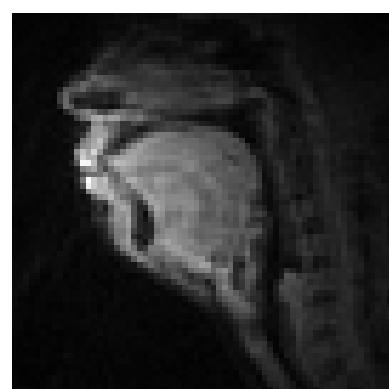
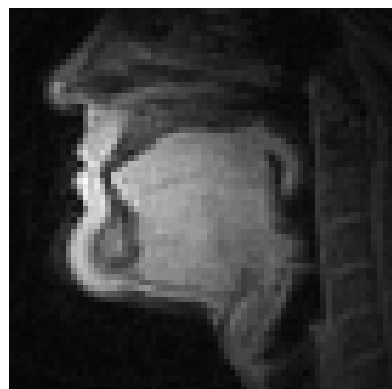
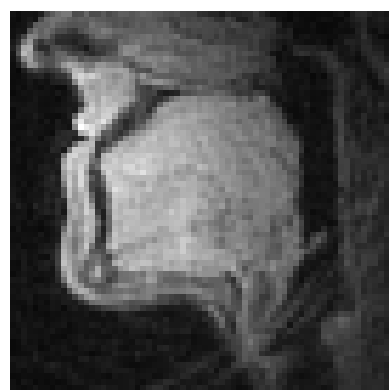
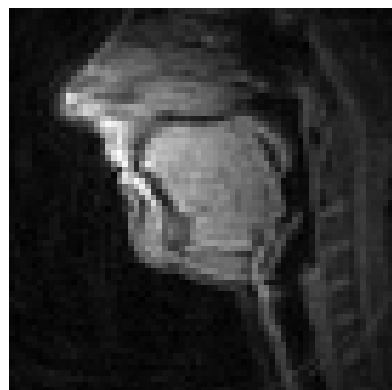


Morphological Variation in the Adult Vocal Tract

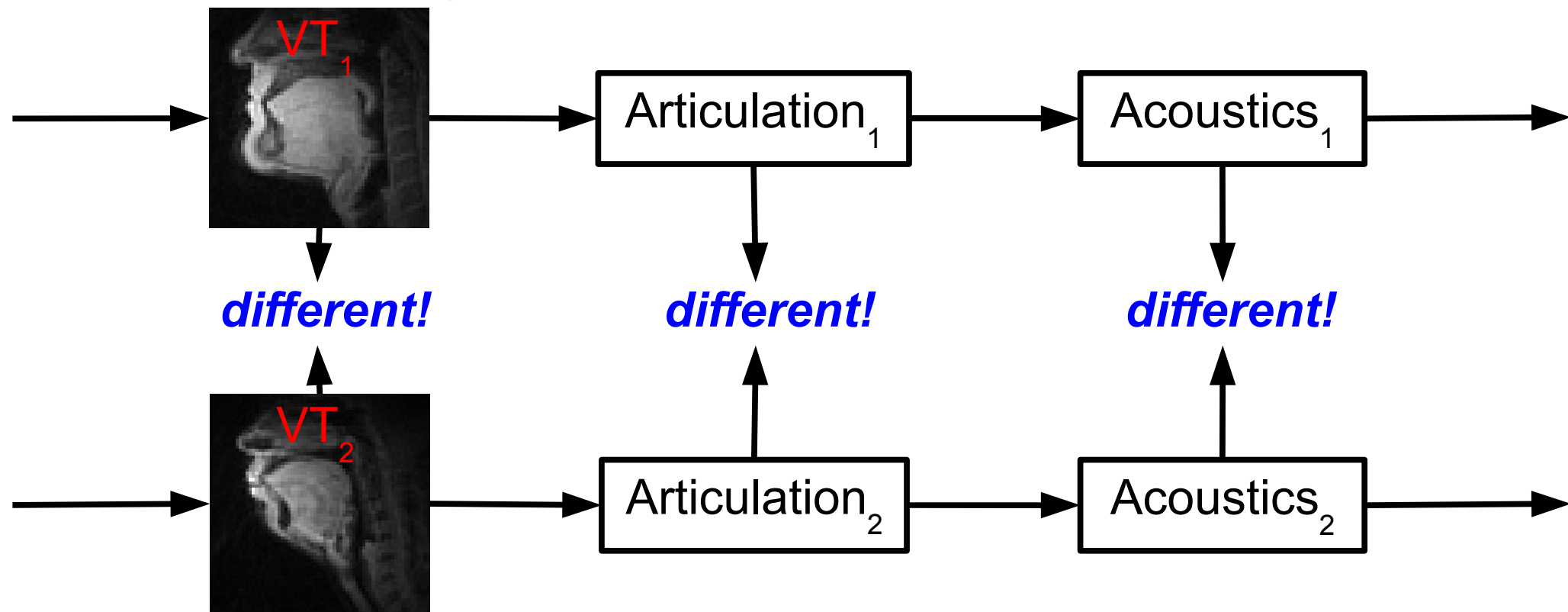
Adam Lammert, Michael Proctor & Shrikanth Narayanan
University of Southern California



