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Investigating changes in connected speech in nonfluent/agrammatic primary progressive aphasia following script training

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APHASIA AND DEMENTIA RESEARCH LABS

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Introduction

- Primary progressive aphasia (PPA)
  - progressive deterioration of speech and language

- Nonfluent/agrammatic PPA (nfvPPA) consensus criteria (Gorno-Tempini, et al. 2011)
  - characterized by
    - agrammatism in language production
    - motor speech impairment (apraxia of speech with or without dysarthria)
  - deficits can co-occur to varying degrees or appear in relative isolation
    - primary progressive apraxia of speech (PPAOS) (Josephs, et al. 2012)
    - progressive agrammatic aphasia (PPA-G) (Thompson & Mack, 2014)

- Limited treatment research in nfvPPA addressing linguistic and motoric deficits explicitly

Introduction

- Interventions from stroke-induced aphasia and AOS literature

  (Ali et al., 2018; Cherney et al., 2008, 2014; Cherney & Halper, 2008; Costello-Yacono & Balasubramanian, 2018; Goldberg et al., 2012; Grasso et al., 2019; Moss, 2009; Szabo et al., 2014; Youmans et al., 2005, 2011)

  - script training has the potential to address linguistic and motoric deficits in nfvPPA

- Video-Implemented Script Training for Aphasia (VISTA) has been shown to be effective for individuals with nfvPPA (Henry et al., 2018)
  - results indicated significant improvement in accurate script production at post-treatment
  - improvements in intelligibility
  - reduction of grammatical errors

Introduction

- Analysis of connected speech allows for evaluation of speech in contexts that more closely resemble real-world communicative conditions
  - time-intensive
  - required expertise

- Computerized Language ANalysis (CLAN) (MacWhinney, 2000)
  - Quantitative Production Analysis (Saffran et al., 1989)
    - c-QPA (Fromm et al., 2020)
  - Northwestern Narrative Language Analysis (Thompson, 2013)
    - c-NNLA (Fromm et al., 2020b)

- Script-training studies have examined a handful of measures of connected speech beyond accuracy of scripted content
  - speech rate (Ali et al., 2018; Cherney et al., 2008, 2014; Cherney & Halper, 2008; Costello-Yacono & Balasubramanian, 2018; Goldberg et al., 2012; Moss, 2009; Szabo et al., 2014; Youmans et al., 2005, 2011)
  - intelligibility (Grasso et al., 2019; Henry et al., 2018)
  - disfluencies (Goldberg et al., 2012; Youmans et al., 2005)
  - % different words produced (Fridriksson et al., 2012)
  - number of grammatical errors per 100 words, % words with grammatical morphemes, subject-verb-object structure production (Grasso et al., 2019; Henry et al., 2018; Goldberg et al., 2012; Costello-Yacono & Balasubramanian, 2018)

Introduction

- We aimed to extend the findings of Henry et al., 2018 by investigating additional treatment-sensitive outcome measures in a larger sample
  - speech fluency
  - grammar
  - informativeness

- We predicted:
  - trained script topics would show a significant difference from pre- to post-treatment
  - changes would differ significantly between trained and untrained script topics from pre- to post-treatment with trained topics demonstrating greater change
    - potential for generalization to untrained topics at the individual level

Participants

- 20 individuals (10 from Henry et al., 2018) meeting 2011 consensus criteria for nfvPPA
- all participants demonstrated motor speech impairment
- 14 demonstrated impaired expressive grammar on standardized testing and in connected speech

Demographics and Speech/Language and Cognition Scores at Pre-Treatment

	mean (SD)
Demographics	
Age	68.45 (5.8)
Sex	12 female, 8 male
Years of Education	16.65 (2.6)
Handedness	19 right, 1 left
Speech, Language and Cognition	
Mini-Mental State Examination (30)	27.3 (2.4)
Western Aphasia Battery AQ (100)	86.42 (9.0)
PPVT-short (16)	14.78 (2.0)
AOS rating[a] (0=none - 7=profound)	3.2 (1.2)
Dysarthria rating[a] (0=none - 7=profound)	1.85 (1.7)
Northwestern Anagram Test (%)	64.39 (21.8)

[a] from Wertz et al. (1984); AQ = Aphasia Quotient, PPVT = Peabody Picture Vocabulary Test, AOS = Apraxia of Speech

Methods

- Participants were treated using VISTA
  - six individualized scripts were developed for each participant in a collaborative process
    - four scripts entered treatment one at a time; two remained untrained
    - scripts were balanced for linguistic measures of grammar and complexity
  - speech samples collected pre-treatment informed the length, complexity, and rate of the scripts
    - Cat Rescue picture description
    - Grandfather Passage reading
    - speech in response to open-ended questions
  - scripts were treated in twice weekly sessions with a clinician
  - video stimuli were created for the scripts
  - homework consisted of unison speech production practice (speech entrainment, Fridriksson et al., 2012) for 30 minutes/day with video of their script

Example Scripts from 2 Participants

Dancing

I like to dance a lot. I memorize many routines. My husband and I do competitive country western dancing. We do eight different dances.

