

BioSensics™

#5967: Longitudinal Digital Speech Assessment In Progressive Supranuclear Palsy (Session: P4-06)

Kyurim Kang^{1*}, İlkay Yıldız Potter^{2*}, Ram Kinker Mishra², Rylee Cole², Tejas Pawar², Charlie Weige Zhao³, Antje S. Mefferd⁴, Michael de Riesthal⁴, Ashkan Vaziri², Anne-Marie Wills³, Alexander Pantelyat¹

1. Department of Neurology, Johns Hopkins University School of Medicine, Baltimore, MD, USA
3. Department of Neurology, Massachusetts General Hospital, Harvard Medical School, Boston, MA, USA

2. BioSensics LLC, 57 Chapel St, Newton, MA, USA
4. Vanderbilt University Medical Center, Nashville, TN, USA



* Equal contribution

Introduction

- Progressive Supranuclear Palsy (PSP) is a rare neurodegenerative parkinsonian disorder.
- PSP is often misdiagnosed as Parkinson disease, leading to delays in correct diagnosis
- Patients frequently experience speech difficulties, functional decline and reduced quality of life.

Subjective Assessment
Inter-rater variability¹

In-Clinic Assessments
Snapshot of the disease²

Limited Expertise
Infrequent assessment^{2,3}

Problem: Current assessments lack sensitivity to disease symptoms, complicating clinical trials.

- BioDigit Speech solution:** A state-of-the-art software solution to extract voice outcomes from digital speech assessments
- Prior cross-sectional work²:** Achieved >90% sensitivity/specificity differentiating PSP from PD and other neurodegenerative diseases using ML.
- The gap:** Cross-sectional findings are established, but longitudinal speech trajectories in PSP remain poorly characterized.

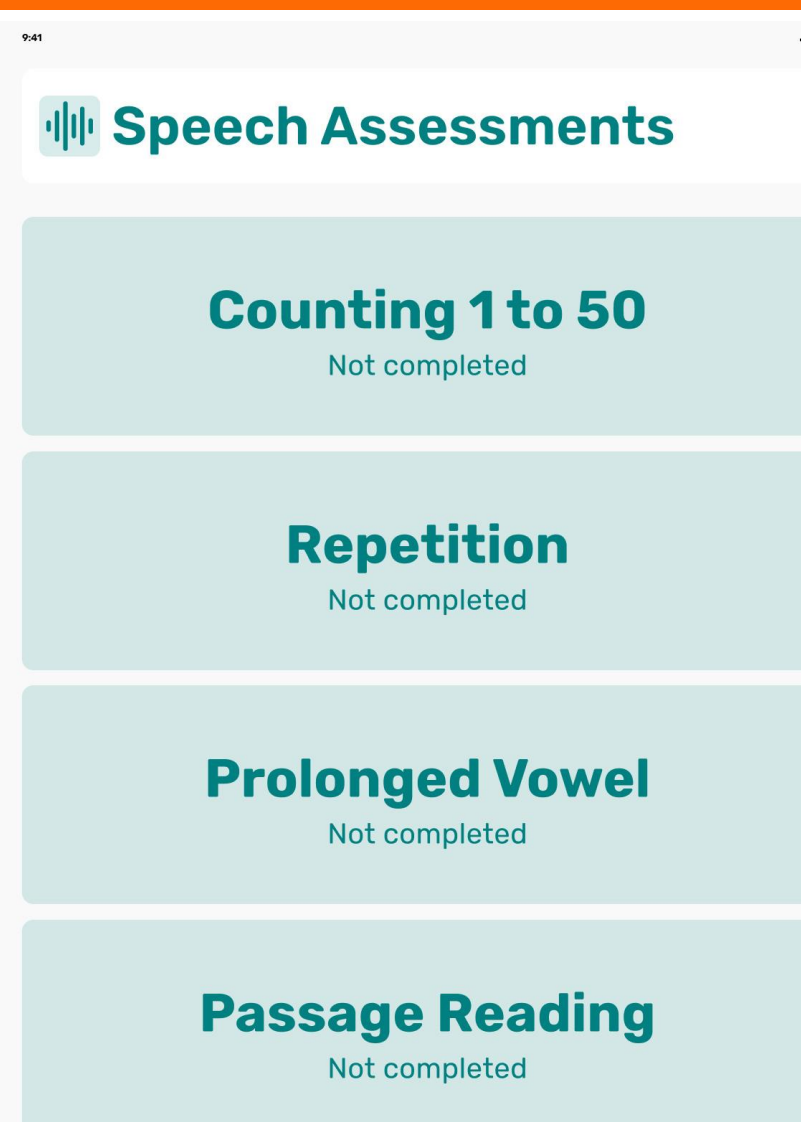
BioDigit Speech solution

What is BioDigit Speech™?

