2aSC25. Articulatory reuse in good-enough speech production strategies

Matthew Faytak — University of California, Berkeley — mf@berkeley.edu

173rd Meeting of the ASA, Boston, MA   Poster PDF at goo.gl/6AFcbn (2.5 MB)

Overview

Hypothesis: when creating new L2 motor programs, L2 learners use trial-and-error learning based on modification of L1 motor programs, a strategy that emerges from so-called "good-enough" motor control (Loeb, 2012)

Goal: Search for evidence of "re-use" (little to no modification) of L1 motor programs in L2 articulations

Test case: Lingual ultrasound of vowels spoken by English-dominant learners of French, plus syllabic and non-syllabic rhotics

Findings: Lingual motor programs for /y ø/ cluster with L1 English phones, some of which are less obviously good starting points for "hacking," e.g. rhotics

Global L1–L2 "shift" of all phones in articulatory space could be attributed to **language-specific articulatory setting**; difficult to disentangle from modifications to specific phones

Suggestive of trial-and-error learning and good-enough (non-optimal) control operating in most of the adult L2 learners studied

Materials and methods

Subjects: 33 English-native learners of French residing in Berkeley, CA (10 M), at least two semesters of classroom exposure

Stimuli are of the form $əC_1V_2C_2$ for English, or $aC_1V_2C_2$ for French; C_1 and C_2 are non-lingual consonants, and V_2 is target vowel

Blocks (counterbalanced order):

- **English**, written stimuli for /i ɪ eɪ ɛ æ a ɔ oʊ ʊ u ɹ ɚ/ read
- **French**, stimuli for /i e ɛ a o u y ø/ presented as:
  - **Reading:** read stimuli displayed on teleprompter
  - **Imitation:** recording of a model talker speaking stimulus plays as written stimulus is presented on teleprompter; subjects additionally prompted to imitate model talker's vowel quality

Ultrasound data (107 fps): Ultrasonix SonixTablet, C9-5/10 microconvex transducer, Articulate Instruments head-set; synchronized **audio** (48 kHz sampling rate)

- English and French audio force-aligned using Penn Aligner
- Ultrasound frames extracted from phone midpoints; fed to **Principal Components Analysis** (PCA); first 3 generally displayed, cf. Mielke et al. (2016)
- **Separate PCA for each speaker:** no reference point in ultrasound data to align rotation of speaker-specific solutions to

