

Voice Quality and Laryngeal Complexity in Santiago Laxopa Zapotec

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What is Voice Quality?

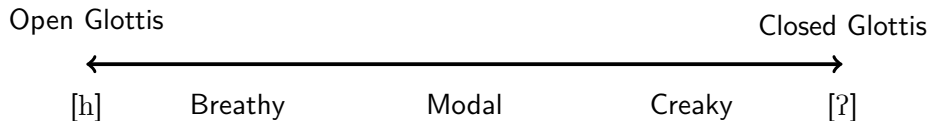
- Describes how the vocal folds vibrate.
- Used for both paralinguistic (e.g., Laver 1968, Podesva 2016) and phonological contrasts (e.g., Esposito & Khan 2020).

Modeling 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).

Voice quality's dimensionality

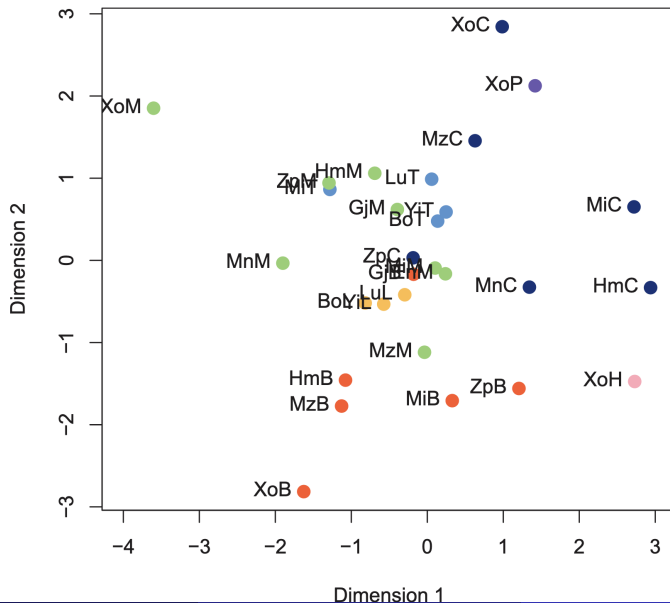
- Early models proposed that voice quality is one dimensional and represents glottal airflow (Ladefoged 1971, Ladefoged & Maddieson 1996).



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.

- 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.



Research Question

Question:

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

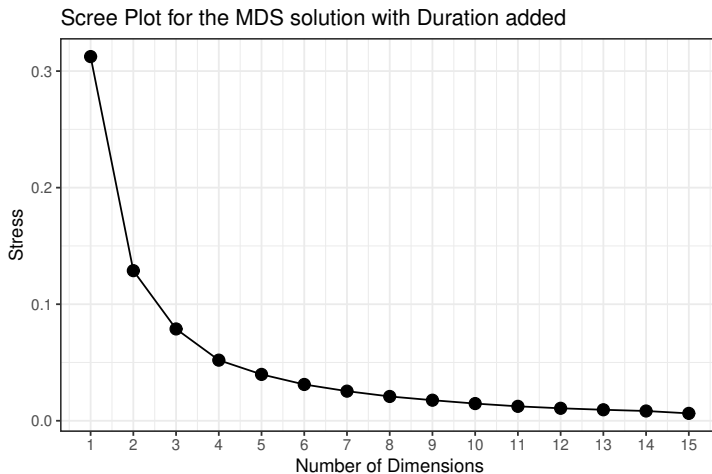
Answer:

- 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.

- 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 ([a̠] or [a̡])
 - Rearticulated ([a̠a̡], [a̡a̠], or [a̠̠])
- Production data was collected from 10 speakers (5 male/5 female).

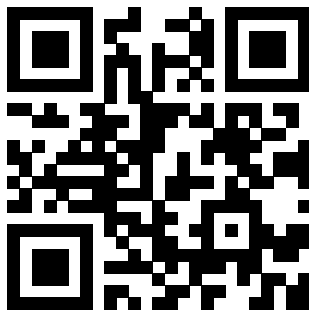
- Multidimensional scaling (MDS; Kruskal & Wish 1978) was used to reduce the dimensionality of the data.
- Acoustic measures used to define the acoustic space, following Keating et al. (2023).
- Speaker x phonation combinations were used for the points in the MDS space.

