e.g., *cup* becomes *pup*) are a salient feature of lvPPA (> %50 of all errors made) but are **NOT** required for diagnosis (3).

Detailing lvPPA speech error patterns in respect to distinctive articulatory or acoustic patterns may provide more precise **diagnoses** and **treatment targets** for lvPPA patients (4). For example, temporal and prosodic acoustic markers differentiate lvPPA and AD even at an early stage of the disorder (5,6).

Nevertheless, it is unclear whether these disrupted phonological features respond to **therapeutic interventions** among lvPPA patients.

TREATMENT OUTCOMES

lvPPA is historically difficult to diagnose and treat (2), with traditional language therapies only showing modest outcomes (3).

Neurorehabilitation via ***transcranial direct current stimulation (tDCS)*** has been shown to produce an enduring change in cognitive performance (7). For example, neurostimulation of the inferior frontal gyrus (IFG) has been shown to facilitate phonological retrieval processes and improve language production and spelling accuracy among neurotypical individuals (8) and lvPPA patients (9). Targeting the IFG with tDCS may assist with phonetic-acoustic processing among lvPPA patients.

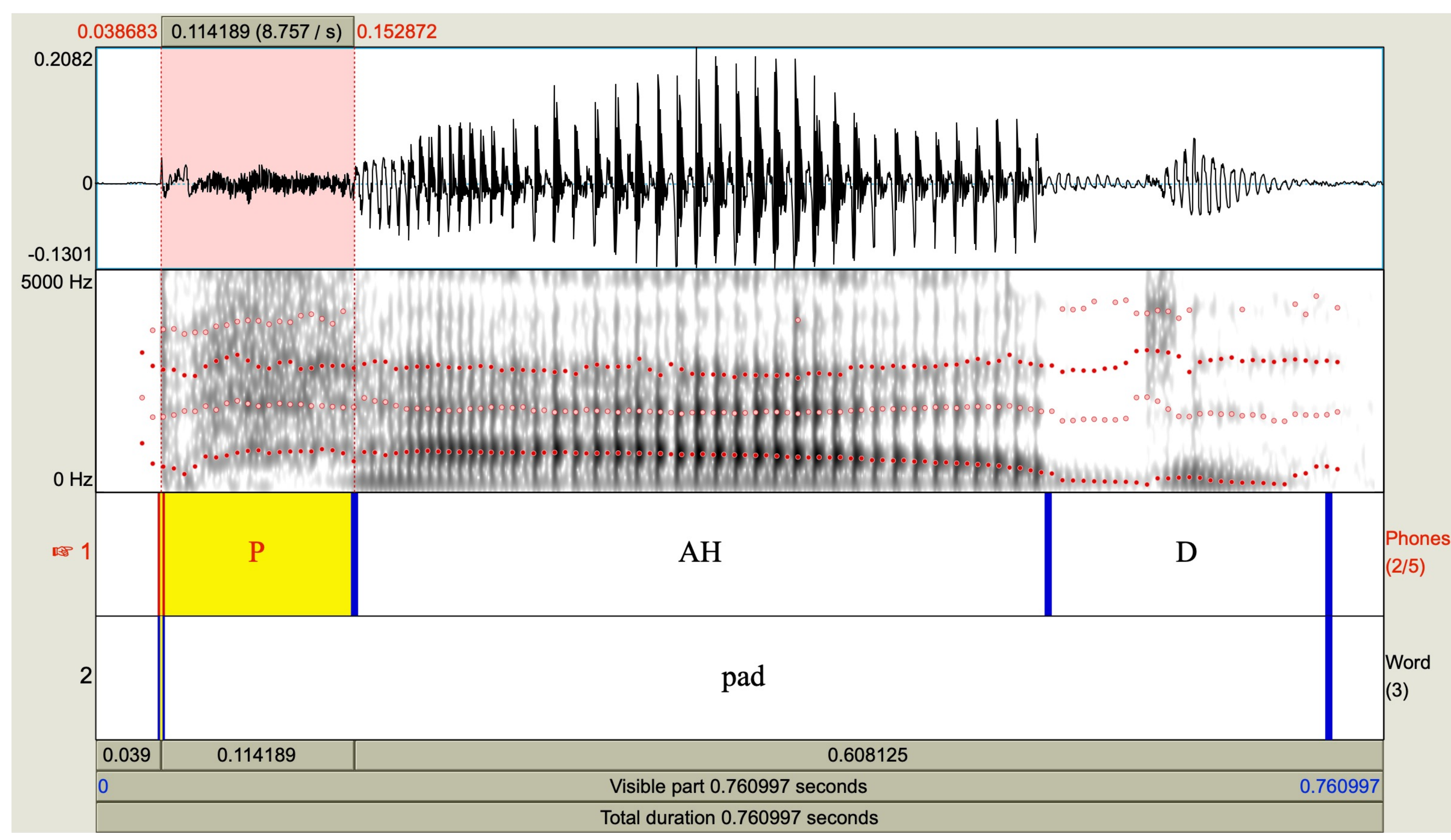
PROPOSED STUDY

KEY QUESTIONS OF FOCUS

1. How would one characterize the acoustic features of lvPPA in relation to other aphasic variants and neurotypical individuals?
2. How does the distribution of acoustic features in lvPPA speech compare prior to and after different treatment types (language therapy alone or combined with neurorehabilitation)?
3. How do people respond to therapy relative to the severity of their language impairment with respect to their acoustic speech characteristics?