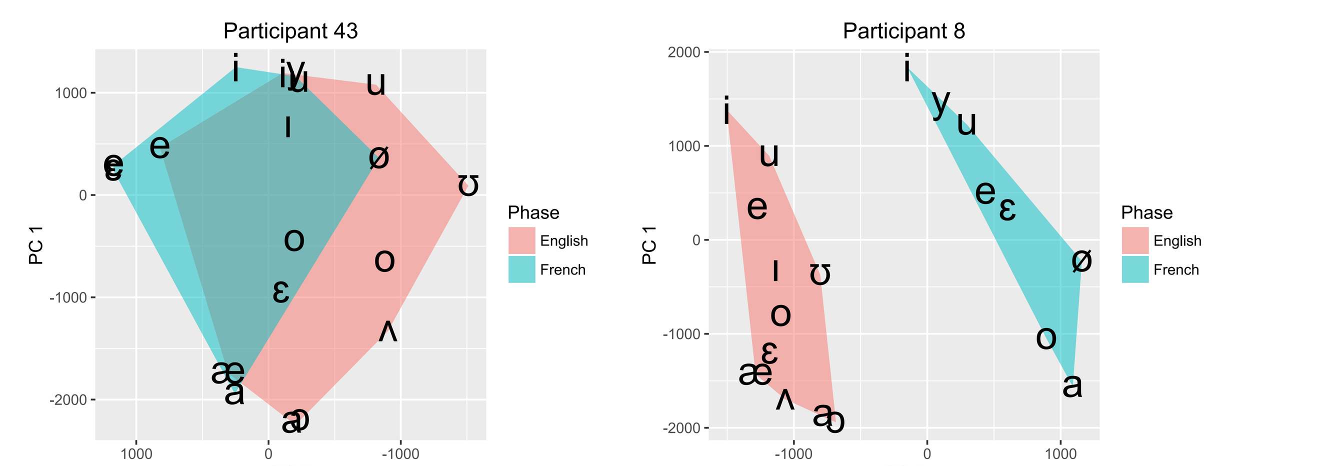
L1/L2 articulatory setting

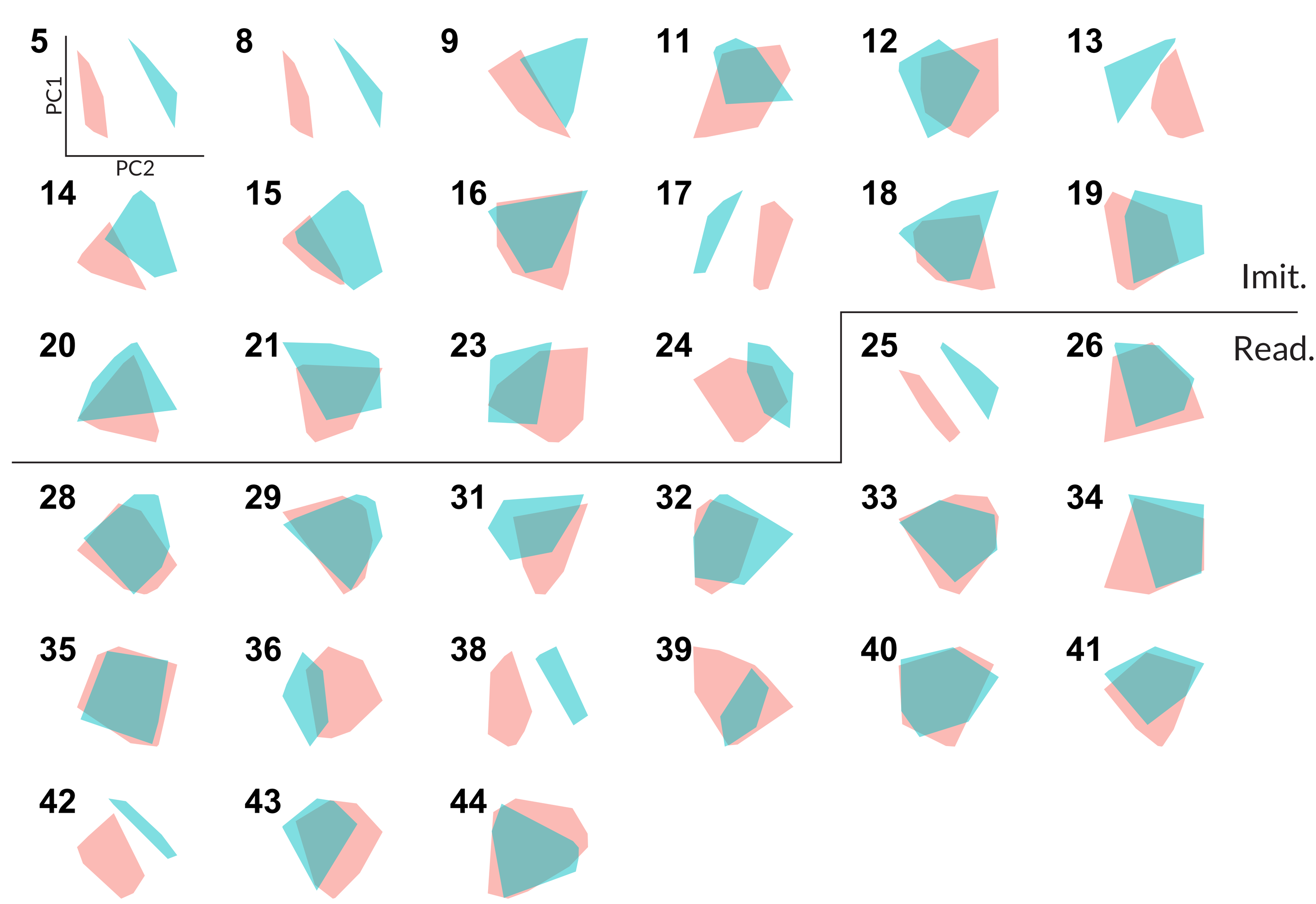
May be a **separate, confounding change** to L2 productions relative to L1 (Wilson and Gick, 2014)

