The Acoustic Landscape of Voice Quality

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What is Voice Quality?

- Describes how the vocal folds vibrate.
- Used for both paralinguistic (Laver 1968, Podesva 2016) and phonological contrasts (Esposito & Khan 2020).
- Long been established that phonation contrasts have correlates in the acoustic signal (e.g., Fischer-Jørgensen 1968).

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Modeling voice quality

- Long been established that phonation contrasts have 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 these measure, or combinations of them, to model voice quality in a variety of languages (e.g., Blankenship 2002, Brunelle & Kirby 2016, Esposito 2012).

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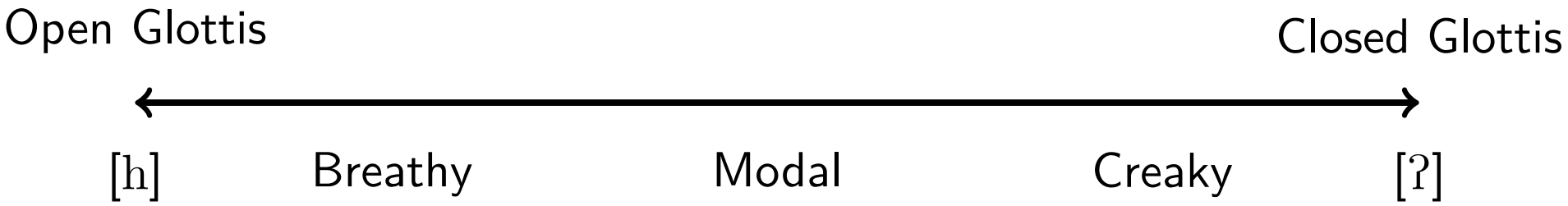
Voice quality's dimensionality

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



Voice quality's dimensionality

- 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.
  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.
  - First dimension = periodicity and energy.
  - Second dimension = spectral tilt and periodicity.

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Research Question

Question:

- Can this same dimensionality reduction be found for a single language?
- If so, what do the dimensions correlate with?

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Research Question

Answer:

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

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Data

- Data comes from fieldwork on Santiago Laxopa Zapotec (SLZ).
- SLZ is a good candidate because of its four-way phonation contrast.
  - Modal ([a])
  - Breathy ([a̤])
  - Checked ([a͡ʔ] or [a͡a̰])
  - Rearticulated ([a͡ʔa] or [a͡a̰a])
- Data was collected from 10 speakers (5 male/5 female).
- Acoustic measures were calculated using VoiceSauce (Shue et al. 2011).