(66 wpm)

Primary Progressive Aphasia

I have primary progressive aphasia, which is a speech problem caused by tau protein in the brain. My speech is no longer fluid or reflexive. Words with more than two syllables are difficult for me. I have to think about what to say before speaking. Please be patient and let me have extra time to talk.

(87 wpm)

Methods

- Probes eliciting responses to script topics were conducted twice pre-treatment and post-treatment

<u>Pre-TX Probe for script topic:</u>
Stocks

Clinician: “Tell me about stocks.”

Participant: “I been uh working on stocks for twenty years. Need…uh need some money for the stocks. Bif…uh dih…up…uh deposit for…uh…posit…uh back and forth you know. But uh…”

<u>Post-TX Probe for script topic:</u>
Stocks

Clinician: “Tell me about stocks.”

Participant: “I been uh purchase stocks for two decades. I want dividends there four percent or higher. I want uh talk to my stock broker every day which stocks to buy. I wait for my stock broker’s report could make a decision. Are you interested in the stock market?”

Methods

- Responses to script probes were transcribed and coded using CHAT (Codes for the Human Analysis of Talk, MacWhinney, 2000) & CLAN
  - trained undergraduate and graduate research assistants blinded to timepoint
  - reliability conducted on one time point for each participant
  - coding in CLAN by trained graduate research assistant

- Transcriptions were analyzed using CLAN for:
  - mean length of utterance in morphemes (MLUm)

    (Nobis-Bosch et al., 2011; increase in script-related morphemes: Cherney et al., 2008; Cherney and Halper 2008)
  - words per minute (WPM)

    (Ali et al., 2018; Cherney et al., 2008, 2014; Cherney & Halper, 2008; Costello-Yacono & Balasubramanian, 2018; Goldberg et al., 2012; Moss, 2009; Szabo et al., 2014; Youmans et al., 2005, 2011)
  - fluency disruptions per hundred words* (Goldberg et al., 2012; Youmans et al., 2005)
  - proportion of open to closed class words

    (Ash et al., 2010; Thompson et al., 1997; Wilson et al., 2010; Nobis-Bosch et al., 2011)
  - propositional idea density

    (stroke-induced nonfluent aphasia: Bryant et al., 2013; Ferguson et al., 2013; Fromm et al., 2016; Ulatowska et al., 1981, 1983; distinguishing between PPA subtypes: Vander Woude, 2017)
  - grammatical complexity index

    (improved production of grammatical morphemes: Cherney et al, 2008; Cherney & Halper, 2008; Goldberg et al., 2012; production of more SVO structures: Costello-Yacono & Balasubramanian, 2018)

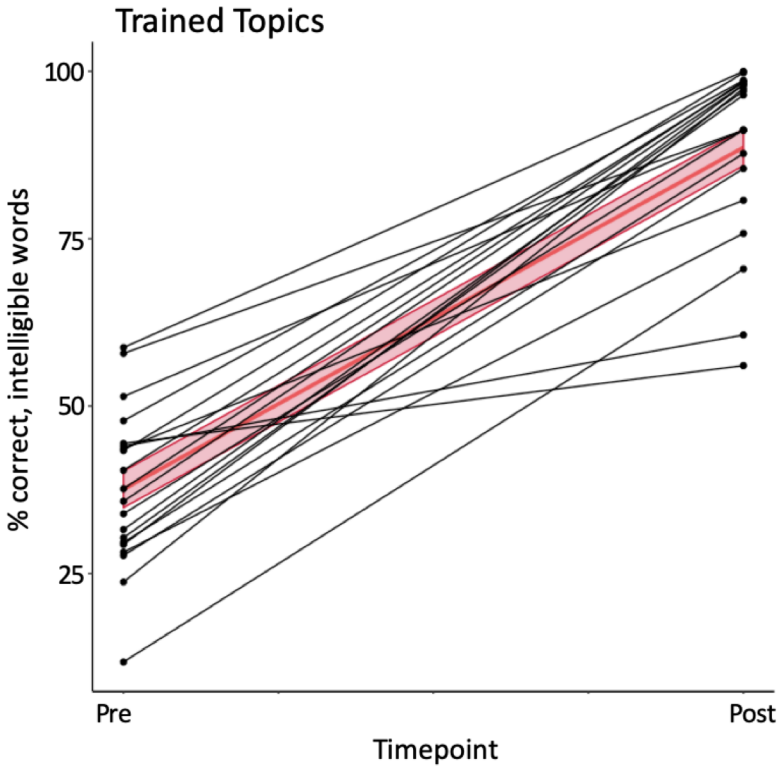
- Percent correct intelligible scripted words