No two vocal tracts
are exactly alike:

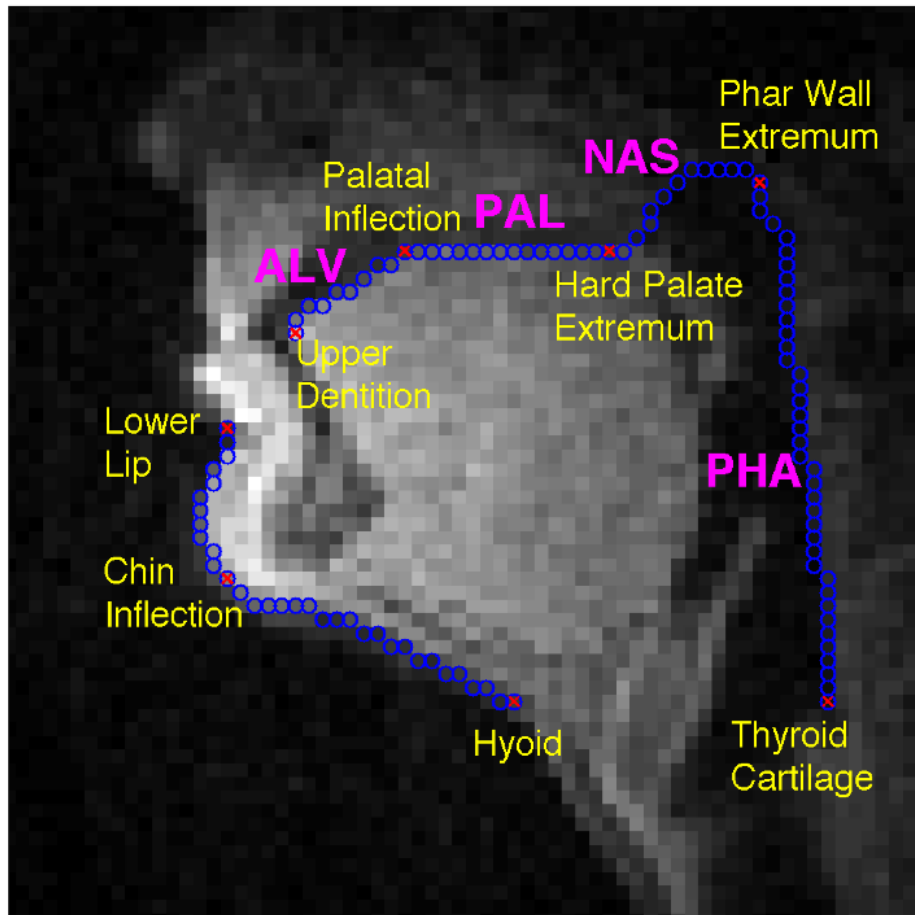
- Proportions
- Structural shapes
- Structural orientations

Morphology is Part of Speech Production



- Morphology is:
 - variable
 - a potential source of variability
- Do subjects maximize articulatory or acoustical similarity?
- A window into speech production goals

Subject Pool & Morphological Features



30 Adult Subjects

- Sex:

19 male	11 female
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- Race:

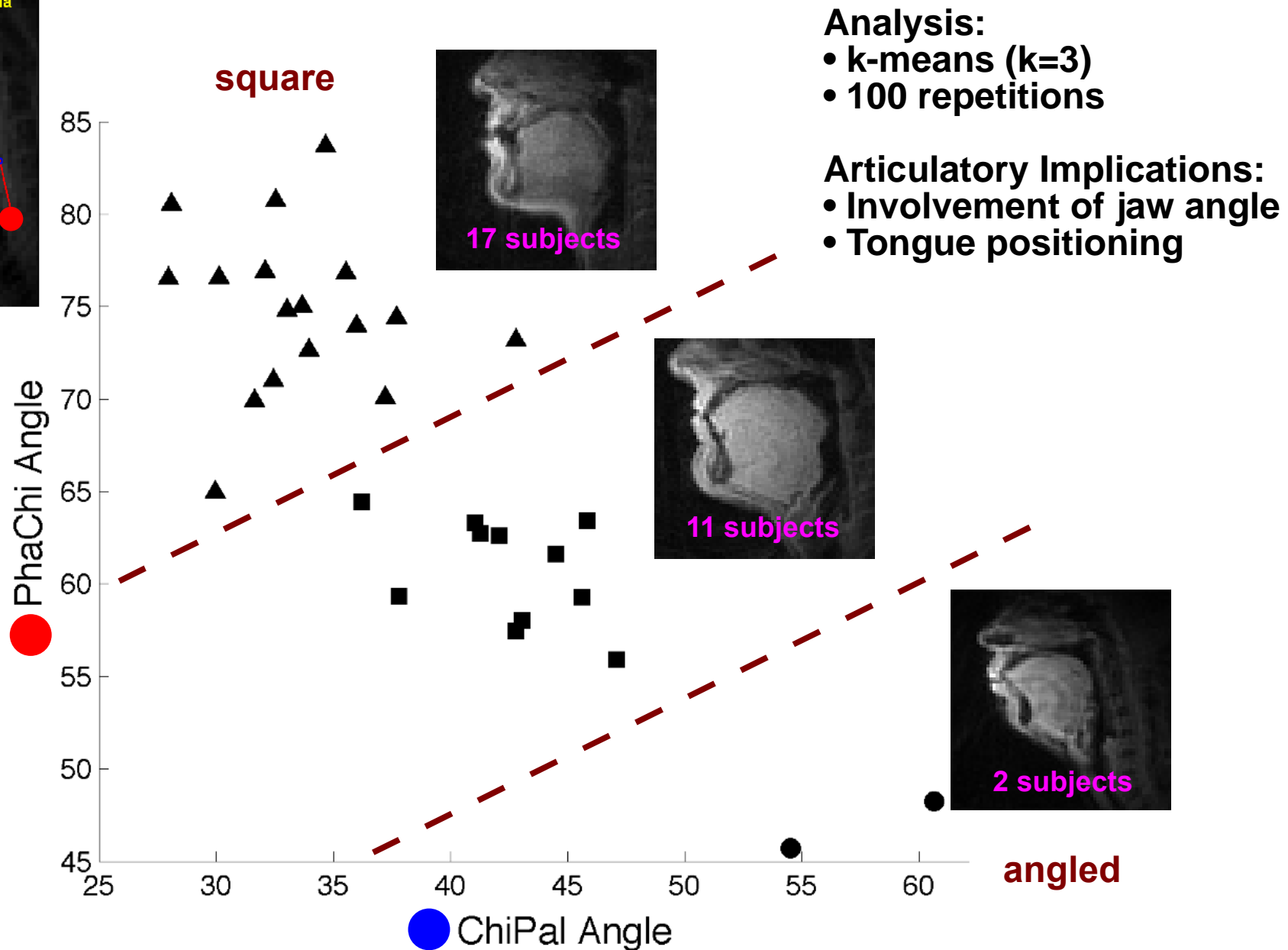
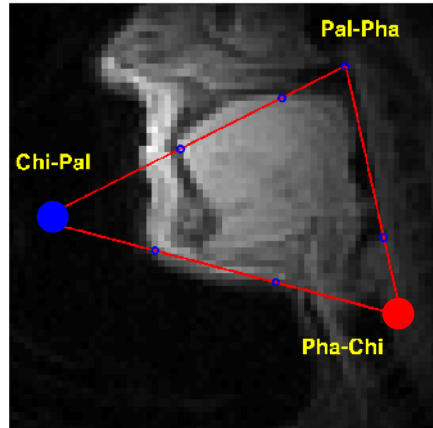
24 caucasian	6 asian
--------------	---------
- Language Background:

16 English	8 German
5 Mandarin	1 Hindi

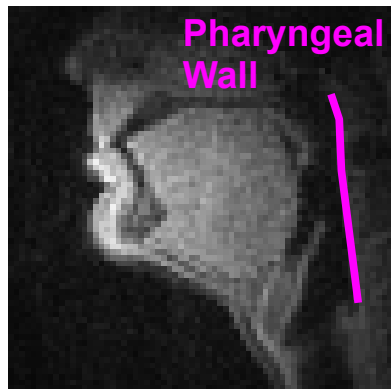
Traces

- Rest position (respiration)
- Hard structures only
- Anatomical landmarks

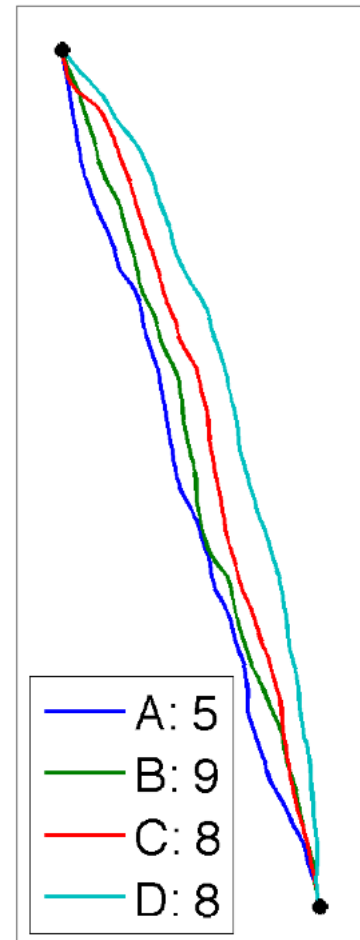
Orientation of Key VT Structures



Variations in Pharyngeal Wall Shape



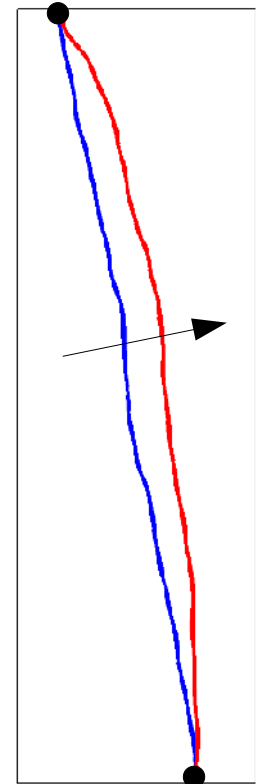
- Degree of concavity is the major variation
- Implications VT resonances for vowels/approximants



Analysis:

- k-means (k=4)
- 100 repetitions

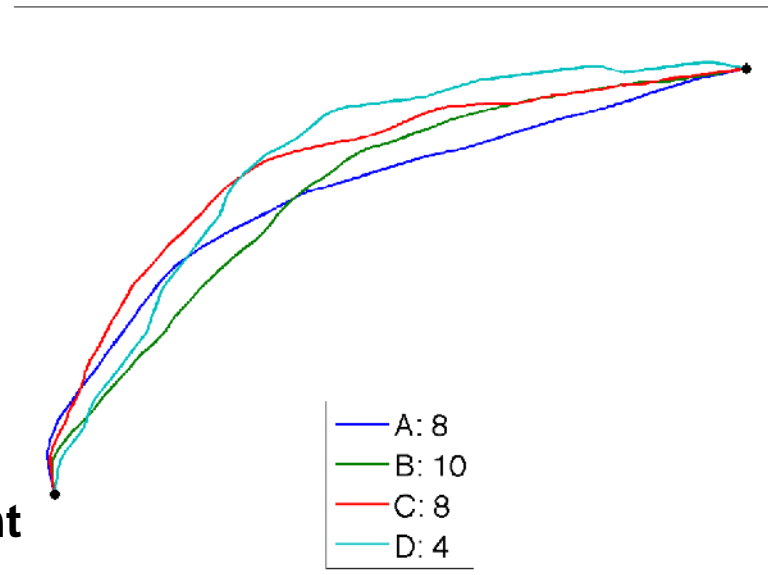
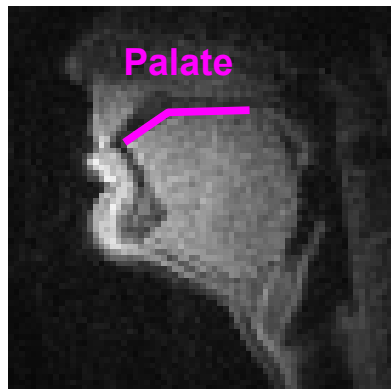
78% of Variance



Analysis:

- PCA
- 1st comp.