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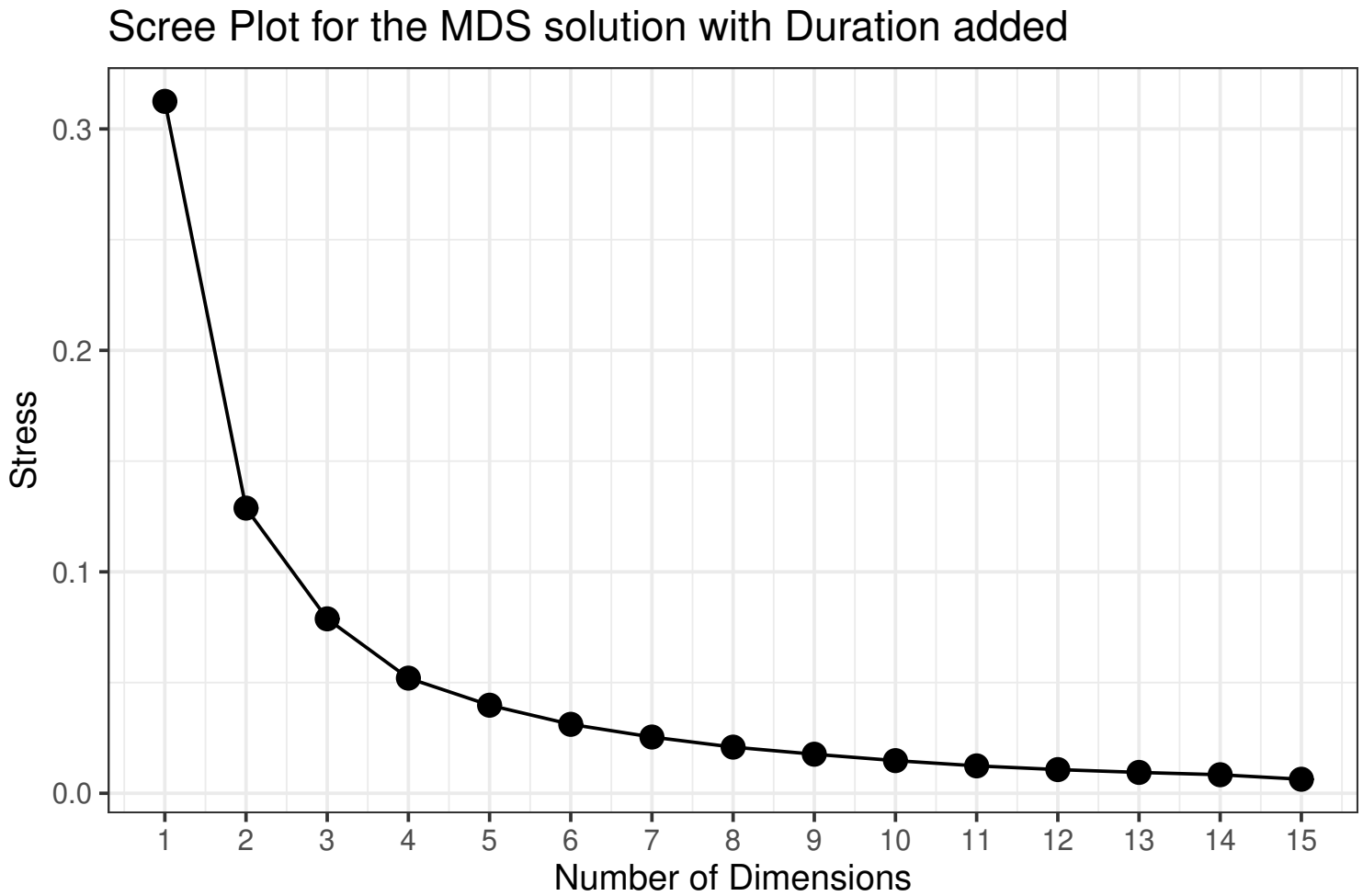
MDS analysis