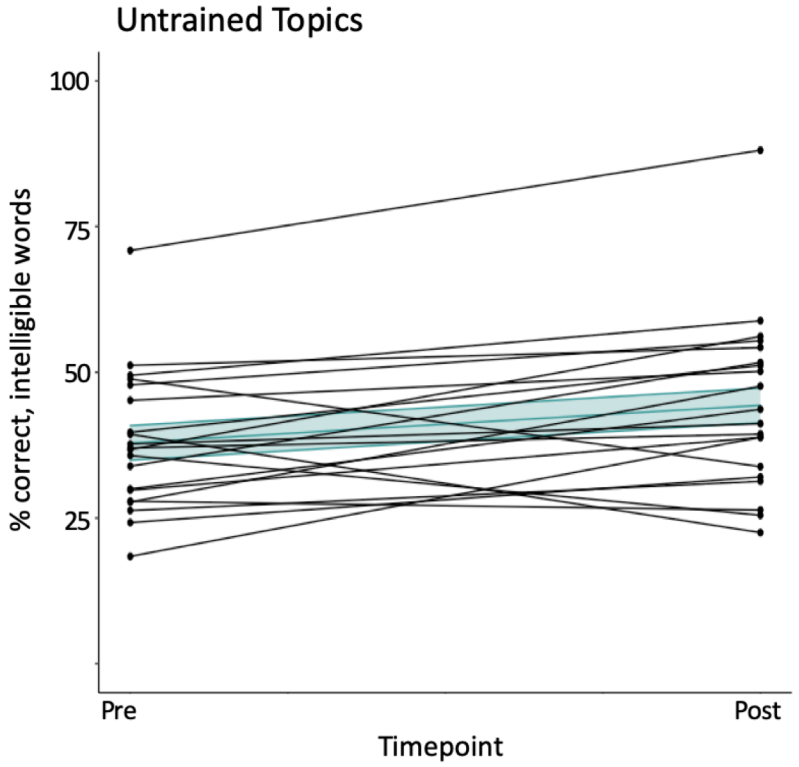
* Indicates measures which require additional coding beyond transcription in CLAN

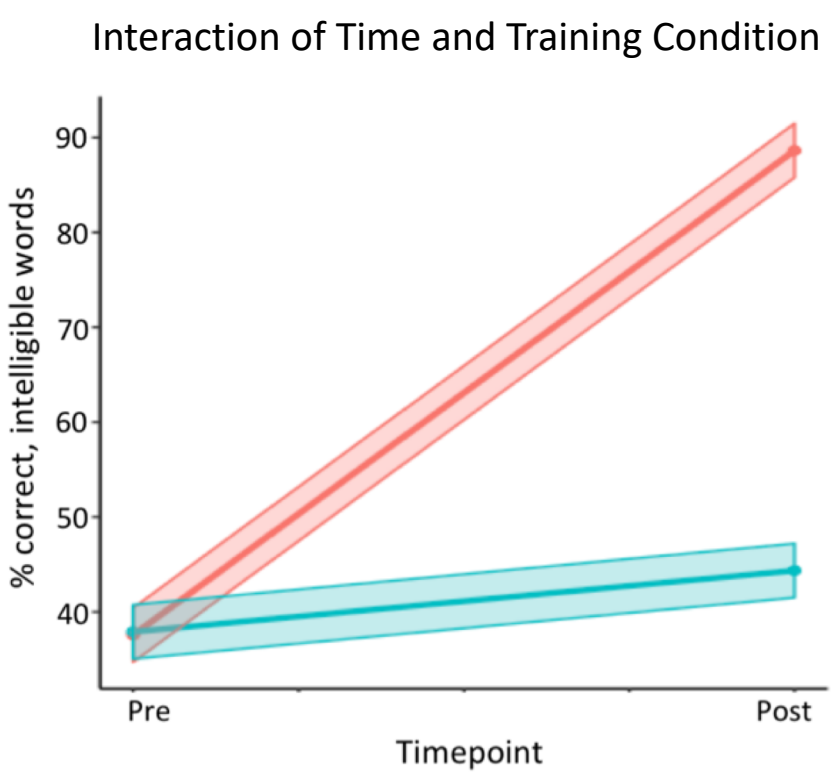
Methods

- For each measure, data for each script for two observations at each time point from pre-treatment and post-treatment were used in the analysis
- A series of mixed-effects linear regression models with a fixed effect of timepoint and a random intercept for participant
  - to infer specificity of observed training effects
    - mixed-effects linear regression models with an interaction term of time (pre and post-treatment) and condition (trained and untrained) and a random intercept for participant were performed
  - trained script topics assessed via one-tailed tests
  - untrained script topics assessed via two-tailed tests