- AI-powered software extracting >40 independent vocal features from digital speech assessments
- Captures phonatory, articulatory, prosody and intelligibility features
- Uses automated speech recognition and audio waveform/spectrum/cepstrum analysis

Deployment

- BioDigit Home:** remote tablet-based assessments from home
- BioDigit Clinic:** supervised in-person assessments
- BioDigit Cloud:** secure, HIPAA-compliant data storage
- Validated** in 11 languages | NIH-funded (R44AG080861)



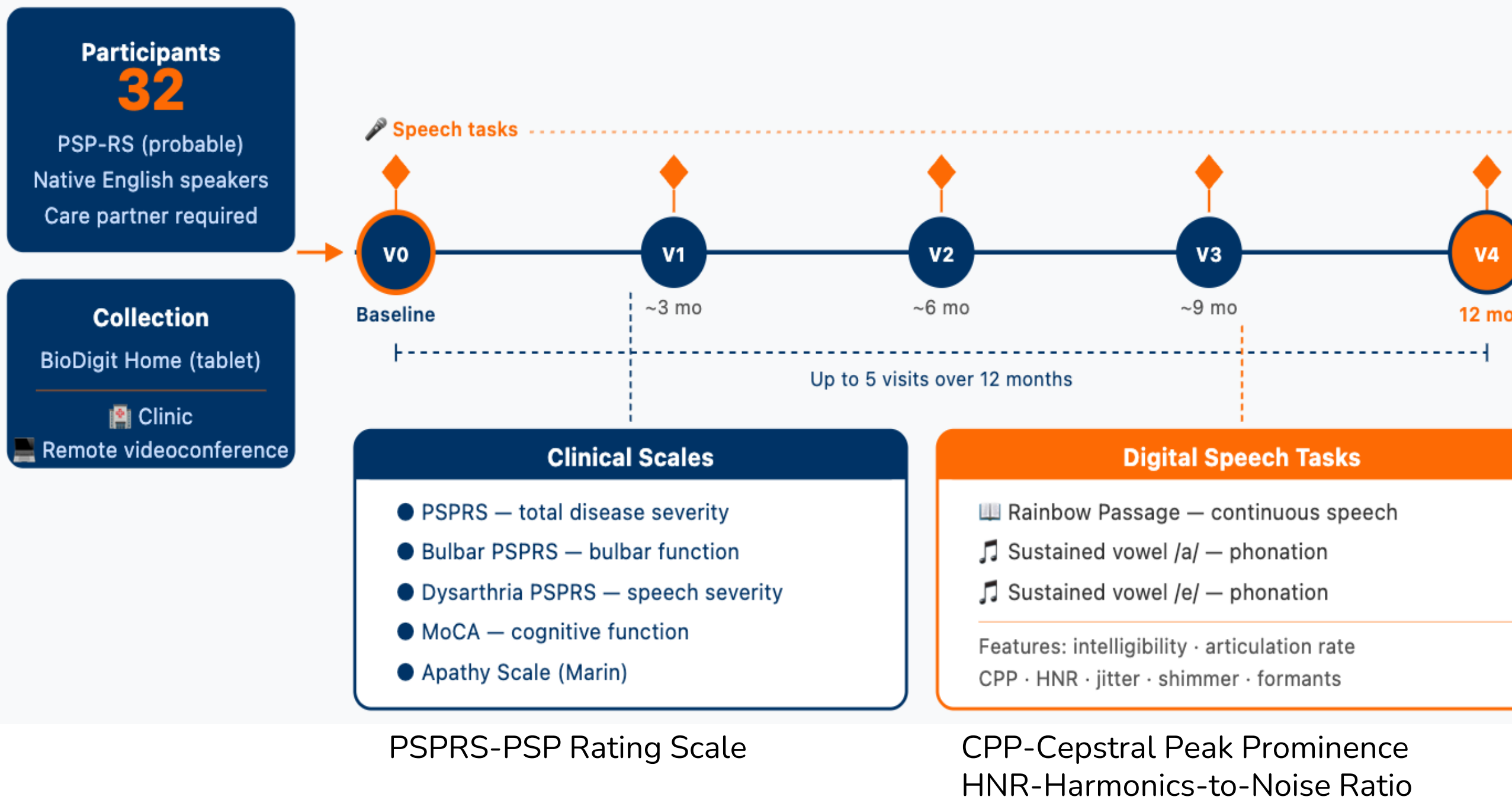
Study Design and Patient Characteristics