ACOUSTIC FEATURES OF FOCUS

Vocal reaction time	Latency time before initiating sentence repetition(s).
Phonation time	Mean vowel phonation duration, consonant phonation duration (e.g., voice onset time [VOT], frication, nasality, etc.).
Pause ratio	Number of total pauses (including silent or not) per second.
Speech rate	Number of words, syllables, and/or phonemes per second.
Intensity range	Distance between maximum and minimum vocal intensity (dB).
Fundamental frequency (F0), min., max., and range	Measurement of and distance between maximum and minimum f0 measured (Hz).
Formant frequencies	The resonant frequencies of the vocal tract (F1, F2, F3, F4, etc.).



ANALYZING RECORDED SPEECH PRODUCTIONS

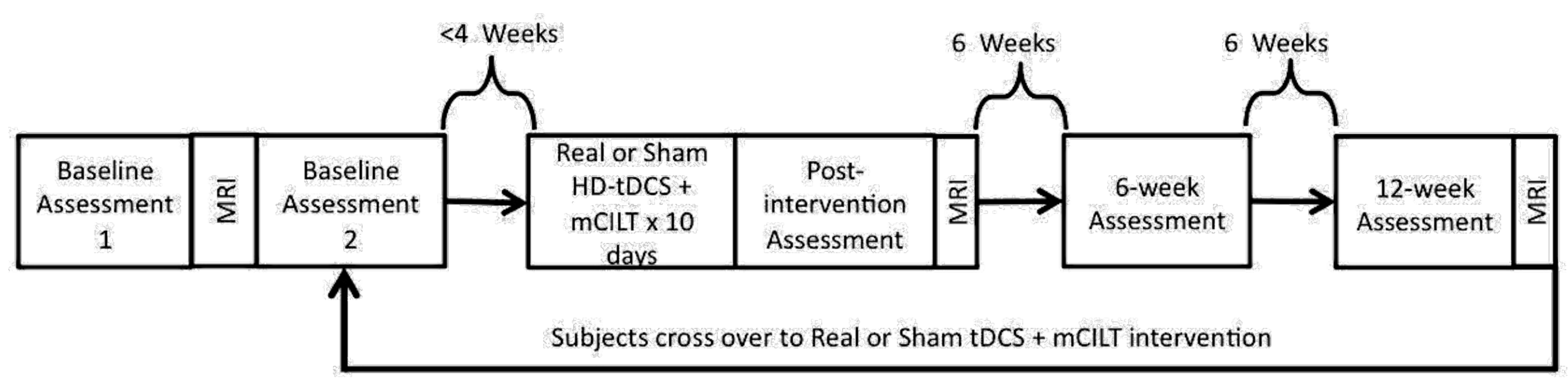
Speaker data can be analyzed using PRAAT. Durational measures, such as VOT and vowel length can be annotated and measured using a TextGrid, as shown in the left image.

Fundamental frequency (f0) and vowel formant measurements (F1, F2, F3, etc.) in PRAAT are calculated with semi-automated algorithms. Scripts can then easily extract measurements and time alignments to be analyzed with other software.

As described in the table above, a combination of acoustic features could reveal errors that arise from neighboring speech segments coalescing into similar sounds. For example, an adjacent back vowel could cause an alveolar to be backed into a velar sound. Acoustic features could provide clues for different types of coarticulatory phenomena.

SPEECH PRODUCTION DATA

Speaker data is available through the LCNS laboratory at the University of Pennsylvania: Collected dataset of lvPPA baseline and post-treatment speech samples (*N* = 33; aged between 45-80 years old) taken from a larger treatment study that involves neuroimaging and neuromodulation.



Data include participant productions from the following assessments before and after language therapy and/or tDCS:

- Western Aphasia Battery (i.e., WAB), which can be used to generate a global aphasia severity score, and the Aphasia Quotient (i.e., WAB AQ; 10,11), which will serve as the primary behavioral outcome measure
- Semi-structured speech sample for speech fluency, grammaticality, lexical retrieval and speech sound errors (12)
- Tasks from the NACC Uniform Data Set FTLD Module, including single word reading, single word repetition, sentence reading, and sentence repetition.

This speech data will be transcribed, time-aligned, and segmented in PRAAT, as described above.

PREDICTIONS

ANTICIPATED RESULTS

PPA disrupts critical centers of the language network experience. lvPPA is associated with impaired lexical retrieval and an impacted phonological loop in the brain (2). tDCS may be able to enhance language therapy by strengthening connections between brain regions involved in phonological and acoustic processing.

HYPOTHESES

1. lvPPA patients will produce speech errors that metathesize sounds across words during production, which in turn, will be reflected in atypical acoustic feature measurements. False starts and hesitations in lvPPA distinctly may impact vocal reaction time, phonation time, and pause ratio measurements.
2. Compared to people who did not receive non-invasive neural stimulation, vocal reaction times, vowel phonation times, consonant phonation times, and phonation time deviation are expected to be less in duration; the pause ratio is also expected to be lower; the speech rate is expected to be higher and the f0 ranges are expected to be within a more regular set of values.
3. tDCS intervention and language therapy should improve severity scores. Improvement among more severe aphasic patients should be more dramatic compared to less severe aphasic patients. If the above acoustic changes are an indication that speech has become more fluent, this should also be reflected on their global severity score as determined by the WAB.

FUTURE DIRECTIONS

If there is no tDCS effect, then we could look at the baseline phonetic characteristics to see who is a responder to language therapy. Other metrics can demonstrate whether participants responded in some manner to stimulation.

Acoustic analysis contributes to facilitating early and specific diagnosis therefore expedite early care to slow progression of symptoms.

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