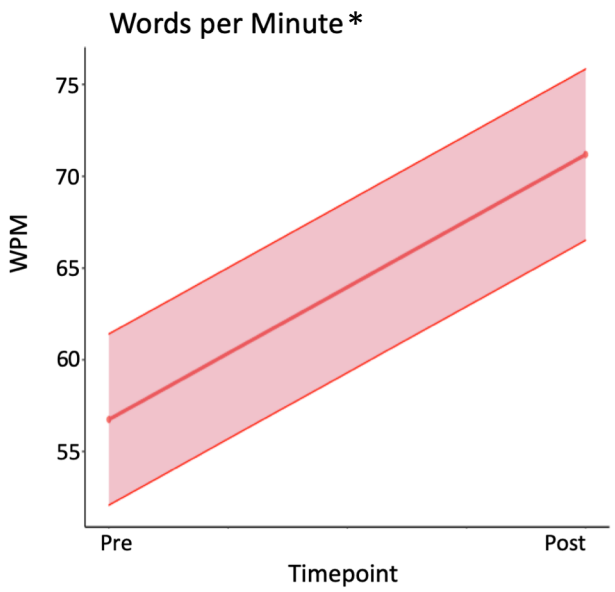
Fixed Effect of Time on Script Accuracy and Interaction of Time and Training Condition

