Voice Quality and Laryngeal Complexity in Santiago Laxopa Zapotec

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Outline

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Research Overview

- What my research is about:

Research Questions

Questions:

- How is acoustic space for phonation in a single language structured?
- Which measures are important for capturing phonation contrasts?
- How do these measures help explain SLZ's laryngeal complexity?

Research Questions

Answers:

- Yes; we find a three-dimensional space.
- Dimensions in Santiago Laxopa Zapotec are correlated with:
  1. First/third dimension = glottal-airflow continuum.
  2. Second dimension = nonmodal-to-modal continuum.

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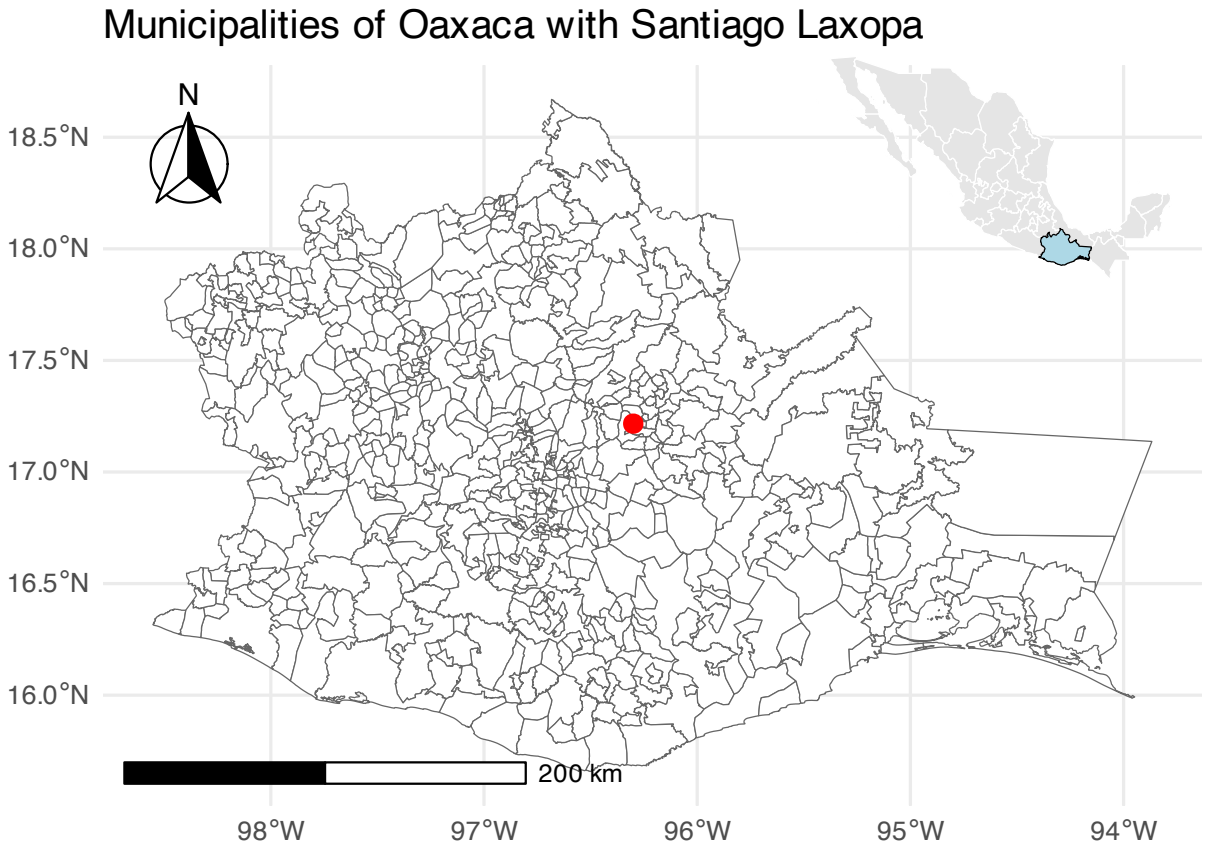
What is Voice Quality?

- Describes how the vocal folds vibrate.
- Used for both paralinguistic (e.g., Laver 1968, Podesva 2016) and phonological contrasts (e.g., Esposito & Khan 2020).

Santiago Laxopa Zapotec

- Santiago Laxopa Zapotec (SLZ; *Dille'xhunh Laxup*) is a Sierra Norte variety of Zapotec.
- Spoken by c. 1,000 speakers in Santiago Laxopa and in diaspora.



Phonation in SLZ

- SLZ has a four-way phonation contrast:
  - Modal ([a])
  - Breathy ([a̤])
  - Checked ([a͡ʔ] or [a͡a̰])
  - Rearticulated ([a͡ʔa], [a͡a̰a], or [a̰])
- SLZ's phonation contrasts are used in both the phonology and the morphology.