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

Number of Dimensions



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Dimensionality in SLZ

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

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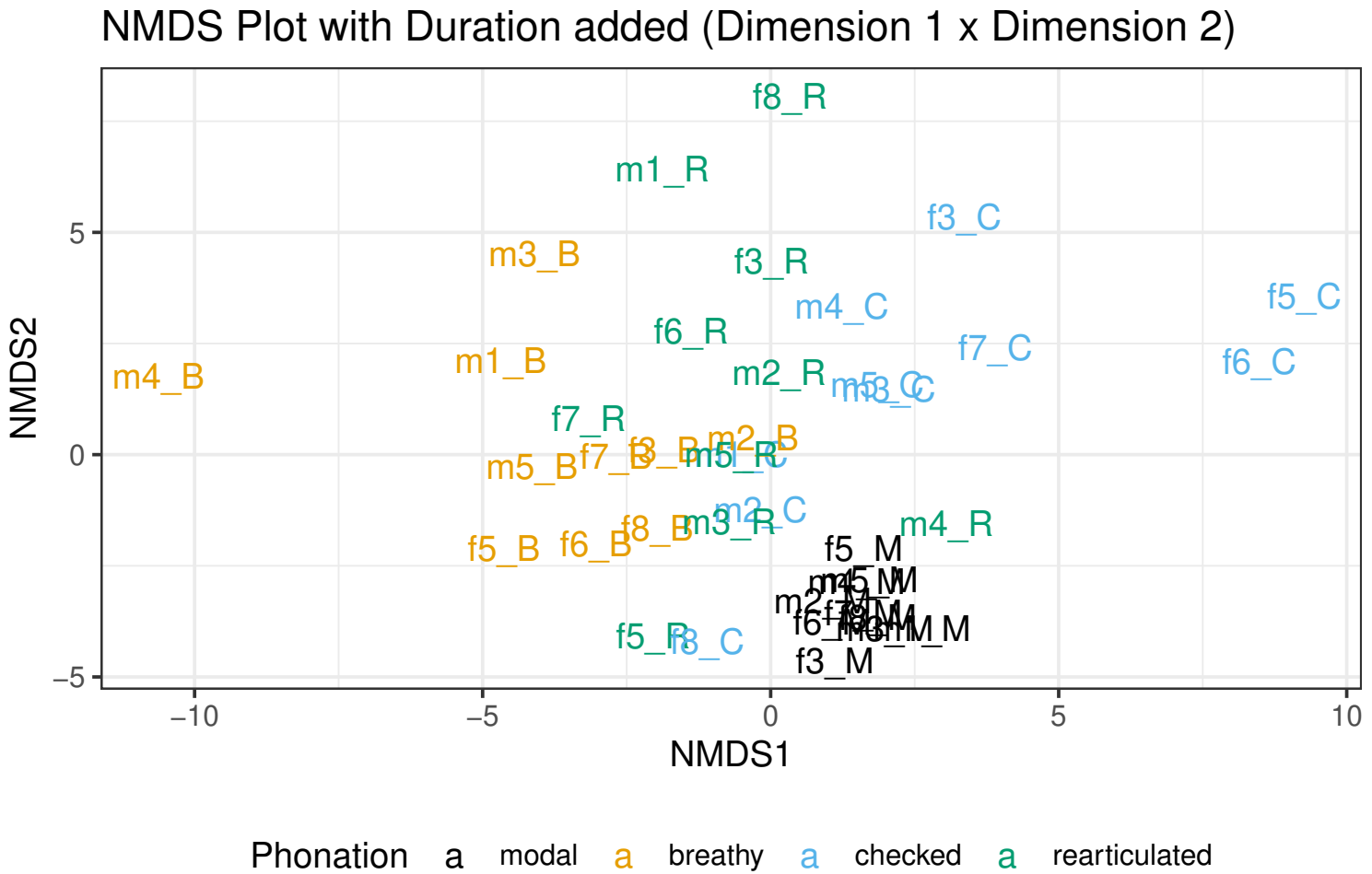
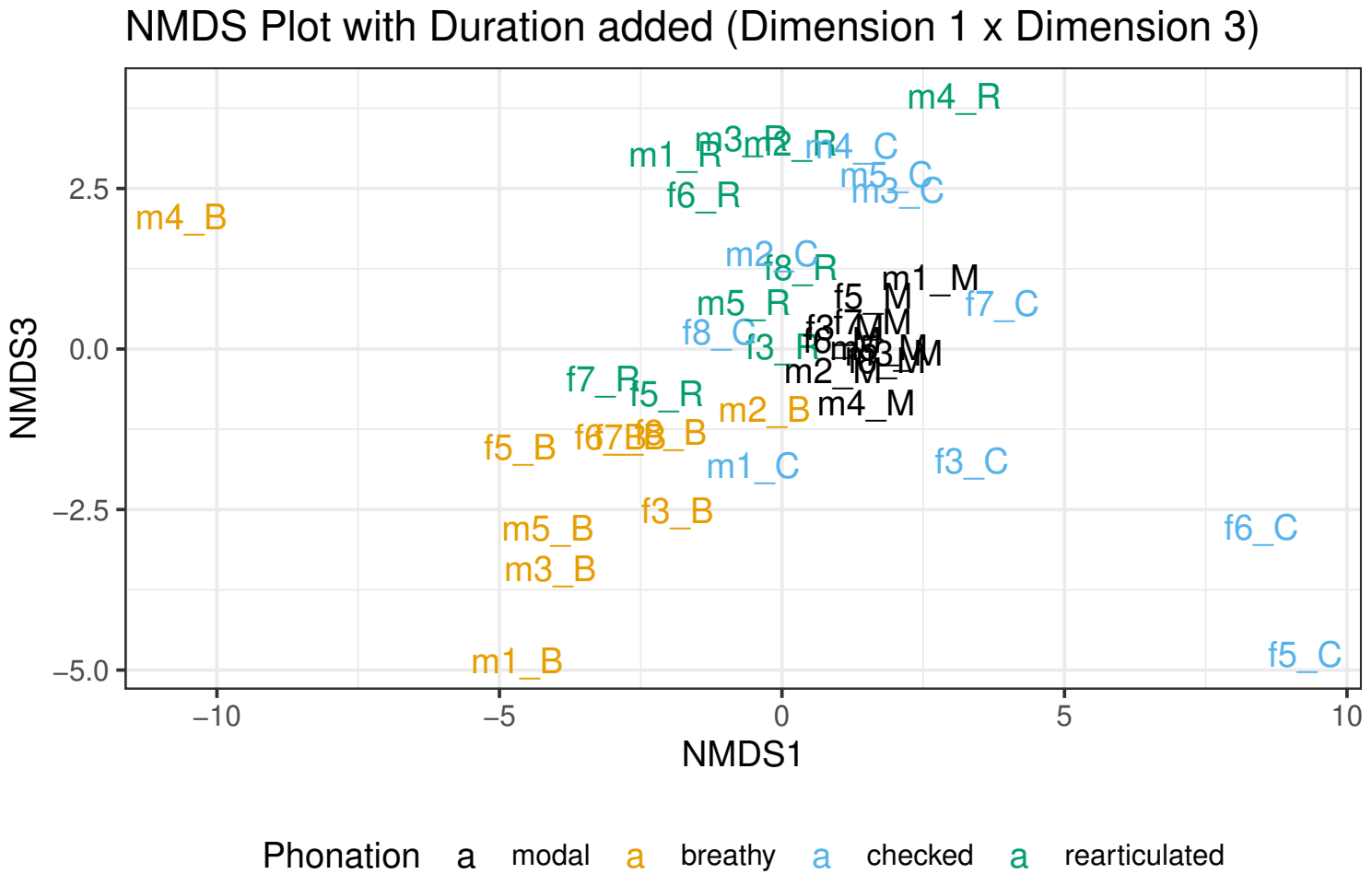
Dimensionality in SLZ

