### Introduction

Apraxia of Speech (AOS) is difficult to differentiate from aphasic production problems and from dysarthria. Diagnostically, it would be an improvement if AOS were more clearly characterized in objectively measurable acoustic terms. Deviations in consonantal voice-onset-time (VOT) have been associated with AOS (e.g., Basilaes, 2016).

Previous studies on vowel production were inconclusive or concluded that AOS does not affect vowel production (e.g., Jakobs et al., 2010). If control over the speech apparatus is impaired, this may be reflected in increased variance of vowel formant production.

AOS and/or dysarthria may affect vowel space, i.e., articulatory range.

We measured formants in vowels produced during spontaneous speech by speakers with and without AOS, and assessed to what extent formant characteristics were predictive of aphasia, AOS and dysarthria, as well as AOS severity, based on the Apraxia of Speech Rating Scale (ASRS; Strand et al., 2014).

### Data Extraction

- Speech samples were manually organized into utterances, words, consonants and vowels, labeled on separate tiers in PRAAT (Boersma, 2001).
- Voice Onset Time (VOT) data were extracted for voiced and voiceless consonants separately (Basilaeis, 2016).
- First (F1), second (F2) and third (F3) formants extracted using PRAAT script (Lennors, 2000).
- Only monophthongs bearing primary stress in content words were included in the analysis: /a, e, ê, i, ï, o, u, ù, a, ù.
- Formants normalized using Nearey’s (1978) shared logmeang procedure, to reduce participant-specific variance, e.g., gender-related (Adank et al., 2004).
- Standard deviations around the means calculated for normalized F1, F2 and F3.
- Vowel space estimated by formant centralization ratio, based on three vowels: /a, i, u/ (FCR3; Sapir et al., 2010, see Karlsson & Van Doorm, 2012).
- All variables converted to z-scores, to remove scale differences and facilitate comparison of parameter estimates.

### Analyses

- **Multiple Correlations**: see Table
- **LDA 1: predicting 6-group way membership**:
  - Entered: Voiceless VOT
  - Classification success 28.3% (22.6% cross-validated)
- **LDA 2: predicting 3-group way membership**:
  - Entered: F1; Voice VOT SD; F2 SD
  - Classification success 52.8% (50.9% cross-validated)

### References


**Conclusions**

- Speakers with AOS do have unstable vowel production, as reflected in dispersion around the mean of the second formant. This suggests instability of tongue positioning along the horizontal plane in oral space.
- Together with a raised F1 (mandible lowering?) and increased VOT in voiceless consonants, F2 SD predicts AOS in stroke survivors.
- Compared to mean formant and VOT values and VOT dispersion, F2 dispersion is the stronger predictor of AOS severity.
- Speakers with dysarthria have a decreased VOT in voiceless consonants, suggesting a tendency to voice these consonants.
- Vowel space is not affected by AOS, aphasia, or dysarthria.

**Acoustic measures of both consonants and vowels may improve classification of motor speech impairments after stroke, and differentiation from aphasic output problems.**

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