Tone in SLZ

Interaction of Tone and Phonation in SLZ

Measuring voice quality

- Long been established that phonation has correlates in the acoustic signal (e.g., Fischer-Jørgensen 1968, Klatt & Klatt 1990).
- Gordon & Ladefoged (2001) list several types of measures types that can be used:
  - Periodicity
  - Energy
  - Spectral tilt
  - Pitch
  - Duration
- Linguists have used combinations of these measures to model phonation (e.g., Blankenship 2002, Brunelle & Kirby 2016, Esposito 2012).

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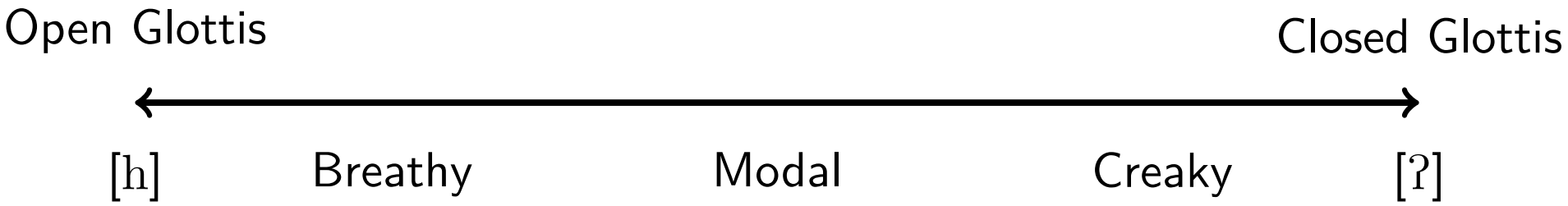
New measures of voice quality

Too many measures

Modeling voice quality

- Early models proposed that voice quality is one dimensional and represents glottal airflow (Ladefoged 1971, Ladefoged & Maddieson 1996).



Voice quality's multidimensionality

- More recent work has shown that voice quality is not one-dimensional, but minimally five-dimensional (e.g., Garellek et al. 2016, Kreiman et al. 2021).
  - Especially in the case of individual speaker differences.
- Garellek et al. (2013) has argued that dimensionality might not be as complex for capturing phonation contrasts.

Keating et al. (2023)

- Explored phonation's cross-linguistic acoustic space.
- Found a two-dimensional space for phonation across 11 languages.
  1. First dimension = nonmodal-to-modal continuum.
  2. Second dimension = glottal-airflow continuum.
- Found that languages with more contrasts used more of the acoustic space than languages with fewer contrasts.
- Found correlations between dimensions and acoustic measures.
  1. First dimension = periodicity and energy.
  2. Second dimension = spectral tilt and periodicity.

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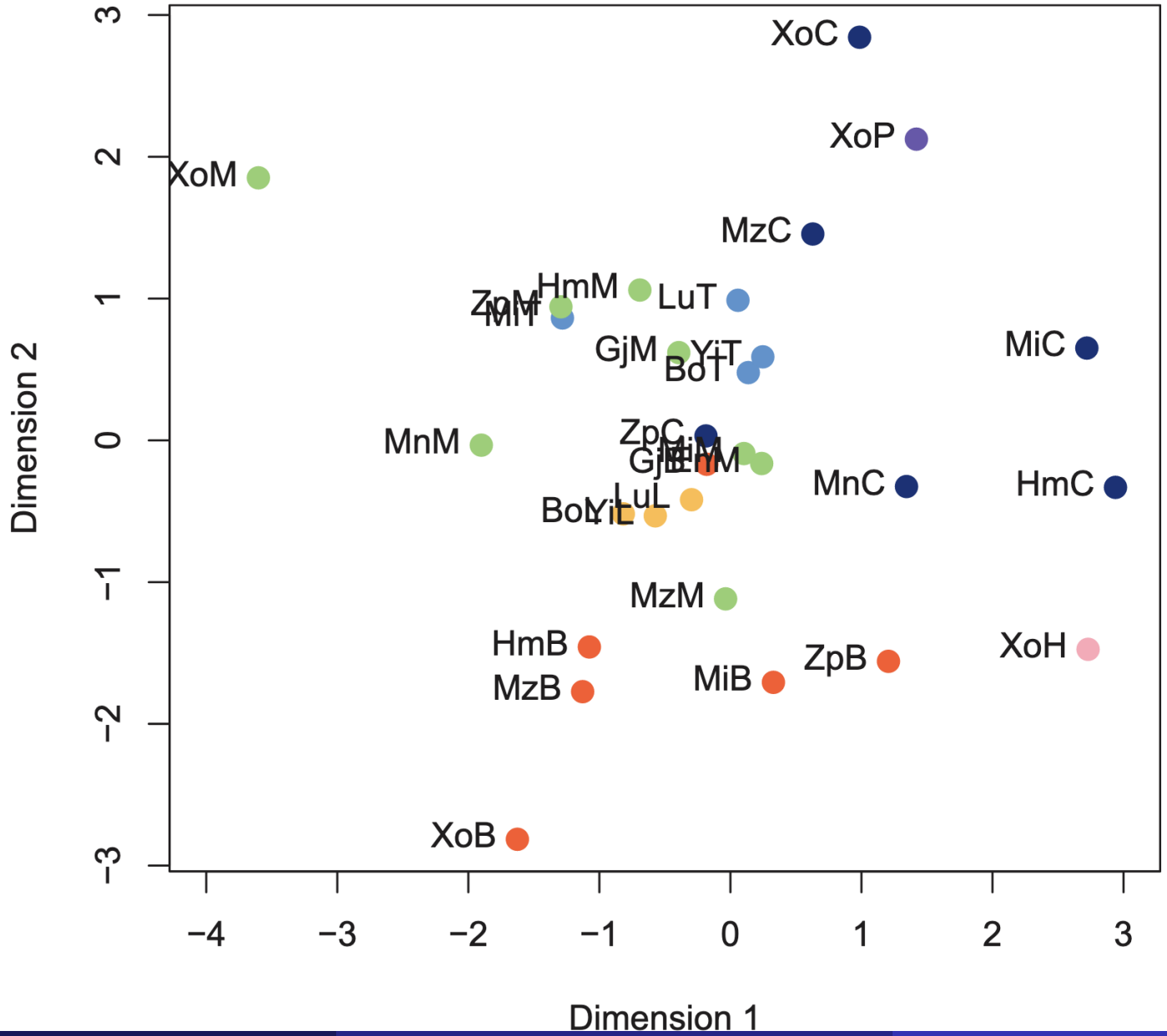
Keating et al. (2023)