Variations in Palate Shape



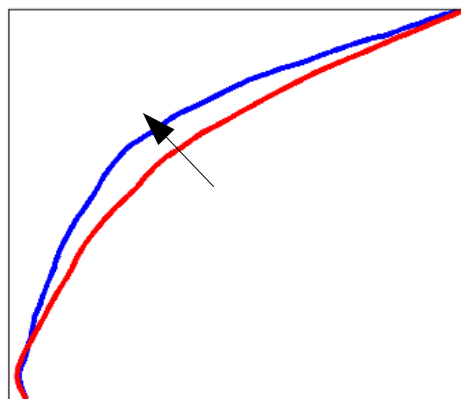
Analysis:

- k-means (k=4)
- 100 repetitions

Implications:

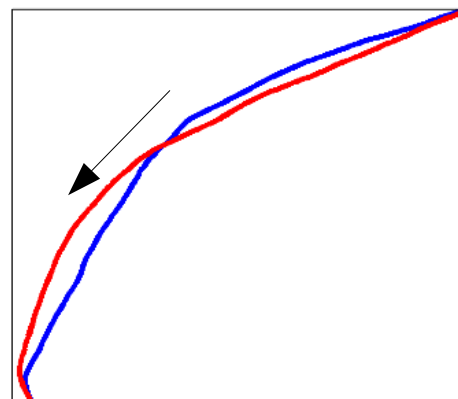
- VT resonances for vowels/approximants
- Tongue shaping for sibilant fricatives

