# Acoustic Variability in Dysarthria: Effects of Articulation Rate and its Relationship with Intelligibility

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## Introduction

- Rate reduction is a popular management strategy in treatment of hypokinetic dysarthria (Yorkston et al., 2007).
- However, not all speakers with dysarthria exhibit improved speech intelligibility when slowing rate (Tjaden et al., 2014).
- Research on the effects of rate changes on stability of sentence-length speech motor movements in dysarthria is sparse and contradictory, with findings of:
  - increased variability at *slow* rate (Kleinow et al., 2001).
  - increased variability at *fast* rate (McHenry, 2003).
- Most speech variability research is based on *kinematic* data, but new techniques enable the assessment of variability of *acoustic* properties as an indirect measure of speech movement stability (Anderson et al., 2008).

### Purpose

Investigate effect of rate changes on measures of sentence-level acoustic variability in dysarthria, and evaluate possible relationships between acoustic variability measures and intelligibility in dysarthria.

## Methods

### Participants

- 23 speakers with PD and mild-moderate *hypokinetic dysarthria* (**HD**)
  18 male, 5 female, age 40-81, M = 66.6, SD = 10.6
- 9 speakers with various neurological diseases and mild-severe *ataxic / ataxic-spastic* dysarthria (**AD**)
  6 male, 3 female, age 37-70, M=57.4, SD=13.9
- 27 age-matched control speakers (**CON**)
  16 male, 11 female, age 35-80, M=57.4, SD=13.9

### Speech Tasks: Variability Measures

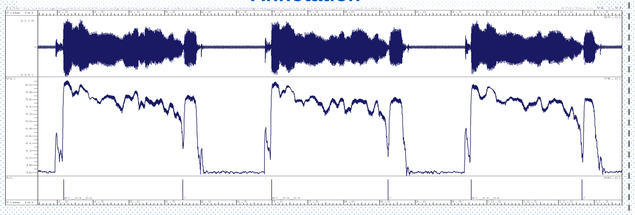
- Repeat the phrase "*Tony knew you were lying in bed*" as similar as possible, around 20 times
- Three speaking conditions:
  - Habitual speech rate (**Hab**)
  - **Slow** speech rate
  - **Fast** speech rate
- Acoustic properties of interest:
  - Sound pressure level (**SPL**)
  - Fundamental Frequency (**F0**)
  - First Formant (**F1**)
- Measures extracted with Functional Data Analysis:
  - Spatial Variability
  - Temporal Variability

### Speech Tasks: Intelligibility Measures

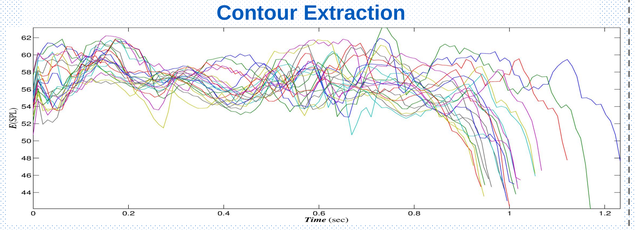
- Engage in a monologue.
- Perceptual judgements (Likert-scaled ratings of intelligibility and listening effort) by 15 undergraduate SLP students; some experience in listening to dysarthric speech

## Data Analysis (example: SPL contours)

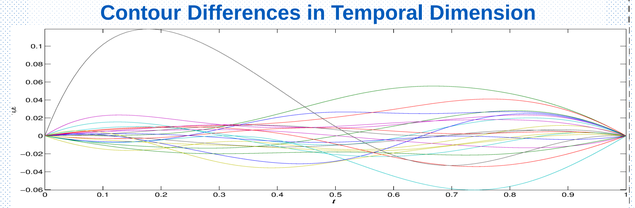
### Annotation



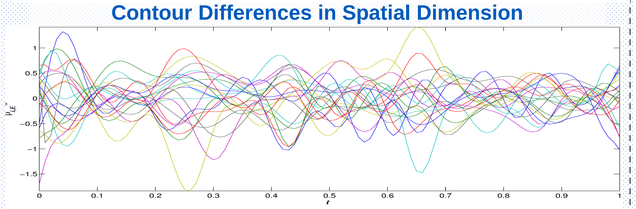
### Contour Extraction



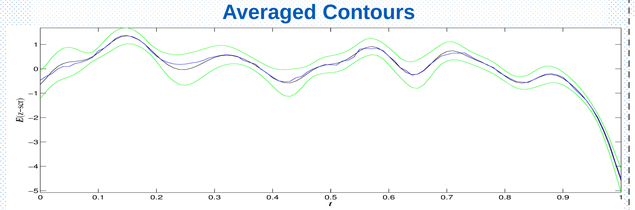

### Contour Differences in Temporal Dimension




### Contour Differences in Spatial Dimension




### Averaged Contours

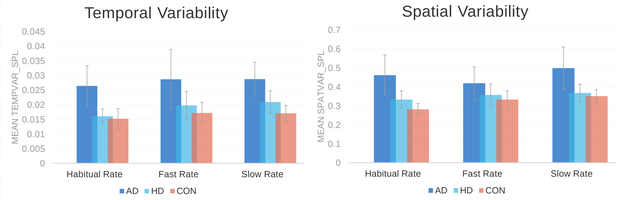



### Statistical Analysis:

- Group and Task comparisons:
  - Linear Mixed Model analyses
  - Group and Task as fixed factors
  - Subject as random factor
  - Sentence duration as covariate
- Correlations between variability and intelligibility:
  - Linear Regression