To gauge overall relationship between L1, L2 articulations, PCA run over all monophthong V in L1 and L2

- The PCs that emerge appear to relate to articulatory primitives (high–low, front–back) Harshman et al. (1977); Nix et al. (1996)
- Participants use different portions of articulatory PC space for L1 and L2, possibly displaying language-specific articulatory settings (even at low experience levels)

Convex hulls drawn about PC1–PC2 category means:





- L1, L2 hulls tend to **overlap less** for participants in imitation condition (Welch's two-sample t-test, $t(31) = 2.81$, $p = 0.00891$)
- Remaining case studies are limited to **reading-only condition** (n=17) to limit confound

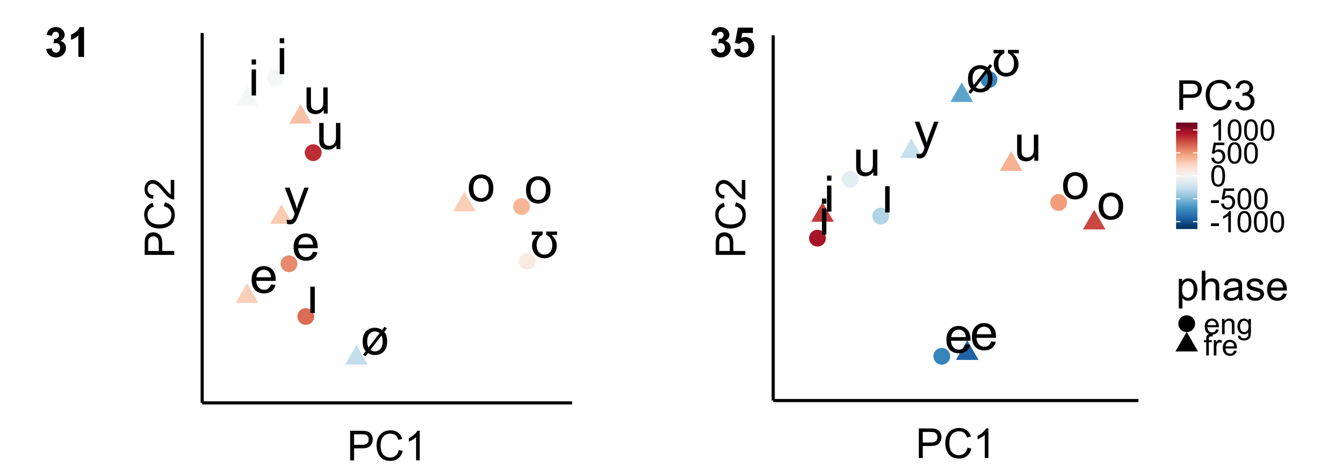
Case 1: L1 /i/ or /u/-like /y/

L1 front rounded vowels have a lingual articulation distinct from front unrounded and back rounded vowels (Wood, 1986); is this the case for L2 learners?