What is Laryngeal Complexity

- Laryngeal complexity is the number of phonation contrasts in a language.
- More phonation contrasts means more complex laryngeal system.
- Laryngeal complexity can be measured by the number of phonation contrasts in a language.
- Laryngeal complexity can be measured by the dimensionality of the acoustic space.

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Phonation's phasing

Implicational hierarchy of patterns

Previous research on laryngeal complexity

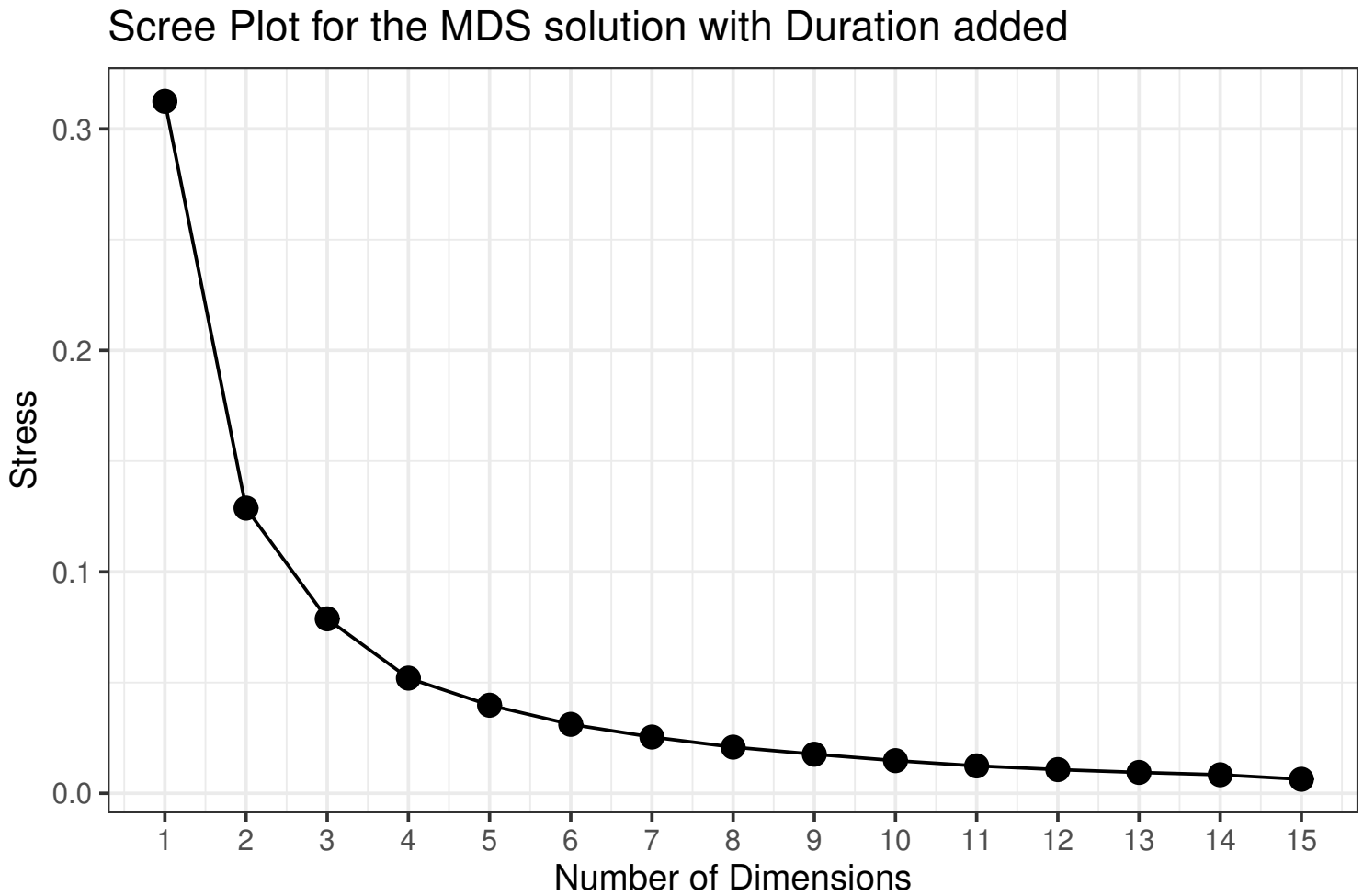
Data

- Data comes from fieldwork on Santiago Laxopa Zapotec (SLZ) from Summer 2023.
- Production data was collected from 10 speakers (5 male/5 female).

MDS analysis

- Multidimensional scaling (MDS; Kruskal & Wish 1978) was used to reduce the dimensionality of the data.
- Acoustic measures used to define the acoustic space, following Keating et al. (2023).
- Speaker x phonation combinations were used for the points in the MDS space.

Number of Dimensions



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Dimensionality in SLZ

- Scan the QR code to see the three-dimensional space.