Number of Dimensions



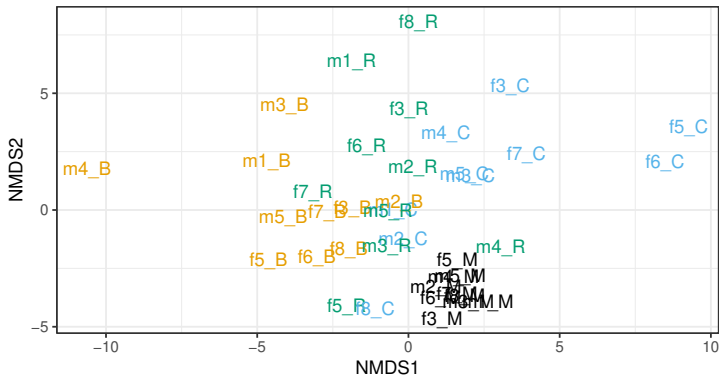
Dimensionality in SLZ

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



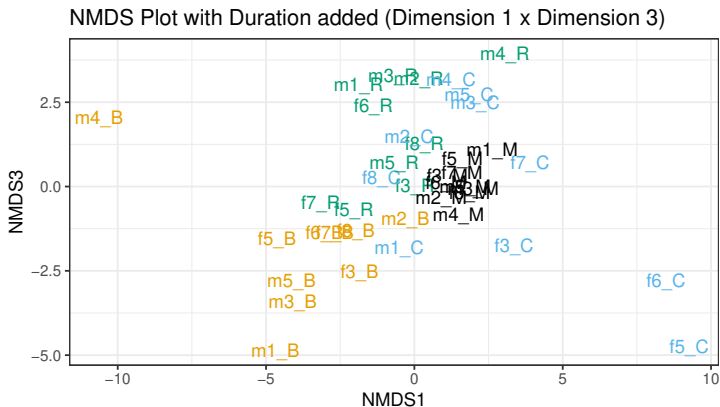
Dimensionality in SLZ

NMDS Plot with Duration added (Dimension 1 x Dimension 2)



Phonation a modal a breathy a checked a rearticulated

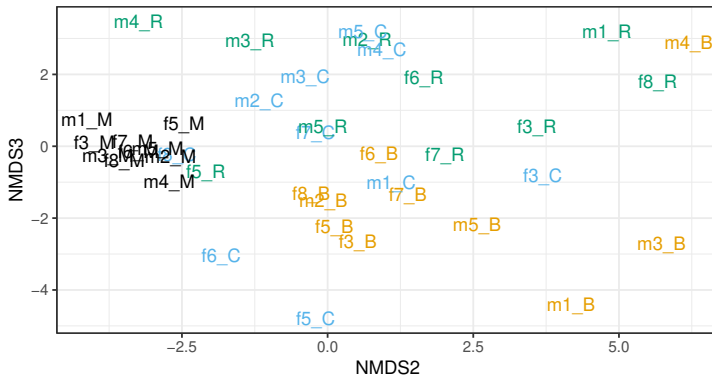
Dimensionality in SLZ



Phonation a modal a breathy a checked a rearticulated

Dimensionality in SLZ

NMDS Plot with Duration added (Dimension 2 x Dimension 3)



Phonation a modal a breathy a checked a rearticulated

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.

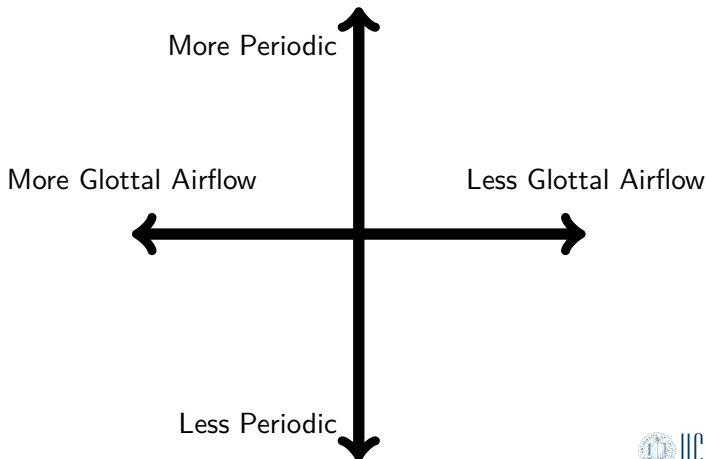
- D1 correlated with spectral tilt measures:
 - $H1^* - A1^*$ ($r^2 = -0.83$)
 - $H1^* - A2^*$ ($r^2 = -0.86$)
 - $H1^* - A3^*$ ($r^2 = -0.81$)
- D2 correlated with periodicity and energy:
 - $HNR < 500$ Hz ($r^2 = -0.79$)
 - $HNR < 1500$ Hz ($r^2 = -0.80$)
 - Energy ($r^2 = -0.79$)
- D3 correlated with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

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.



- 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?

Duxhklhenhu' lhe' (Thank you)



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Variable Importance