Variable at baseline	Overall (n = 32)
Age, years	69.1 ± 6.0
Marin Apathy Evaluation Scale*	56.0 ± 9.2
Bulbar PSPRS subscale score	2.1 ± 1.8
Total PSPRS	34.0 ± 11.6
Disease duration, months	11.9 ± 11.0
Female, n (%)	12 (37.5)
Ethnicity, n (%)	
Not Hispanic or Latino	32 (100)
Race, n (%)	
Black/African	1 (3.1)
Asian	1 (3.1)
White	30 (93.8)



IRB : JHU + MGB

ClinicalTrials.gov:
NCT05956834



Changes in speech features and bulbar function over time

Cohen's d for 12-month normalized change:

No Dysarthria (n=5)

- Articulatory rate:** d = −1.93
- Intelligibility:** d = −1.75
- Similarity¹:** d = −1.65
- Ratio of missing words:** d = 1.29
- Bulbar PSPRS:** d = 1.41
- Dysarthria PSPRS:** d = 0.71

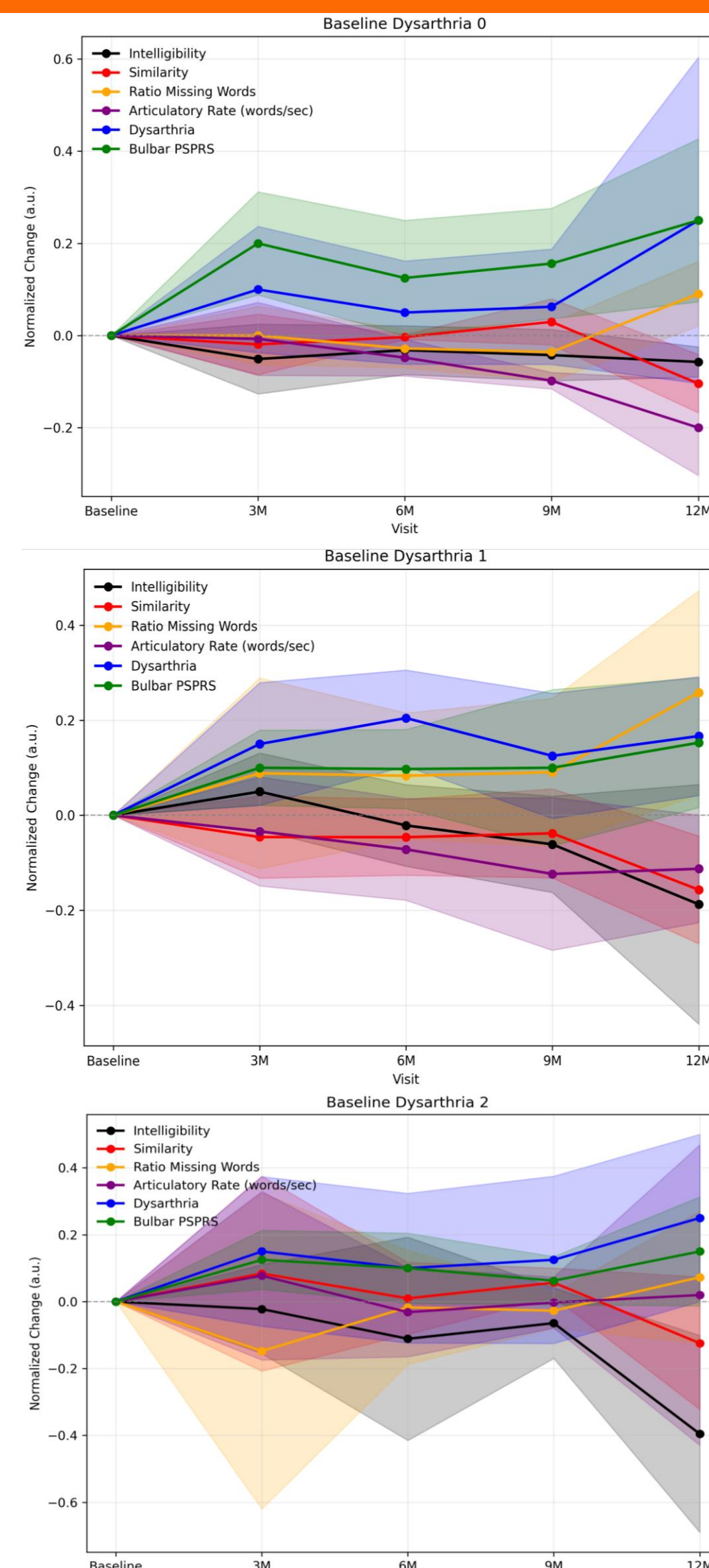
Mild Dysarthria (n=11)