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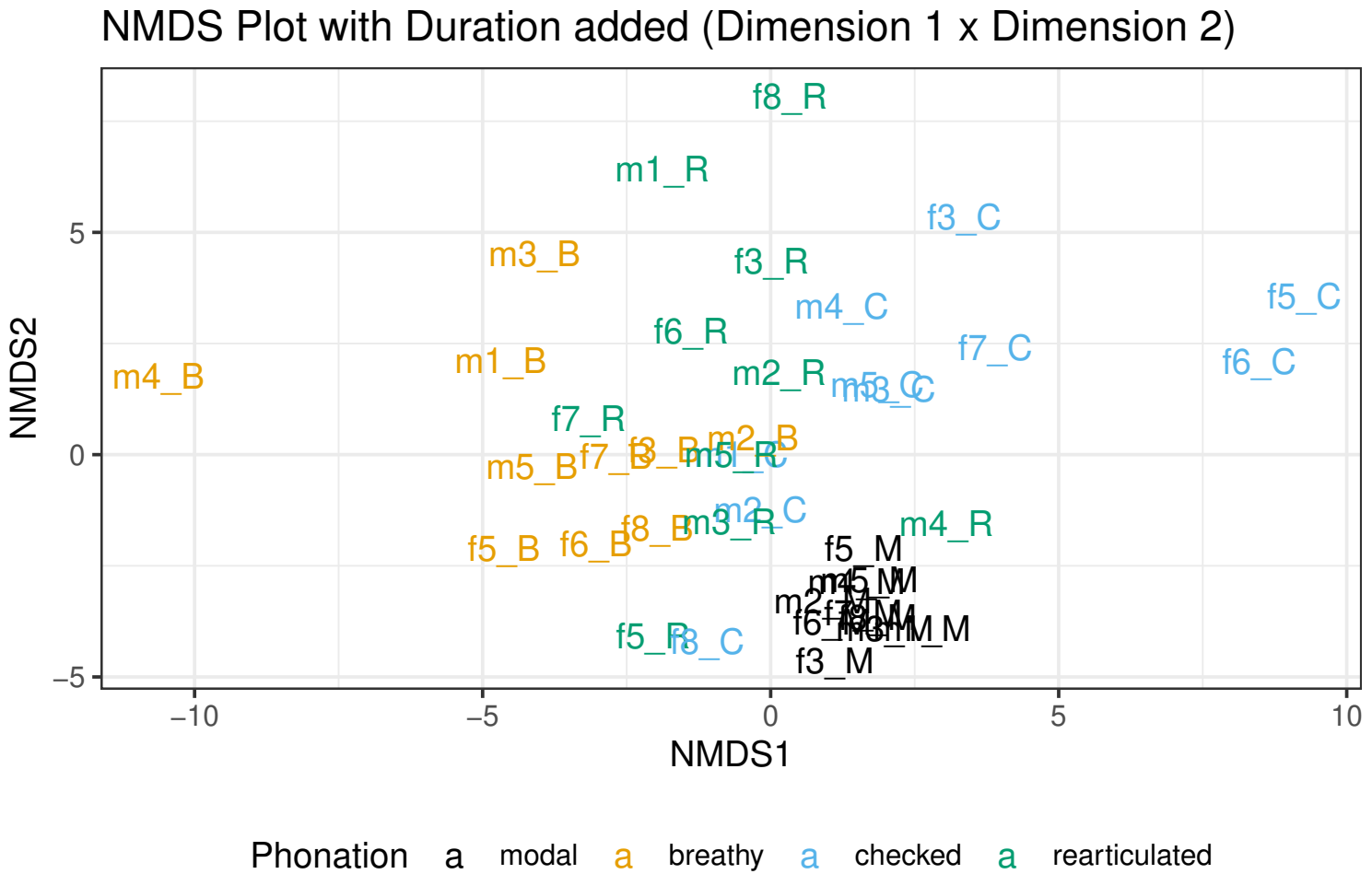
