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Acoustic and Articulatory Dimensions in Sound Patterns

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1. Phonetic Similarity

- **Purpose:** A metric for measuring phonetic similarity, based on several types of phonetic data collected for a range of consonants and vowels.
- **Subjects:** 4 phonetically-trained English speakers
- **Stimuli:** 60 crosslinguistically-frequent consonants and vowels produced by all four speakers (**bold**). 74 less frequent sounds produced by one each. Nine repetitions across three contexts (3 × a__a, 3 × i__i, 3 × u__u)

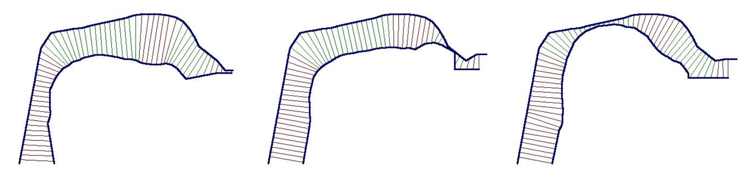
ʘ | ǁ ! ǂ
p pʲ pʷ **t** tʲ **ʈ** **c** **k** kʲ **kʷ** k͡p q qʷ **ʔ**
p' pʰ t' tʰ k' kʰ kʷ' q'
b bʲ bʷ **d** dʲ **ɖ** **ɟ** **g** gʲ gʷ g͡b
ɓ ᵐb ɗ ⁿd ᵑg
ts **tʃ**
ts' tsʰ tʃ' tʃʰ
dz **dʒ**
ɸ **f** fʲ θ **s** sʲ ɬ **ʃ** **x** xʲ xʷ χ χʷ ħ **h** hʲ hʷ
β **v** vʲ ð **z** zʷ **ʒ** **ɣ** ʁ ʕ
m mʲ mʷ **n** nʲ **ɳ** **ɲ** **ŋ** ŋʷ
l lʲ **ɭ** **ʎ**
ɾ **ɽ**
ʋ **r** rʲ **ɻ** **j** **w**

i iː ĩ y **ɨ** ɨː ɯ **u** uː ũ
ɪ ʊ
e eː ẽ ø ʌ **o** oː õ
ɛ ɛː ɛ̃ œ **ə** **ɔ** ɔː ɔ̃
æ **a** aː ã ɑ

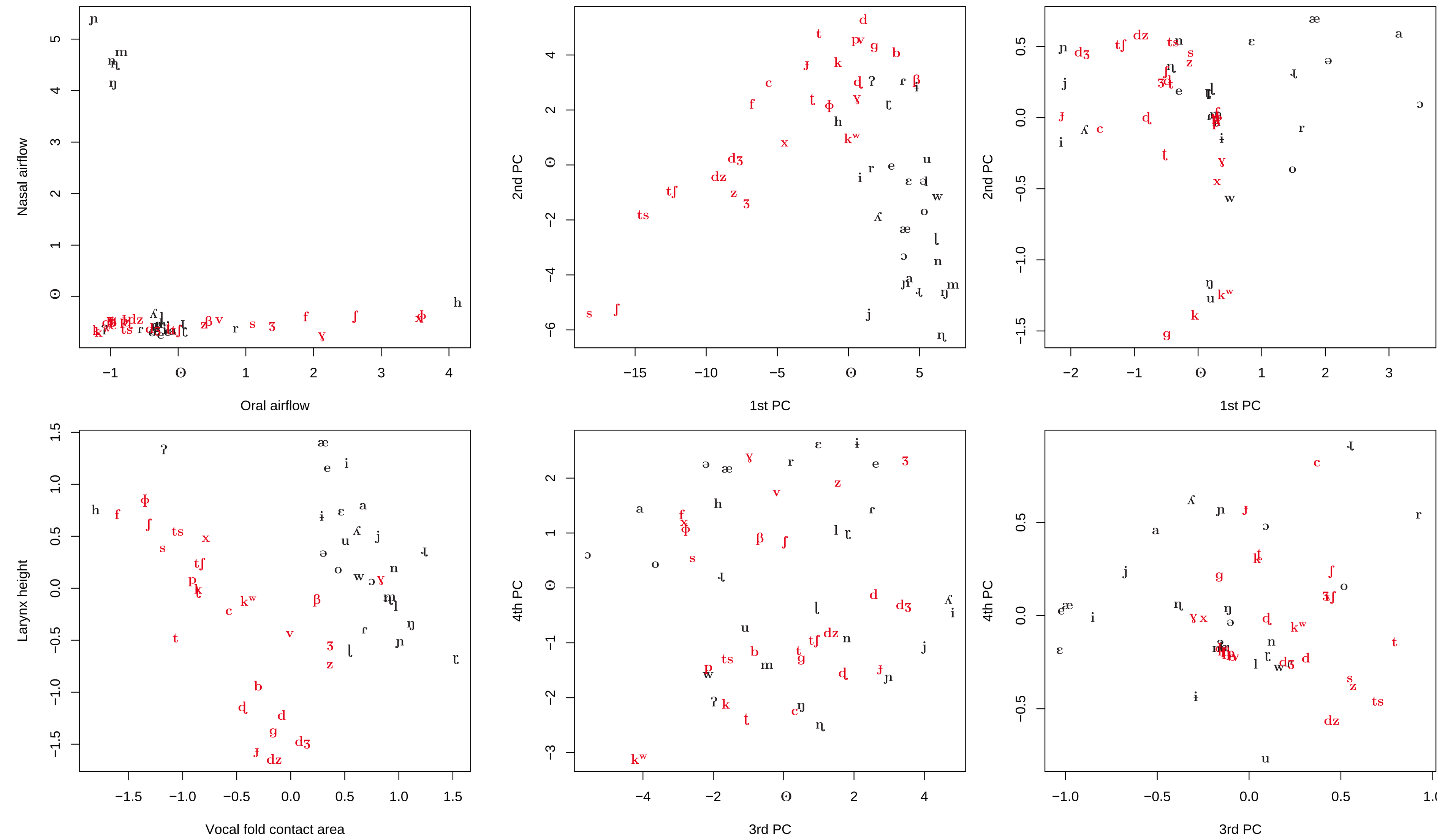
Figure 1: Consonants and vowels recorded for similarity project