- Similarity:** d = −1.38
- Articulatory rate:** d = −1.00
- Intelligibility:** d = −0.74
- Ratio of missing words:** d = 1.21
- Dysarthria PSPRS:** d = 1.33
- Bulbar PSPRS:** d = 1.12

Moderate Dysarthria (n=6)

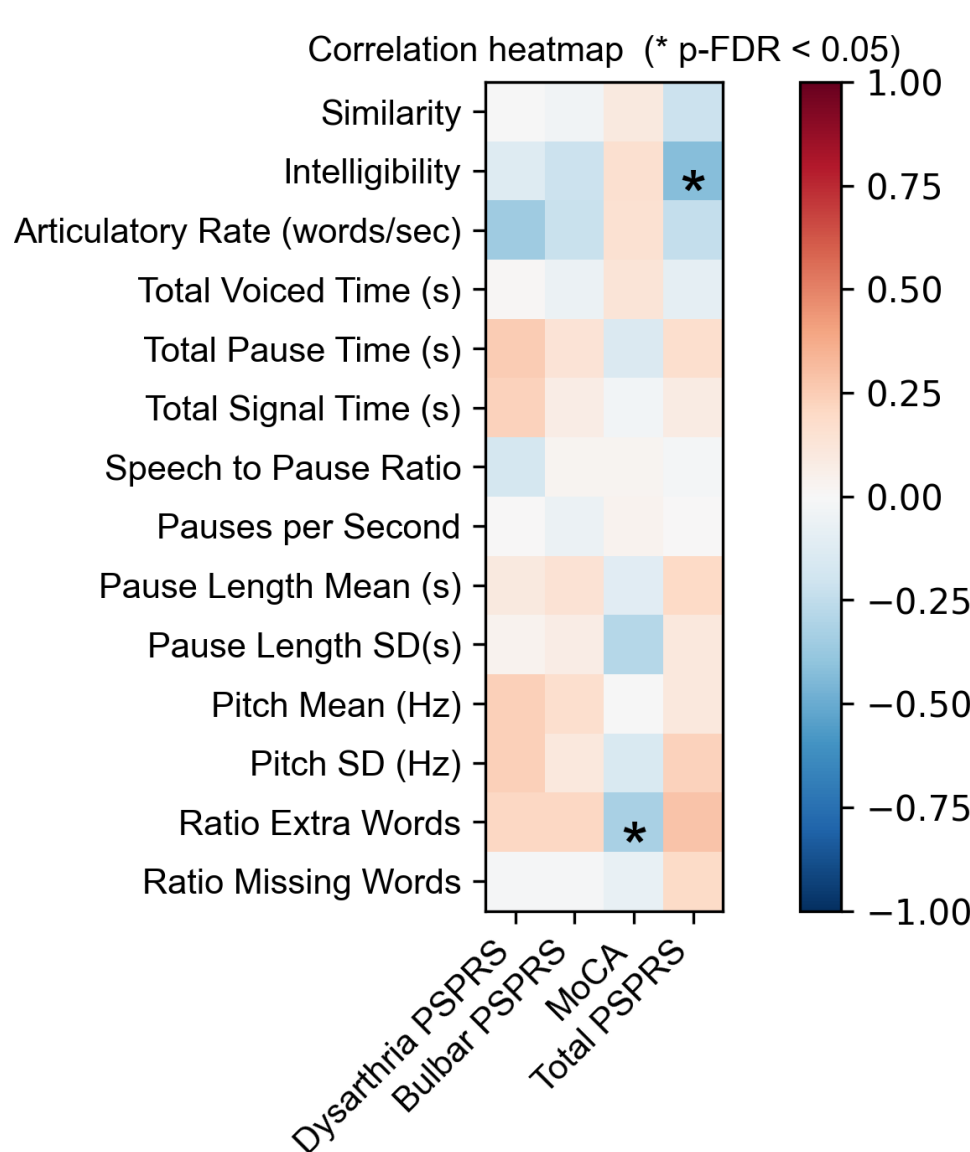
- Intelligibility:** d = −1.34
- Similarity:** d = −0.63
- Ratio of missing words:** d = 0.37
- Articulatory rate:** d = 0.04
- Dysarthria PSPRS:** d = 1.00
- Bulbar PSPRS:** d = 0.92