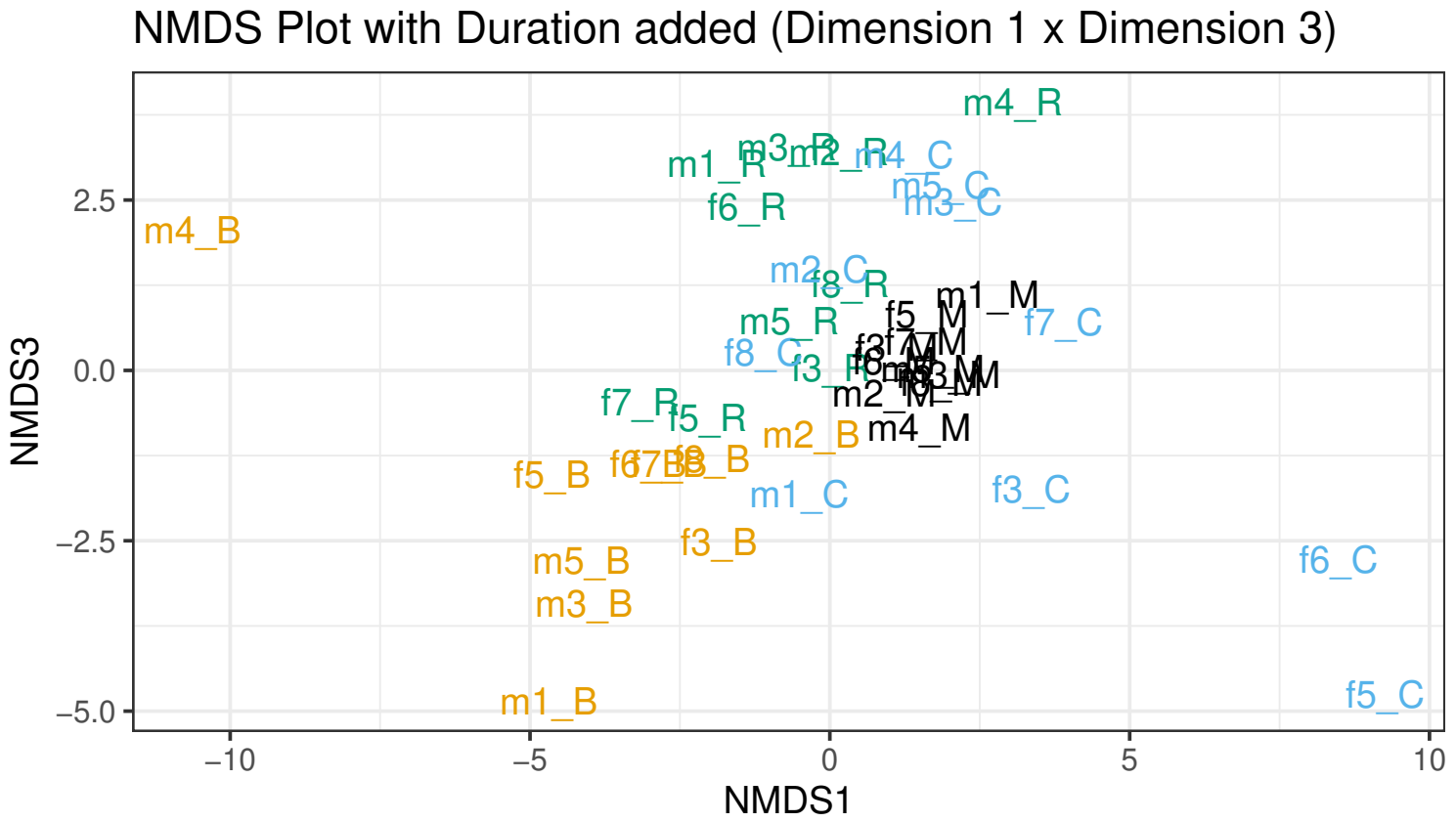
Dimensionality in SLZ