Phonetic similarity measures (Mielke 2011)

- Oral and nasal airflow
- Electroglottography used to measure vocal fold contact area and larynx height
- MFCCs + Dynamic Time Warping + Principal Component Analysis used to measure acoustic distance
- Ultrasound and face video + PCA used to represent vocal tract shape:



Airflow & Laryngeal — Acoustic — Vocal tract shape



Basque	pattern #1
{b d̪ g} → {β ð ɣ} / {i u e o a r ɾ} __ {i u e o a}	

⇓

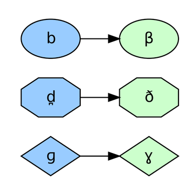


Figure 4: Sample entry, conversion to graph of I-O mappings

2. Sound Pattern Frequency in P-base

- **Content:** P-base is a database of 11,817 phonologically active classes involved in synchronic sound patterns in grammars of 628 varieties of 549 languages (Mielke 2008, Mielke and Kaplan in prep)
- **P-base 2.0** is an ongoing reorganization and expansion of P-base with web-based interface with 6700 sound patterns coded for domain of application, morphological restrictions, optionality, etc..
- Sample of 2249 I-O mappings summarized in Figs. 2-3.

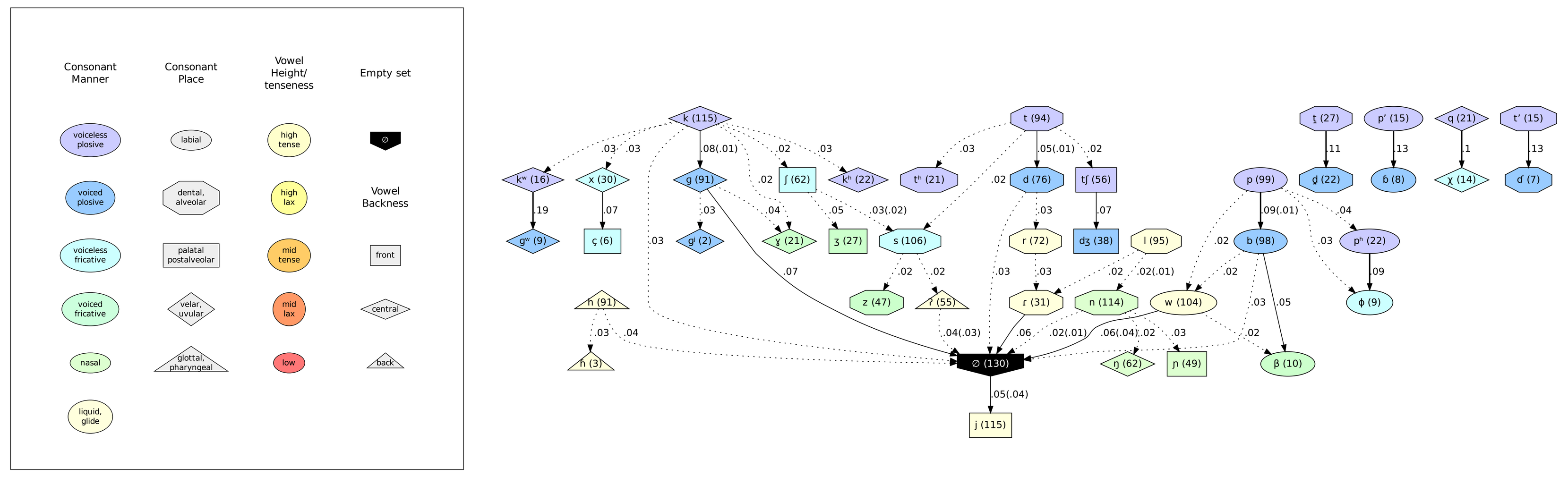


Figure 3: Intervocalic consonant changes only

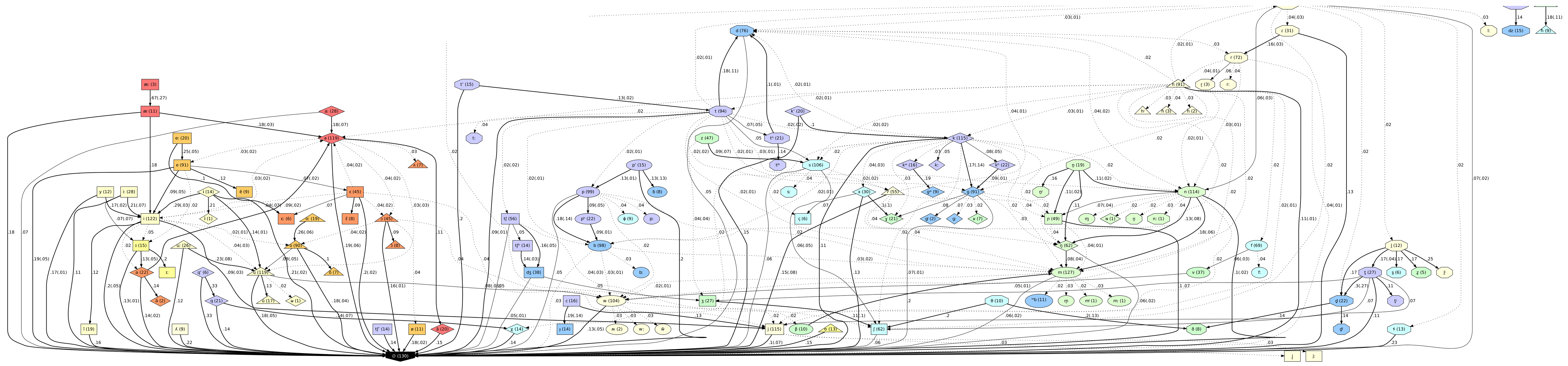


Figure 2: All segmental changes: Nodes/edges represent segments/changes found in more than 1% of languages. Edge labels are the rate of occurrence among languages with the Input sound (rate of change in opposite direction in parentheses). Edge style reflects rate (bold: > .08, dotted: < .05).