¹ Similarity between transcription and passage

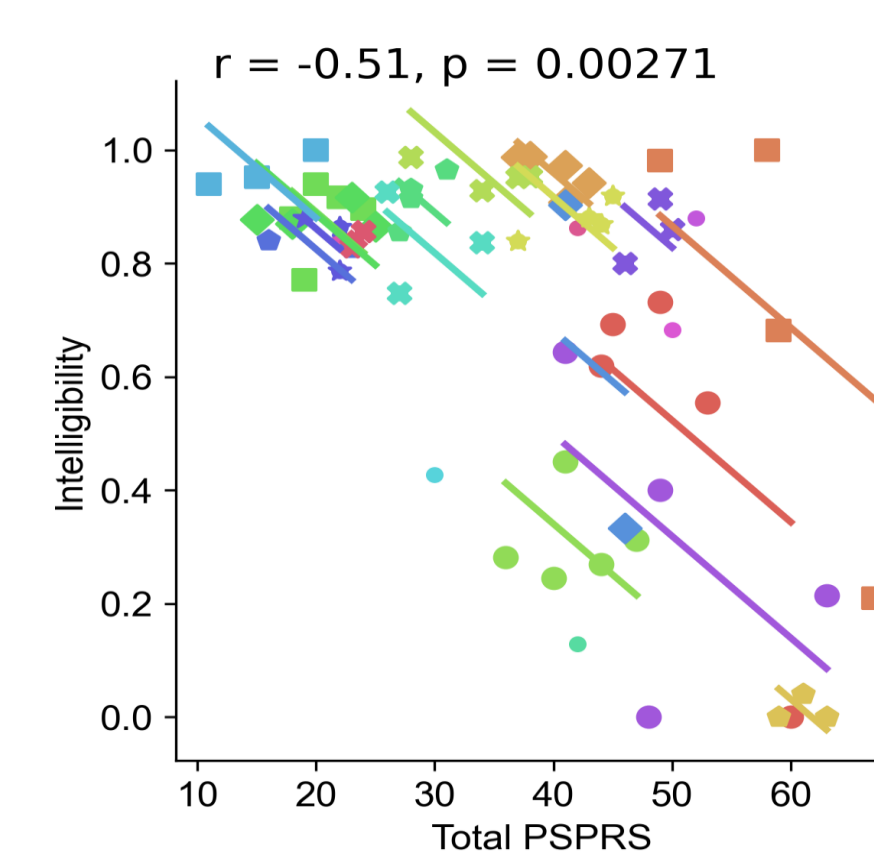


Repeated measure correlations of speech features and clinical ratings

Rainbow Passage (continuous speech)