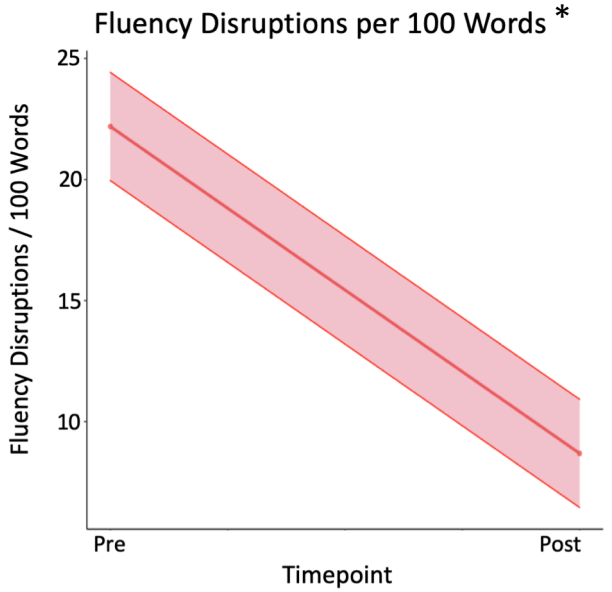


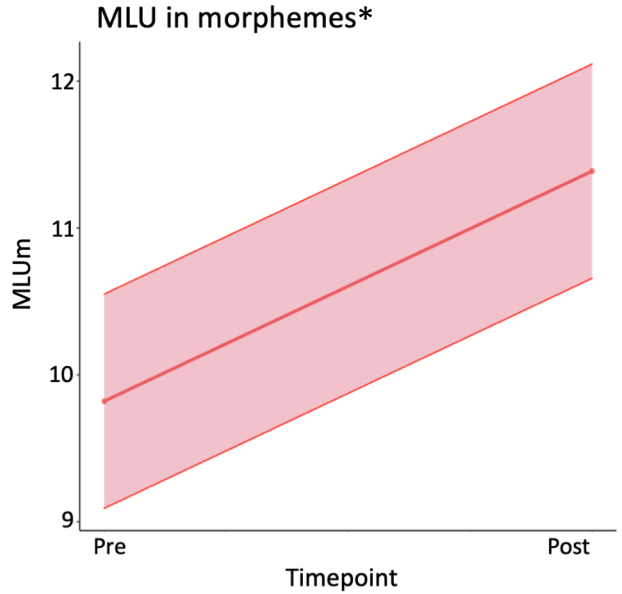


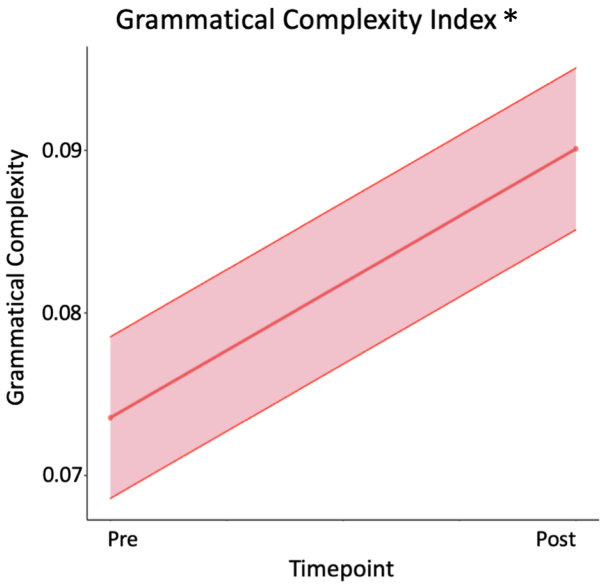


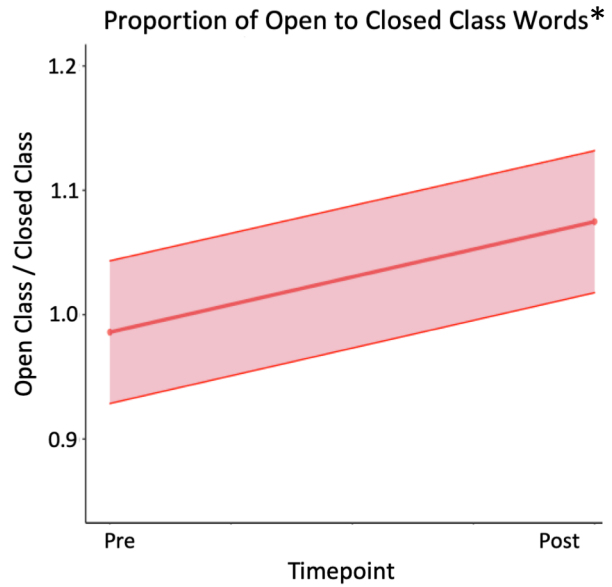
Fixed Effect of Time on Measures for Trained Topics