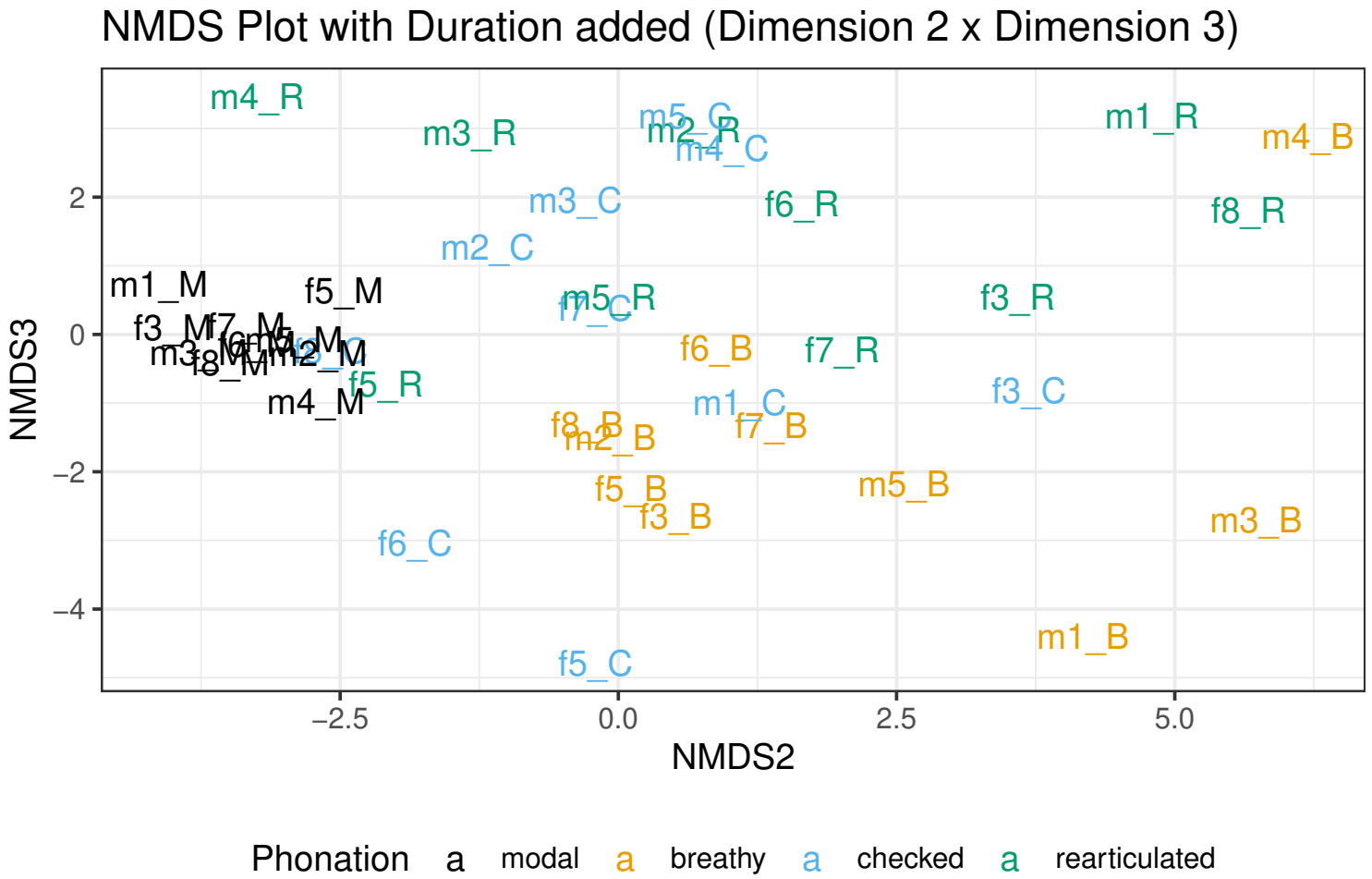


Dimensionality in SLZ



Phonation a modal a breathy a checked a rearticulated

Dimensionality in SLZ



Summary of Dimensions

- Dimension 1 (D1) gives a rough continuum from breathy to creaky.
- Dimension 2 (D2) gives a rough continuum from modal to nonmodal.
- Dimension 3 (D3) gives a rough continuum from breathy to creaky.

