Individual differences in speech production: What is "phonetic substance"?

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Access the database
https://github.com/rsprouse/xray_microbeam_database

Phonetic Substance
Phonological patterns are based in part on the phonetics of speaking and listening.

Mechanism
Phonological patterns emerge historically from phonetically motivated, natural sound changes; based on a "pool of synchronic phonetic variation." [2]

Research question
Is phonetic variation speaker-independent?

The study
- X-ray microbeam data [3] - point tracking
- 42 talkers
- Read speech - words, sentences, stories
- Anatomical measures, palate, vocal tract
- Articulatory vowel space:
  * Range of motion of each pellet on x and y
  * Verticality of cloud of varation
- Coronal fricatives:
  * Tongue shape (T1y-T2y)
  * Tongue fronting (T1x) or raising (T2y)

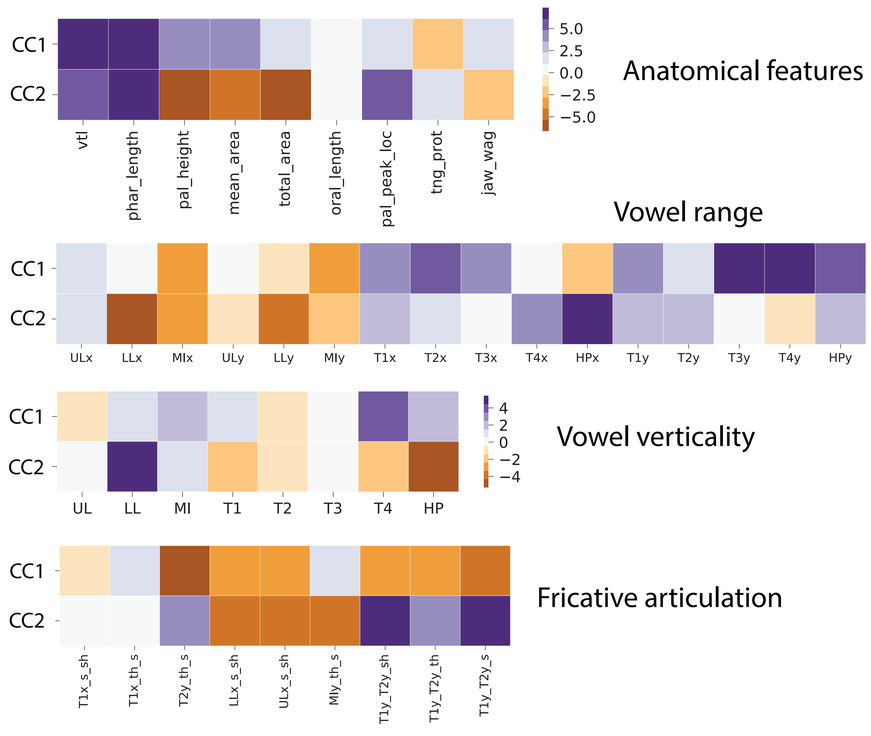
- Canonical Correlation Analysis (CCA)

What is CCA?

"CCA is a method for finding linear correlational relationships between two or more multidimensional datasets. CCA finds a canonical coordinate space that maximizes correlation between projections of the datasets onto that space." [1]

Here we seek to find correlations between *patterns* in the anatomical features, and *patterns* in the articulatory features of vowels and fricatives combined.

Canonical correlation model weights



Results
Two canonical components - example speakers score positive or negative on one component and close to zero on the other.

CC1 - **Long vocal tract** is associated with big vertical range of tongue in vowels.

Short vocal tract is associated with big vertical range of jaw in vowels.

CC2 - **Shallow palate**: horizontal tongue body range in vowels and tip up posure in coronal fricatives.