## Results: Groups & Tasks

### Sound Pressure Level




Overall:
AD > HD ≈ CON

Group comparisons:
Hab, Slow, Fast: AD > HD ≈ CON

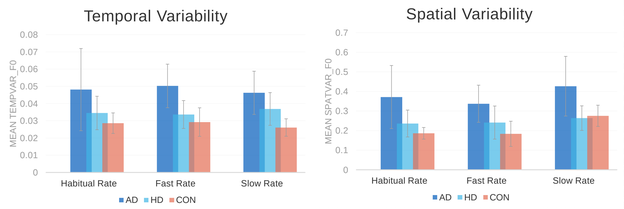
Task comparisons:
**AD: Hab ≈ Slow ≈ Fast**
**HD: Slow ≈ Fast > Hab**
CON: Hab ≈ Slow ≈ Fast

Overall:
AD > HD ≈ CON

Group comparisons:
Hab, Slow: AD > HD ≈ CON
Fast: AD ≈ HD ≈ CON

Task comparisons:
**AD: Slow > Fast ≈ Hab**
**HD: Hab ≈ Slow ≈ Fast**
CON: Slow ≈ Fast > Hab

### Fundamental Frequency




Overall:
AD > HD ≈ CON

Group comparisons:
Hab, Fast: AD > HD ≈ CON
Slow: AD > HD

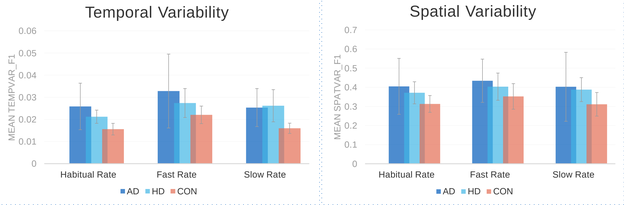
Task comparisons:
AD, HD, CON: Hab ≈ Slow ≈ Fast

Overall:
AD > HD ≈ CON

Group comparisons:
Hab, Slow: AD > HD ≈ CON
Fast: AD > CON

Task comparisons:
**AD: Slow > Hab ≈ Fast**
**HD: Hab ≈ Slow ≈ Fast**
CON: Slow > Hab ≈ Fast

### First Formant




Overall:
AD ≈ HD > CON

Group comparisons:
Hab: AD ≈ HD ≈ CON
**Slow: HD > CON**
**Fast: AD > CON**

Task comparisons:
**AD, CON: Fast > Hab ≈ Slow**
**HD: FAST ≈ Slow > Hab**

Overall:
AD ≈ HD ≈ CON

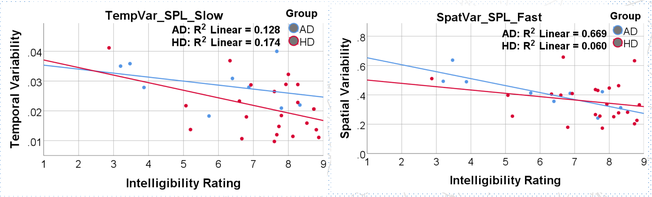
Group comparisons:
Hab, Slow, Fast: AD ≈ HD ≈ CON

Task comparisons:
AD, HD, CON: Hab ≈ Slow ≈ Fast

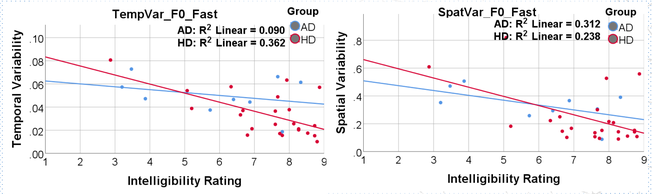
## Results: Correlation Results

The strongest differentiating variability measures were used for further correlational analysis with intelligibility measures.

### Sound Pressure Level




### Fundamental Frequency

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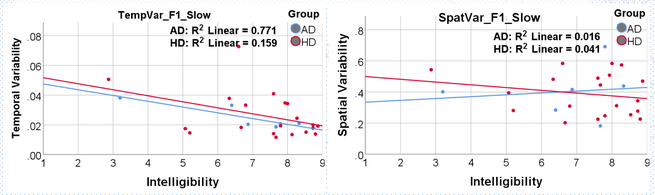


## Summary & Conclusion

- Variability generally higher in dysarthria compared to controls
- Higher severity in AD group reflected in higher variability
- Rate differences dependent on group, task, speech parameter under investigation. Trends:
  - Deviating from habitual rate increases variability
  - AD: slow rate more impact on variability
- Increased variability correlated with lower intelligibility ratings; shows potential as acoustic measure of severity
- Group differences of variability not always reflected in significant intelligibility-variability correlations
- Complicated relationship acoustic variability - intelligibility; associations largely dependent on dysarthria type and speech parameter

## References

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Funding: The Scottish Funding Council (Ph.D. Scholarship) & NIH-NIDCD R01DC004689 (PI; Tjaden)

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