Correlation to Acoustic Measures

- D1 correlated with spectral tilt measures:
  - H1*−A1* ($r^2 = -0.83$)
  - H1*−A2* ($r^2 = -0.86$)
  - H1*−A3* ($r^2 = -0.81$)
- D2 correlated with periodicity and energy:
  - HNR<500 Hz ($r^2 = -0.79$)
  - HNR<1500 Hz ($r^2 = -0.80$)
  - Energy ($r^2 = -0.79$)
- D3 correlated with spectral tilt:
  - residual H1* ($r^2 = -0.72$)
  - H2*−H4* ($r^2 = -0.69$)
  - H2* ($r^2 = -0.68$)

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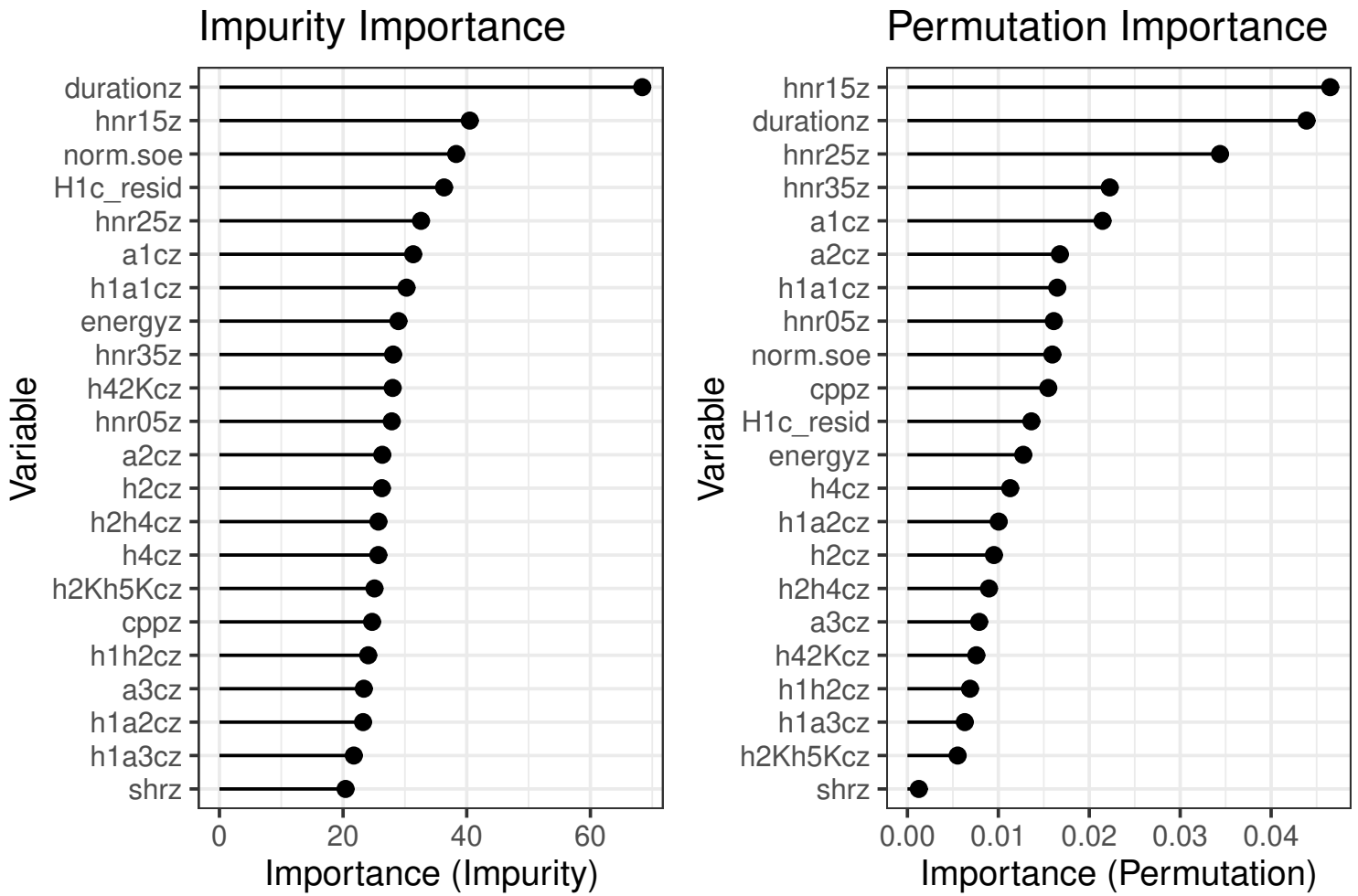
Summary of Acoustic Landscape

- SLZ's phonation occupies a three-dimensional space.
- Dimensions are correlated with glottal-airflow continuum (D1/D3) and nonmodal-to-modal continuum (D2).
- Dimensions are similar to those found in Keating et al. (2023).

What is Random Forest?

Results of Random Forest

Variable Importance



Summary of Random Forest

Generalized Additive Models (GAMs)

- Used to explore the relationship between phonation and the acoustic measures.
- Used to explore the relationship between phonation and the MDS dimensions.
- Used to explore the relationship between phonation and the random forest dimensions.

Measuring Laryngeal Complexity

- Laryngeal complexity is measured by the number of phonation contrasts in a language.
- SLZ has four phonation contrasts.
- The more phonation contrasts a language has, the more complex its laryngeal system is.

Summary of Laryngeal Complexity

- SLZ has four phonation contrasts.
- SLZ's phonation occupies a three-dimensional space.
- Dimensions are correlated with glottal-airflow continuum (D1/D3) and nonmodal-to-modal continuum (D2).
- Dimensions are similar to those found in Keating et al. (2023).