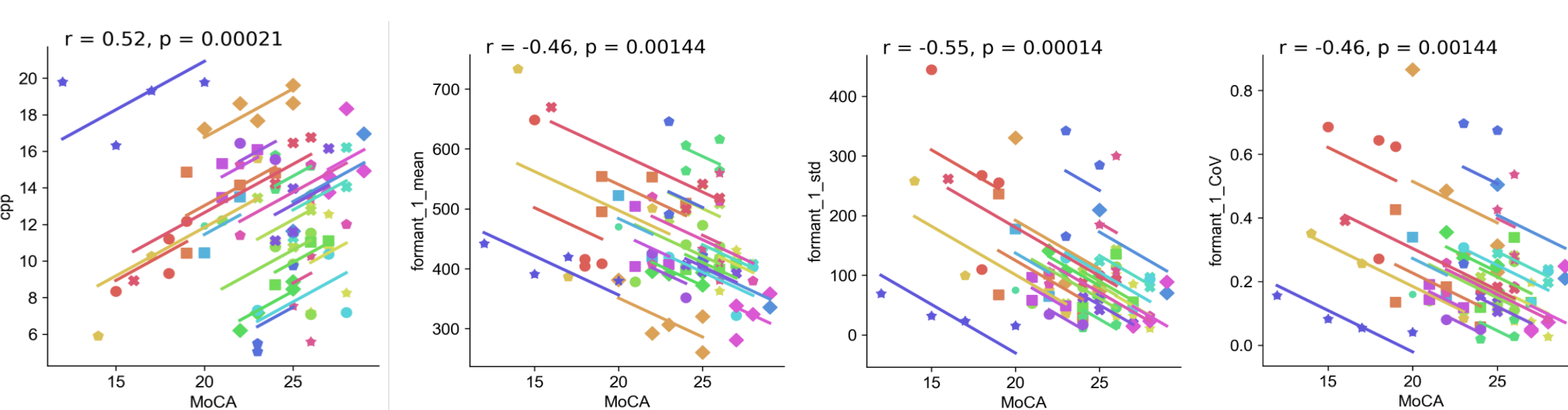


- Lower intelligibility → greater disease severity



Sustained Vowel /e/

- Better voice quality and spectral stability → preserved cognition



Acknowledgment

Research reported in this publication was supported by the National Institute on Aging of the National Institutes of Health under Award Number R44AG080861. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Machine Learning (ML)-based prediction of clinical ratings

Concurrent Clinical Score Prediction

- Cross-validated ML models (from a pool of 17 regressors):

ML model inputs (left) vs. predicted clinical ratings (middle, right):

Feature set	Total PSPRS	Dysarthria
Reading passage	r = 0.24*	r = 0.40*
Reading + age & sex	r = 0.43*	r = 0.52*
Vowels (a+e) + age & sex	r = 0.19	r = 0.28*
Reading + vowels	r = 0.33*	r = 0.47*

- Absolute errors within 16–19% of clinical score ranges
- *Statistically significant correlations of predictions with clinical ratings

Future Score Prediction (3 months ahead)

- Current score + speech features → strong longitudinal predictions:

Feature set	Total PSPRS	Bulbar PSPRS
Reading passage	r = 0.90*	r = 0.62*
Reading + age & sex	r = 0.90*	r = 0.64*
Sustained vowels (a+e)	r = 0.89*	r = 0.68*