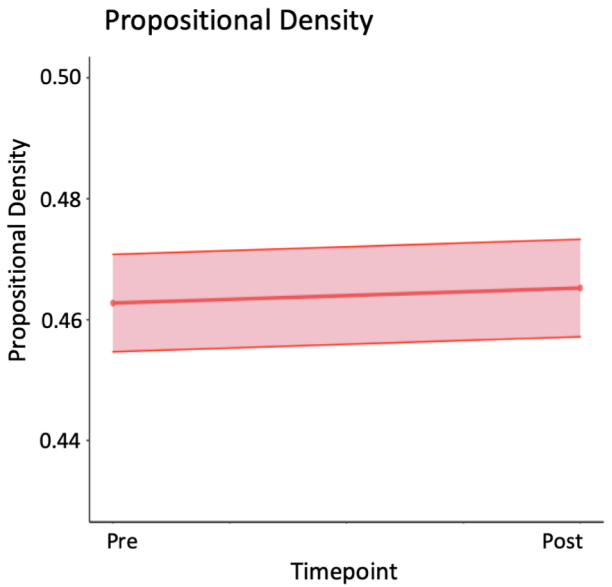




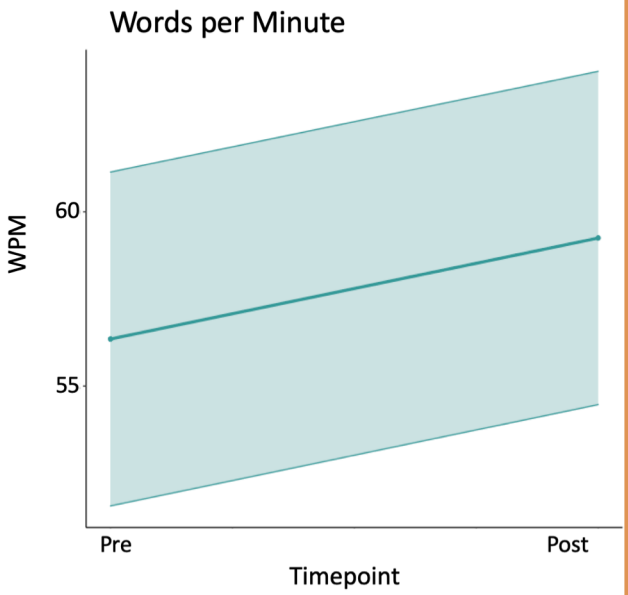


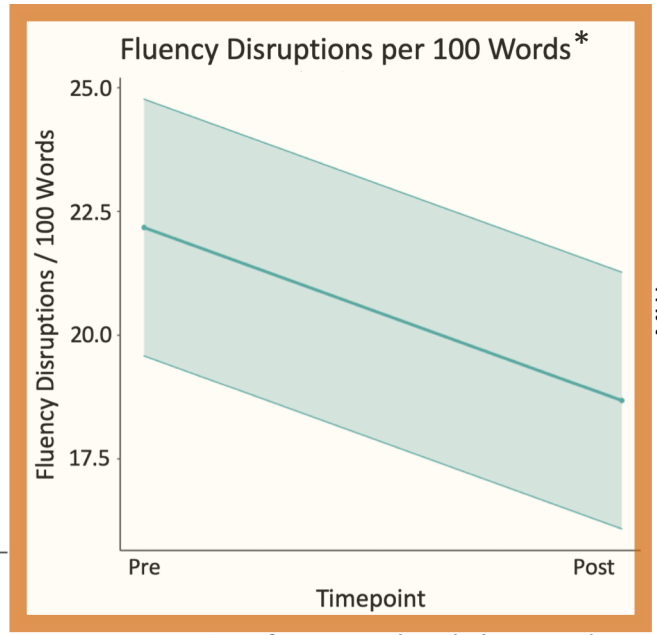


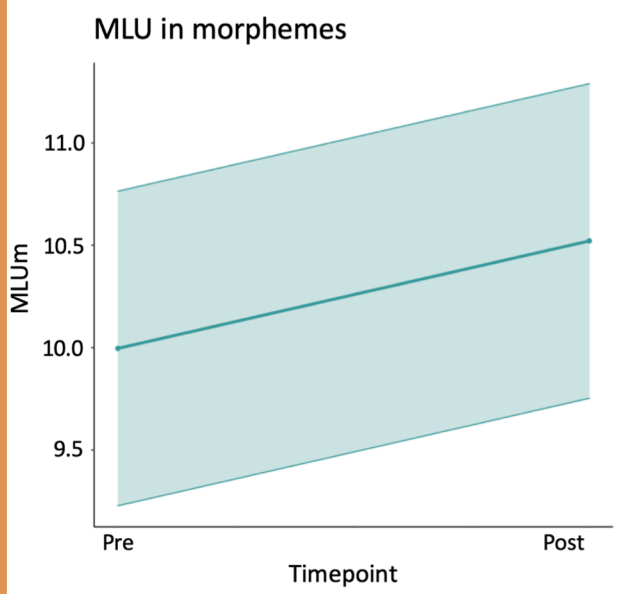


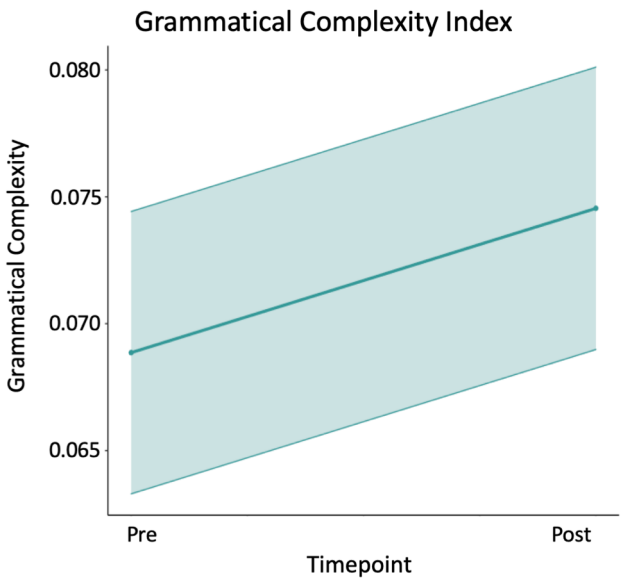


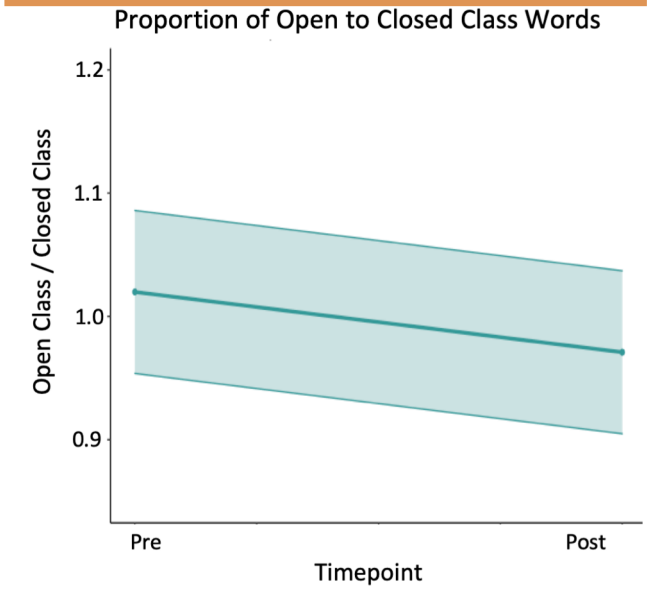
Fixed Effect of Time on Measures for Untrained Topics