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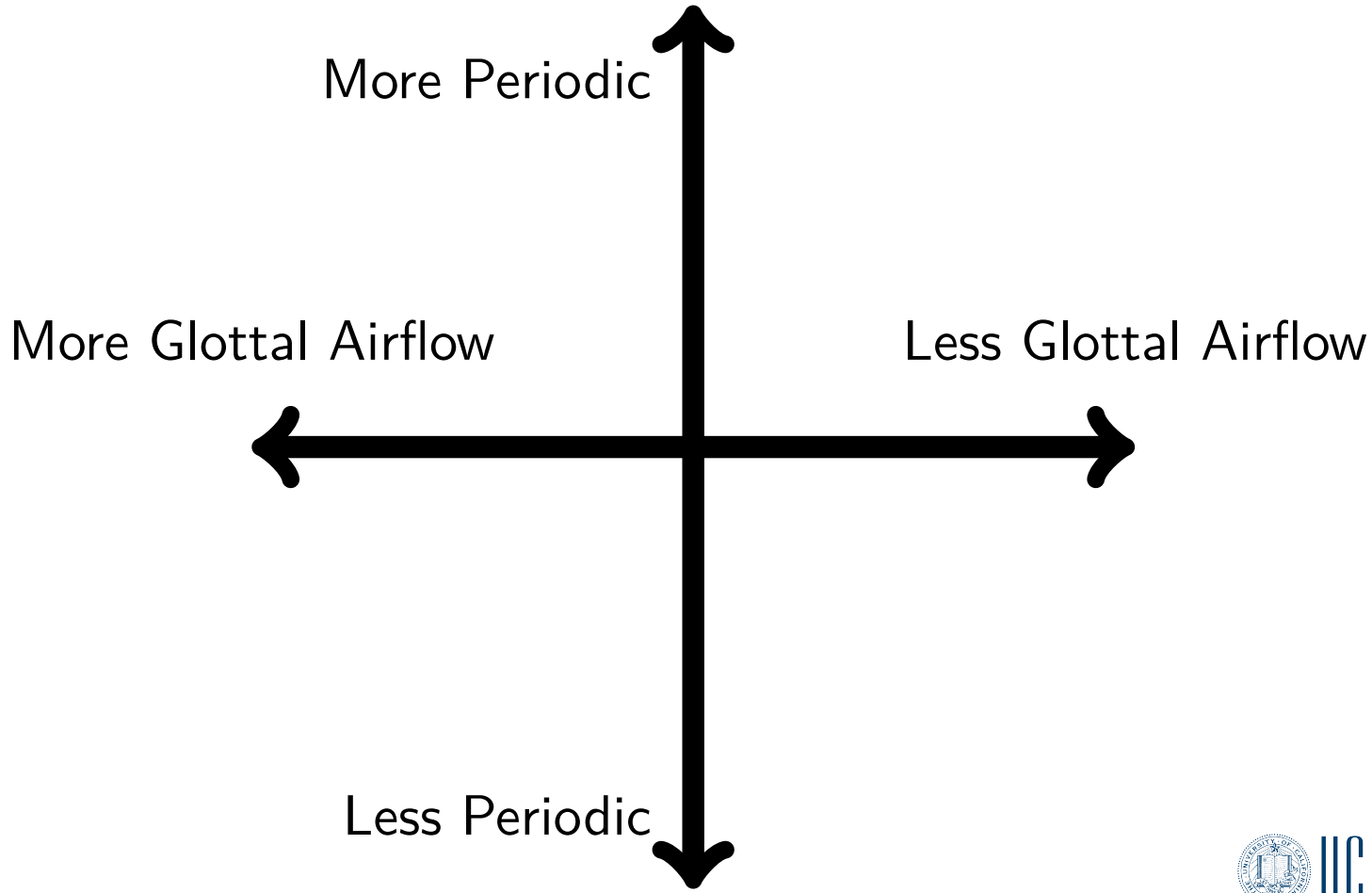
Summary of Results

- SLZ's phonation occupies a three-dimensional space.
- Dimensions are correlated with glottal-airflow continuum (D1/D3) and nonmodal-to-modal continuum (D2).
  - Collaborated with acoustic measure correlations.
- Dimensions are similar to those found in Keating et al.

Summary

- Acoustic space can be reduced to two dimensions.
- More dimensions add more information about these two dimensions.



Summary

- Dimensionality reduction also occurs in a single language.
- Dimensions correspond to glottal-airflow and nonmodal-to-modal continua within a language and cross-linguistically.
- If additional dimensions are added, they only add additional information about these two dimension.

- Outlook
  - What are the perceptual cues that speakers use to distinguish between phonation types?
  - How do these dimensions relate to the phonology?

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Duxhklhenhu' lhe' (Thank you)

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