Key Predictors

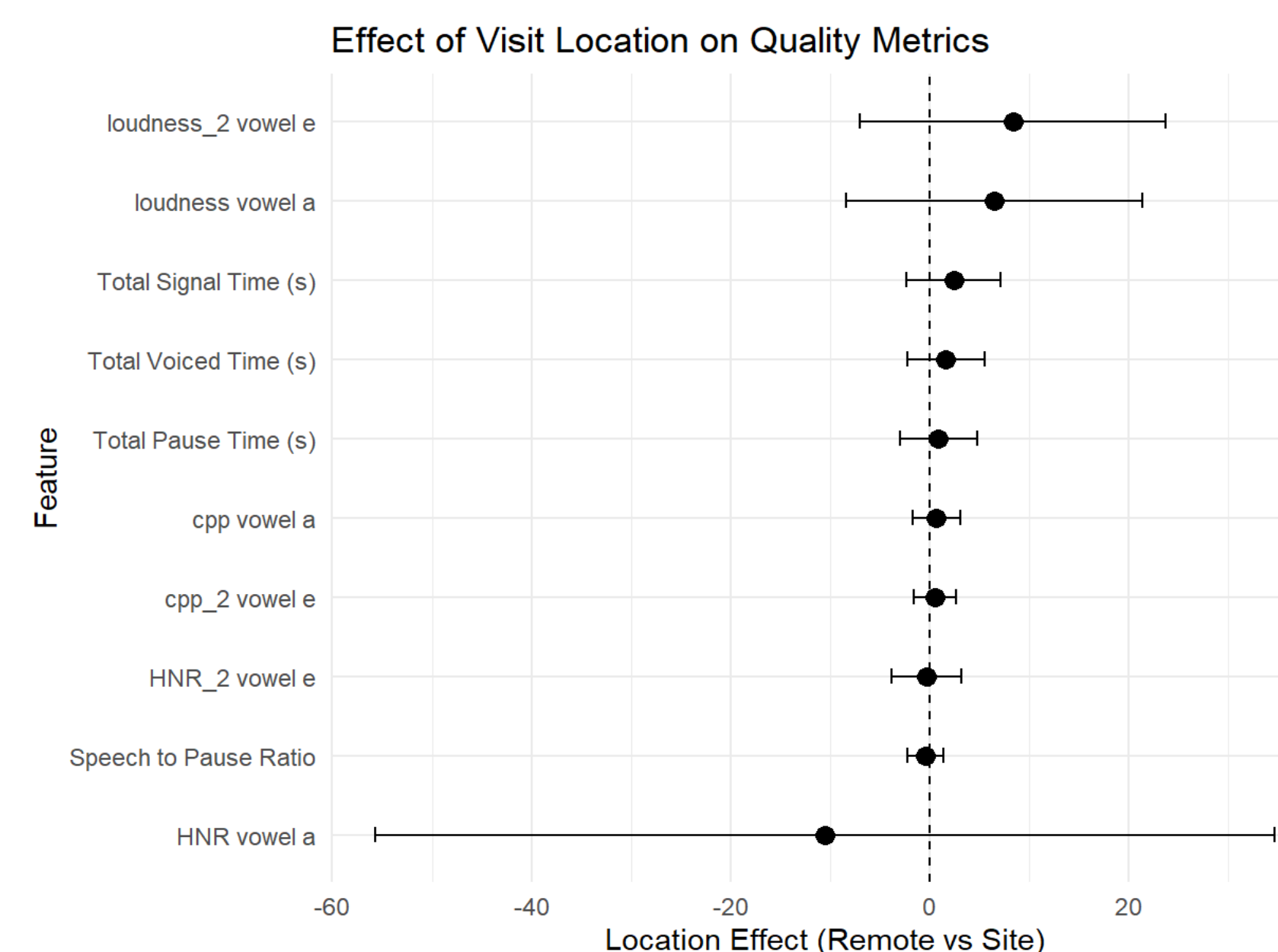
- Intelligibility:** most important feature for future predictions
- Formant measures (articulatory resonance/control)
- Jitter (cycle-to-cycle vocal fold variability)
- Age and sex improve concurrent prediction accuracy

Sensitivity and measurement consistency

Linear mixed-effects models assessed remote vs. in-person recording differences:

- Most estimated differences near zero — all 95% CIs overlap zero
- Slightly higher loudness in remote recordings (not significant)
- Signal duration, voiced time, pause time, CPP: no significant differences
- Visit location did not introduce systematic acoustic bias

Supports validity of remote recordings for digital speech biomarker research



Conclusion

- First 12-month longitudinal digital speech study in PSP-RS
- Speech features capture disease progression with moderate-to-large effect sizes comparable to or greater than those for clinical ratings (d up to −1.93)
- ML models predict current clinical scores (r = 0.43–0.52) and future scores (r = 0.51–0.90)
- Remote assessments valid; digital speech biomarkers scalable and objective for PSP clinical trials

References

- Sharma, Mansi, et al. "Remote at-home wearable-based gait assessments in Progressive Supranuclear Palsy compared to Parkinson's Disease." BMC neurology 23.1 (2023): 434.
- Kang, Kyurim, et al. "Utilizing speech analysis to differentiate progressive supranuclear palsy from Parkinson's disease." Parkinsonism & Related Disorders 115 (2023): 105835.
- Sharma, Mansi, et al. "Longitudinal study of Progressive Supranuclear Palsy (PSP) using remote at-home multi-modal digital assessments and wearable devices (S51.002)." (2023).