46% of Variance



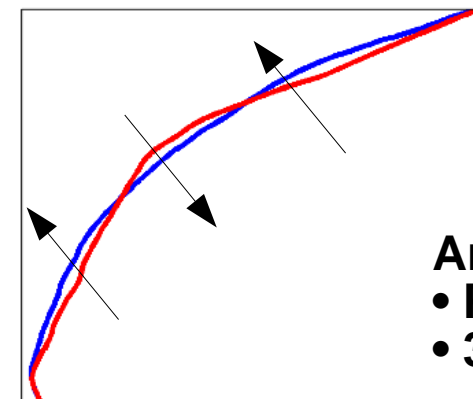
concavity

30% of Variance



inflection location

10% of Variance

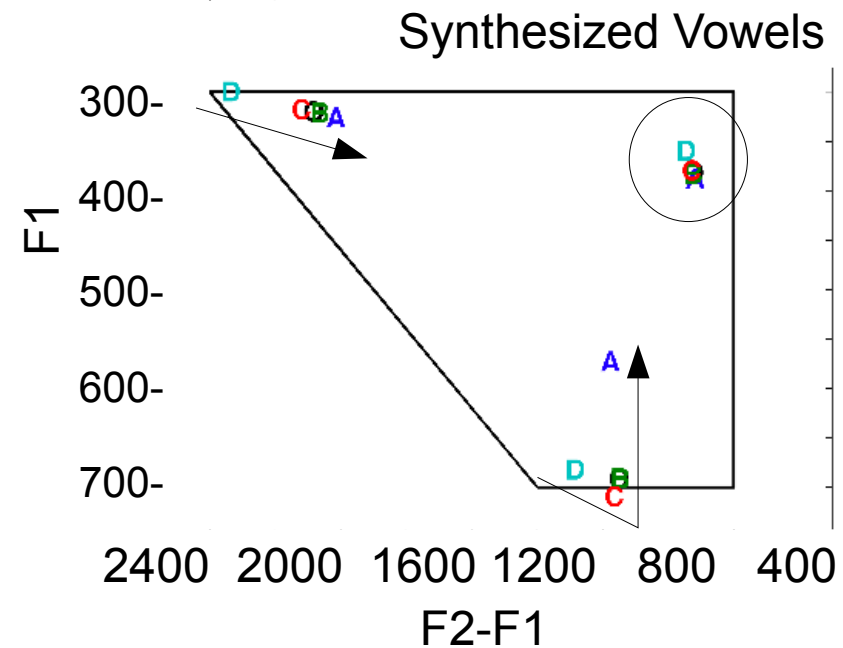
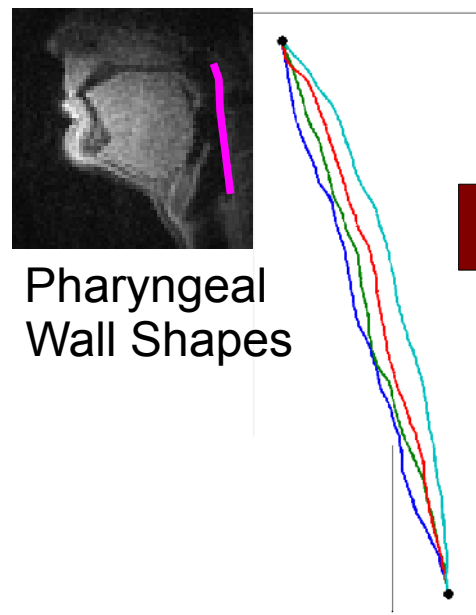
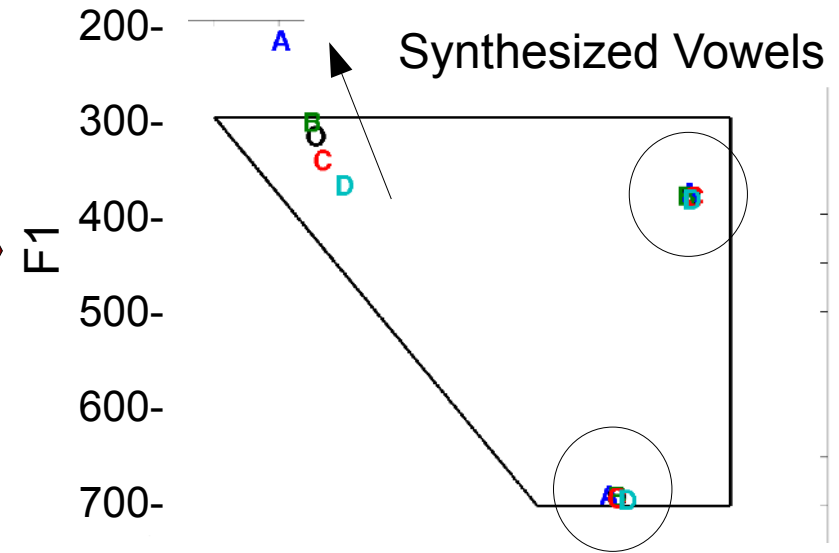
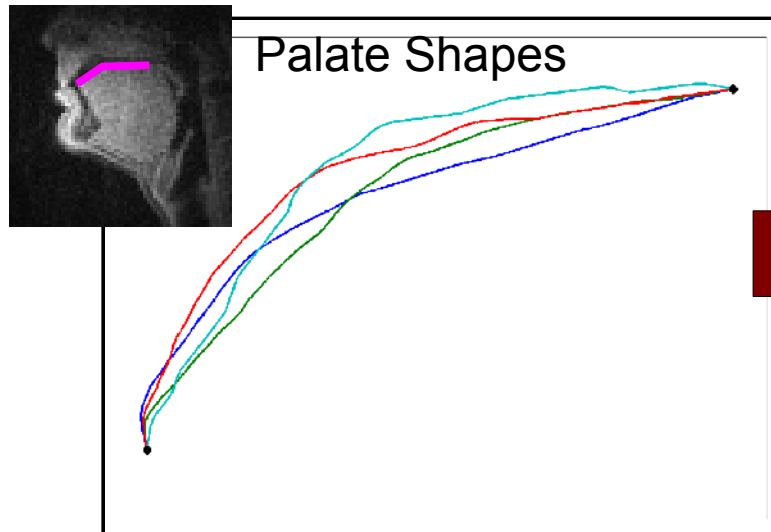