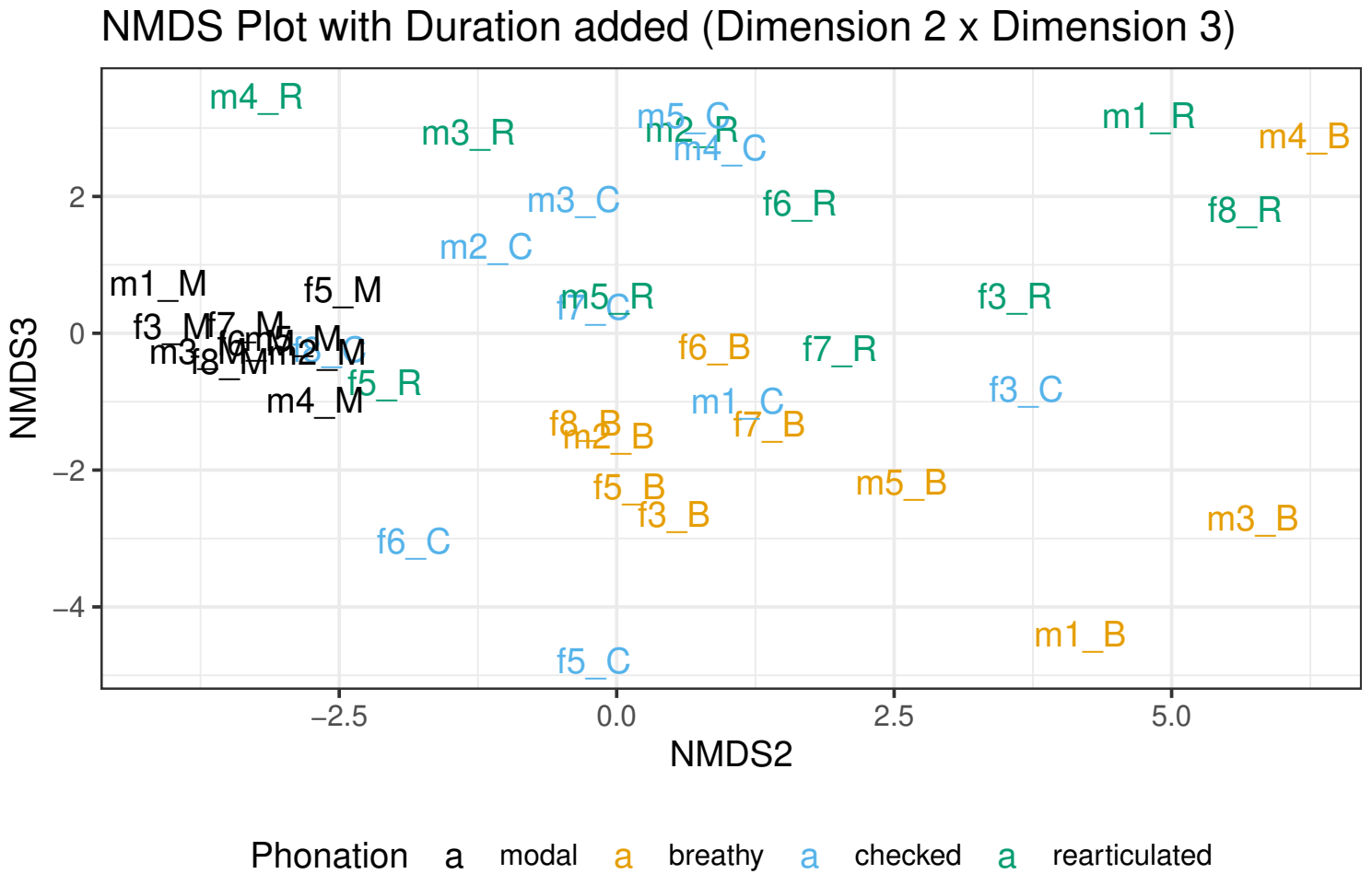


Dimensionality in SLZ



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 Results

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

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