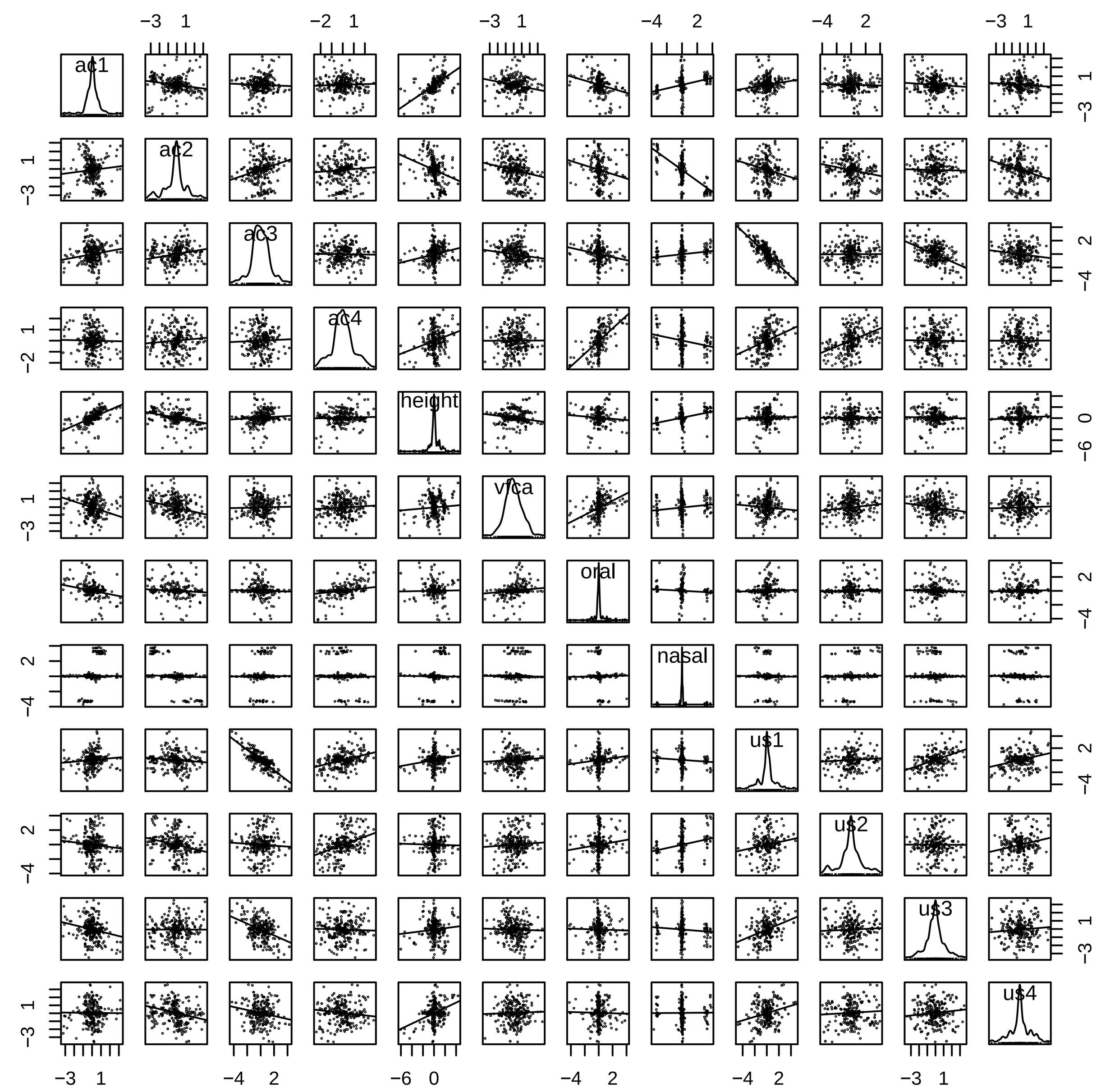


Figure 5: Scatterplot matrix for all acoustic and articulatory dimensions, with regression lines.

3. Dimensions for Sound Patterns

- **Objective:** Look at relationships between acoustic and articulatory dimensions in observed sound patterns
- **Methods:** Examined 626 Input-Output mappings observed in sound patterns in 94 languages, a sample from P-Base, with changes along acoustic and articulatory dimensions recorded for each change.
- **Results:** Figure 5 shows correlations between phonetic dimensions.
- Observed more patterns involving a change of more than one standard deviation in *one* acoustic dimension and *many* articulatory dimensions than vice versa (12:1).
- Change in each acoustic dimension is associated with change in different sets of articulatory dimensions. Table 1 shows articulatory correlates of changes involving a single acoustic dimension (as a percentage of the total number of patterns involving that dimension)

	AC1	AC2	AC3	AC4
Height	n/a	90%	0%	10%
VFCA	n/a	39%	39%	22%
Oral	n/a	20%	0%	80%
Nasal	n/a	89%	11%	0%
US1	n/a	21%	57%	21%
US2	n/a	31%	31%	38%
US3	n/a	18%	64%	18%
US4	n/a	26%	47%	26%

Table 1: Coocurrence of acoustic and articulatory dimensions.

References

Mielke, Jeff (2008) *The emergence of distinctive features.* Oxford: Oxford University Press.

Mielke, Jeff (2011) A phonetically-based phonetic similarity metric. To appear in *Lingua* special issue on phonological similarity.

Mielke, Jeff, and Abby Kaplan (in prep) P-base 2.0.