angularity

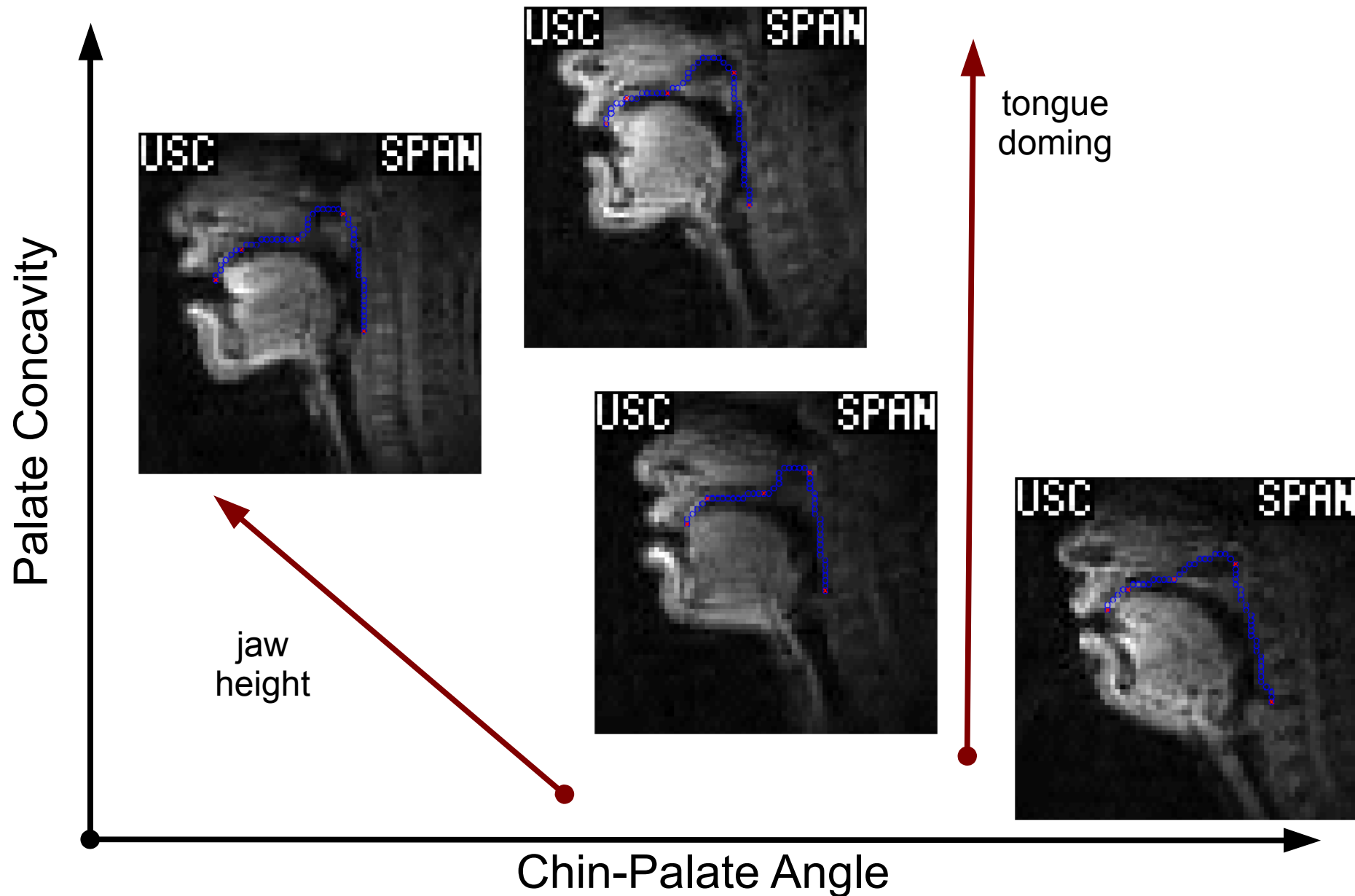
Analysis:

- PCA
- 3 comp's.

Theoretical Impact of Morphology: Acoustic Modeling



Morphological Impact on Articulation: A Case Study of 4 Mandarin /afa/



Summary and Future Work

- Substantial differences between adult VTs
 - Should not be ignored
- Potential for explaining inter-speaker variability
 - One cause variability in acou. and artic.
 - Large potential impact on vowel formants
- A window into speech production goals
- Many kinds of variability remain unstudied
 - Tongue size and shape (place, shaping)
 - Velum size and shape (nasals)
- Ongoing studies of impact on acou. and artic.
 - Sibilant fricatives vs. palate shape
 - Sounds with several articulations (e.g., / l /)
 - Place of articulation

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