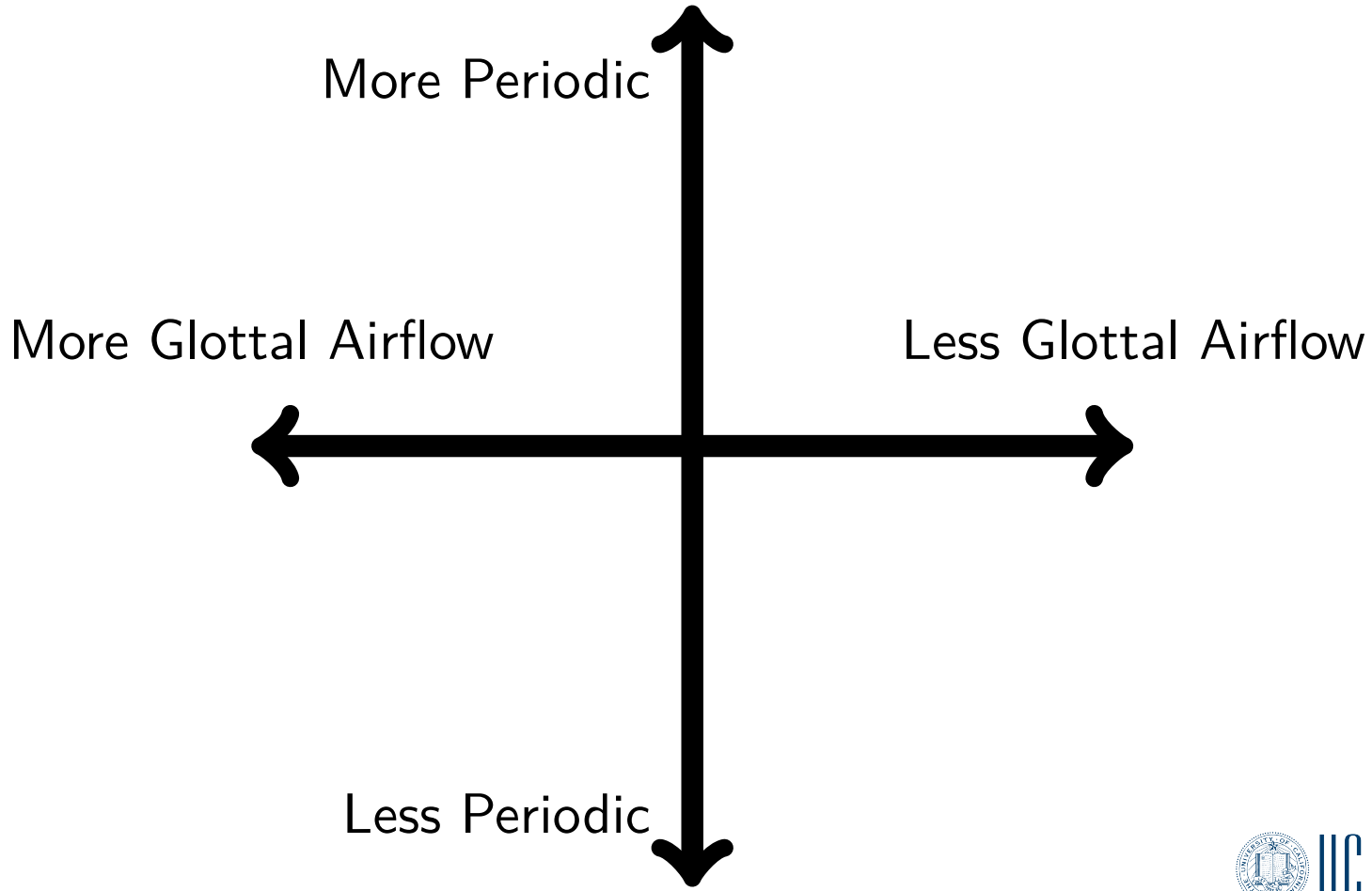
Summary

- 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 periodicity 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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Variable Importance