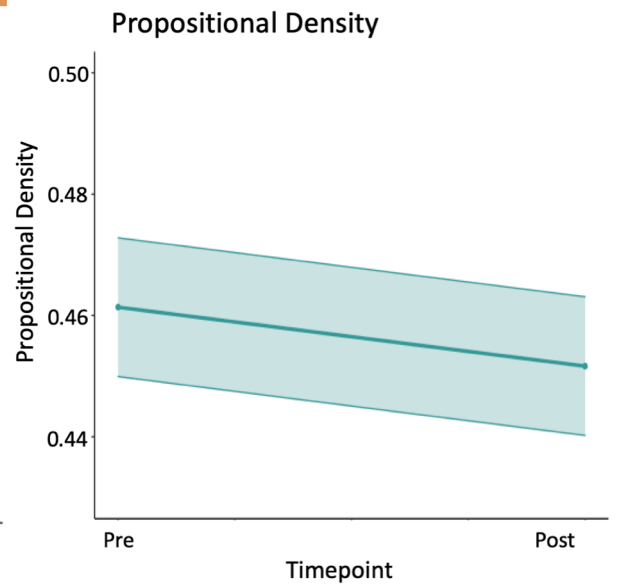




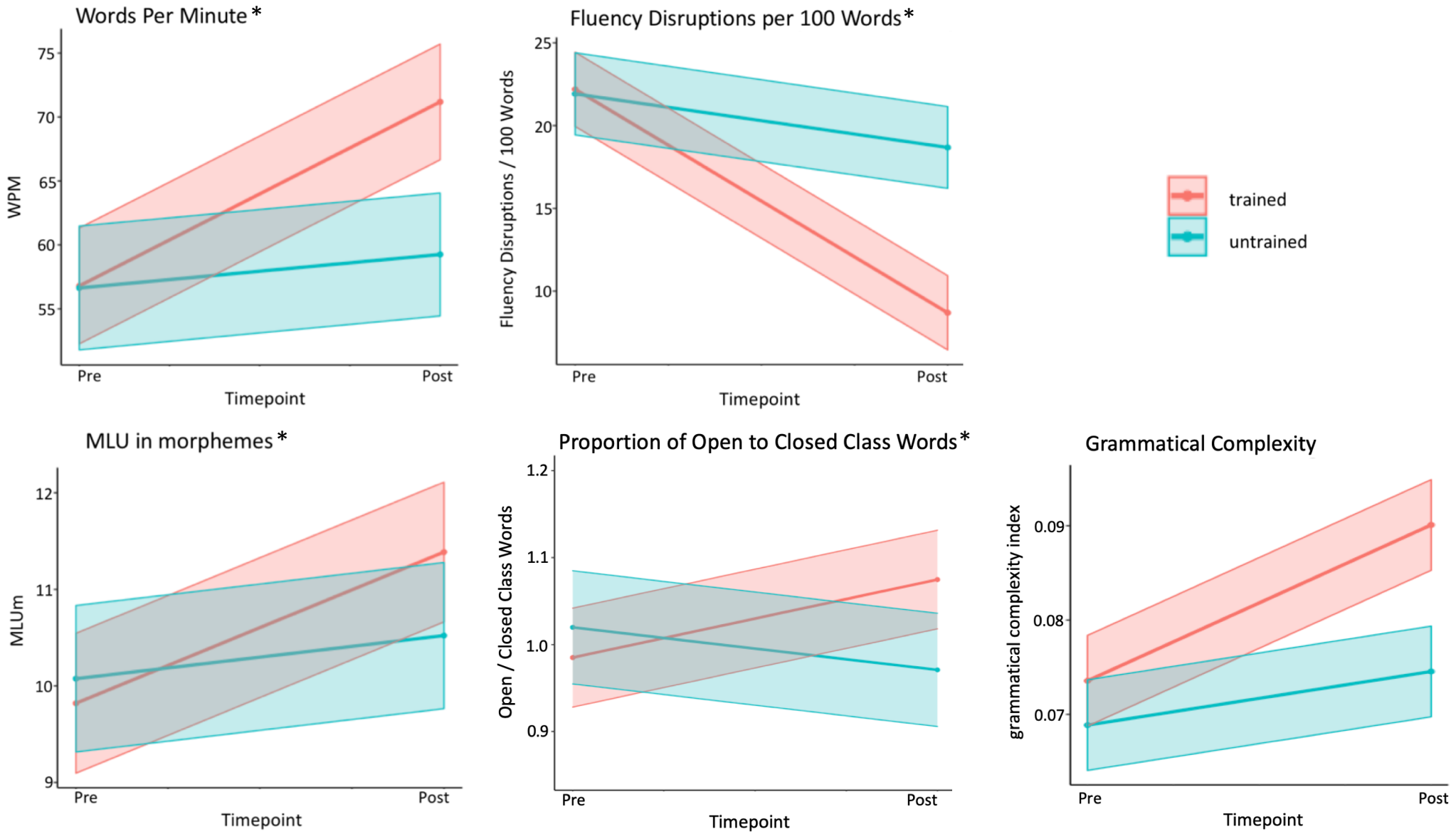








Interactions of Time and Training Condition



Note. Each model includes a random intercept for participant. The y axis presents fitted values from the linear mixed effects model. Standard error is shown in shaded color along the fitted regression line.