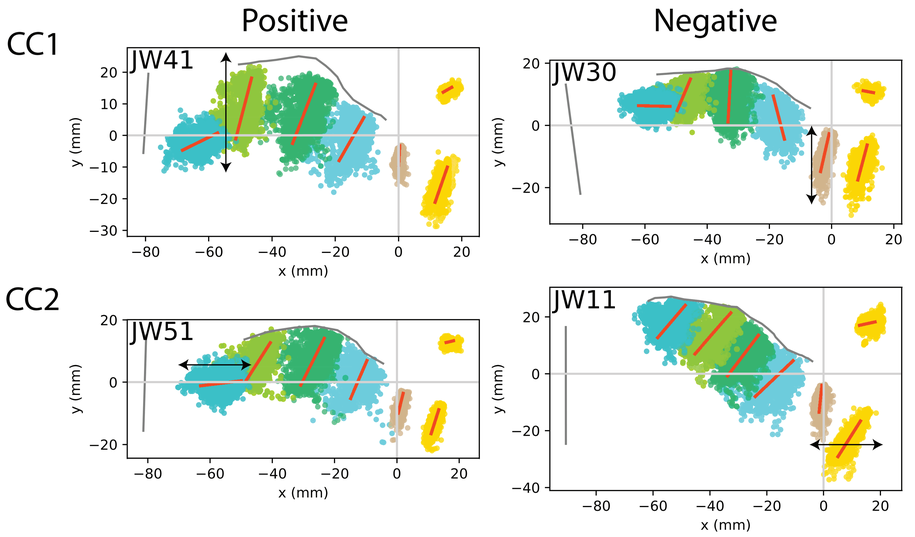
Deep palate: horizonal lip range in vowels, and tip down posture in coronal fricatives.

[1] Bilenko, N.Y. & Gallant, J.L. (2016) Pyrcca: Regularized Kernel Canonical Correlation in Python and its applications to neuroimaging. Frontiers in Neuroinformatics. 10, 49, doi: 10.3389/fninf.2016.00049

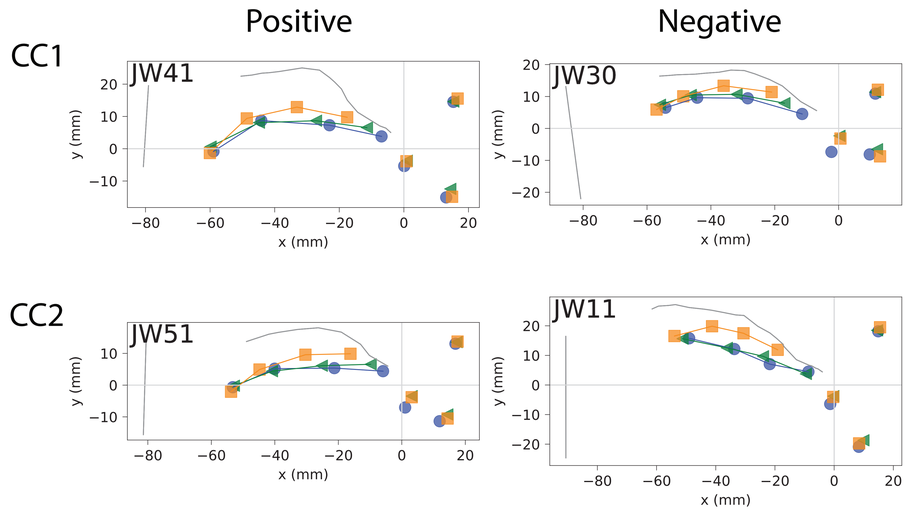
[2] Ohala, J.J. (1993) The phonetics of sound change. In Charles Jones (ed.), Historical Linguistics: Problems and Perspectives. London: Longman. pp. 237-278

[3] Westbury, J.R. (1994) X-ray Microbeam Speech Production Database User's Handbook, Version 1.0. Madison, WI.

Vowels



Fricatives



Conclusion
The pool of variation is tied to talker anatomical variation.

Different speakers contribute differently to the pool of phonetic variation, so phonetic substance is speaker-specific.

Perfect imitation may not be possible, so a process of phonetic approximation may play a pervasive role in shaping phonology.