Discussion

- Complementing previous findings (Henry et al., 2018), we found improvements for trained topics on measures examining:
  - grammar (grammatical complexity, MLUm, proportion of open to closed class words)
  - speech fluency (fluency disruptions)
  - speech rate (WPM)

- Script training has the potential to yield improvements for individuals who present with deficits in grammar and/or motor speech (i.e., apraxia of speech)

- Small numerical improvements were observed for untrained topics on our outcome measures
  - not statistically significant
    - variable numerical improvements at individual level
  - suggests greatest benefit of script training is observed for practiced material

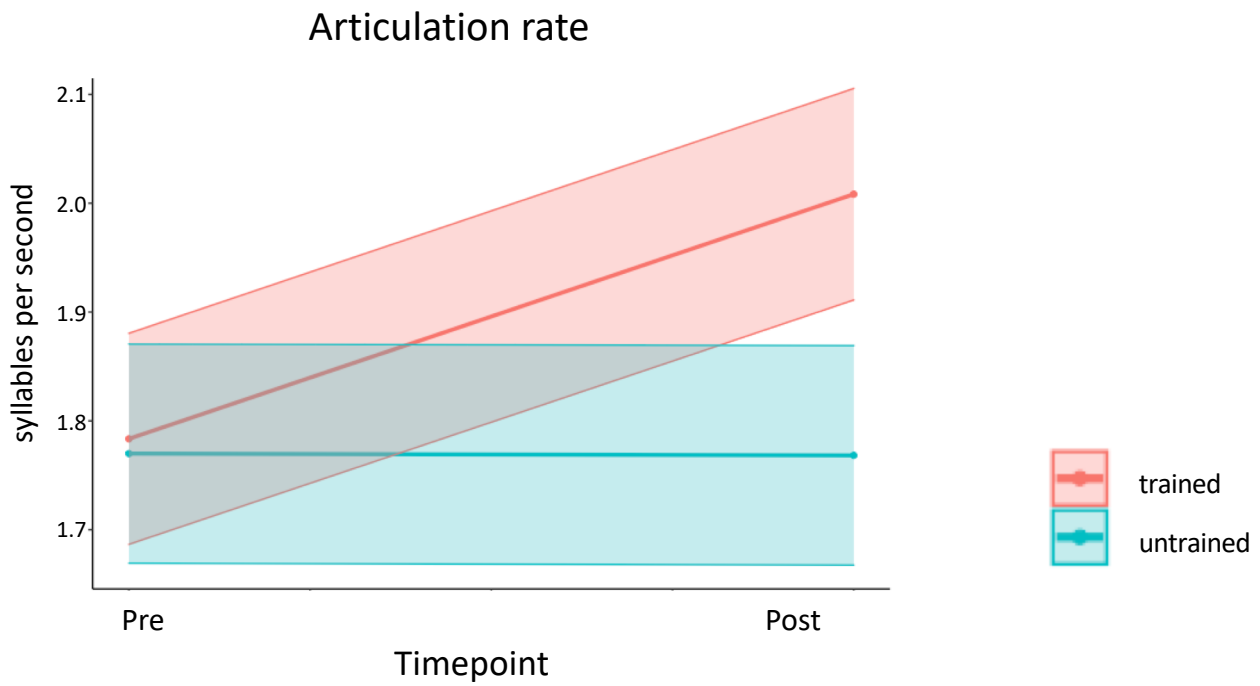
- Relatively automated calculation of connected speech measures which were sensitive to treatment in this population hold potential for application in clinical settings

Discussion

- Future Directions
  - Examine potential differential effects for individuals with relatively isolated deficits (motor speech vs. agrammatism) versus mixed phenotypes
  - Examine whether treatment-induced improvements on relevant outcome measures generalize to other connected speech tasks
  - Evaluate relatively automated analysis methods in conjunction with automatic speech recognition to further reduce time-demands
  - Employ acoustic analysis to further inform treatment effects

Next Step: Acoustic Analyses

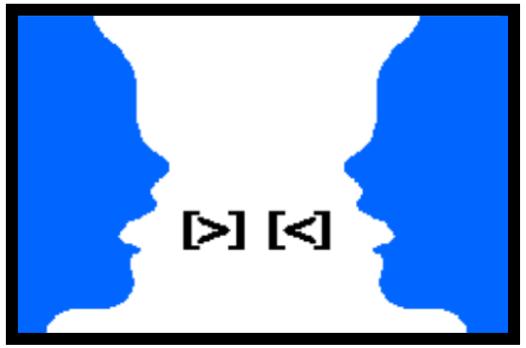
- Articulatory and prosodic metrics differentiate between nfvPPA and logopenic PPA in connected speech samples (Haley et al., 2021)
- Speech timing measures show a significant and specific effect of treatment for trained topics
  - syllables per second of phonated time (articulation rate)
  - mean time between syllable onsets
  - mean pause duration
  - speech-to-pause ratio



Acknowledgements

APHASIA RESEARCH AND TREATMENT LAB

CHAT and CLAN



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