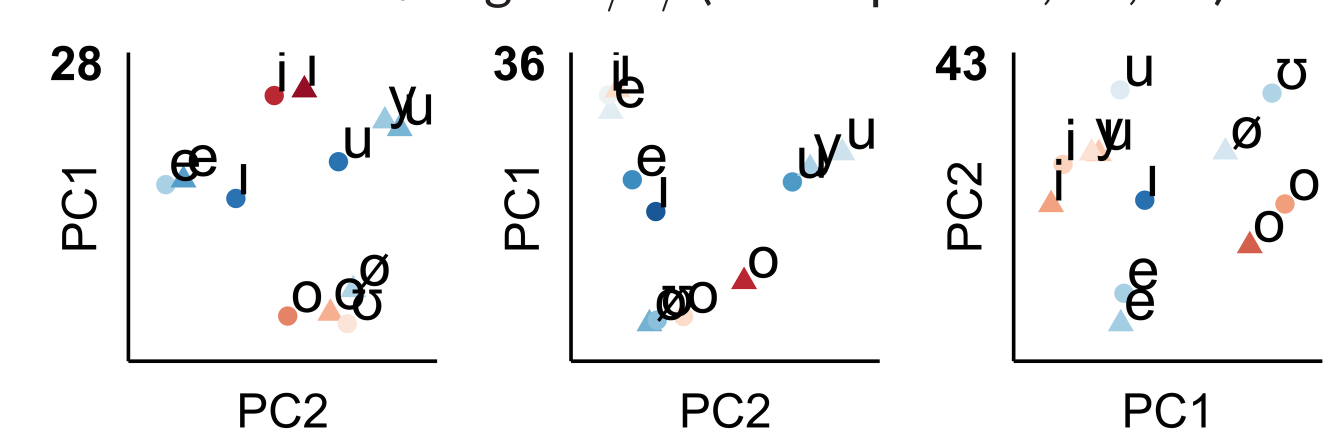
PCA run over subset of Eng/Fre front unrounded V /i, e/ (and Eng /ɪ/), Eng/Fre back rounded V /u, o/ (and Eng /ʊ/), and Fre front rounded V /y, ø/

- Pulls out front–back variation into a low-numbered PC
- Clusterings observed in whole-vowel-space PCA are largely preserved

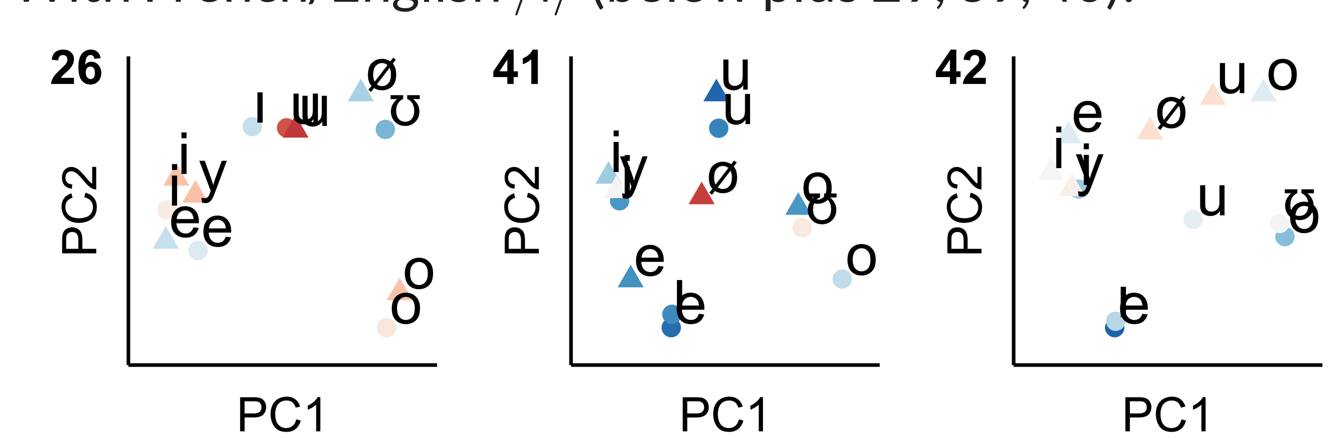
Five participants **maintain native-like separation** of French /i, y, u/ (below plus 25, 33, 40)



However, **most participants cluster** /y/ **with other vowels.** With French/English /u/ (below plus 32, 38, 44):



With French/English /i/ (below plus 29, 39, 40):



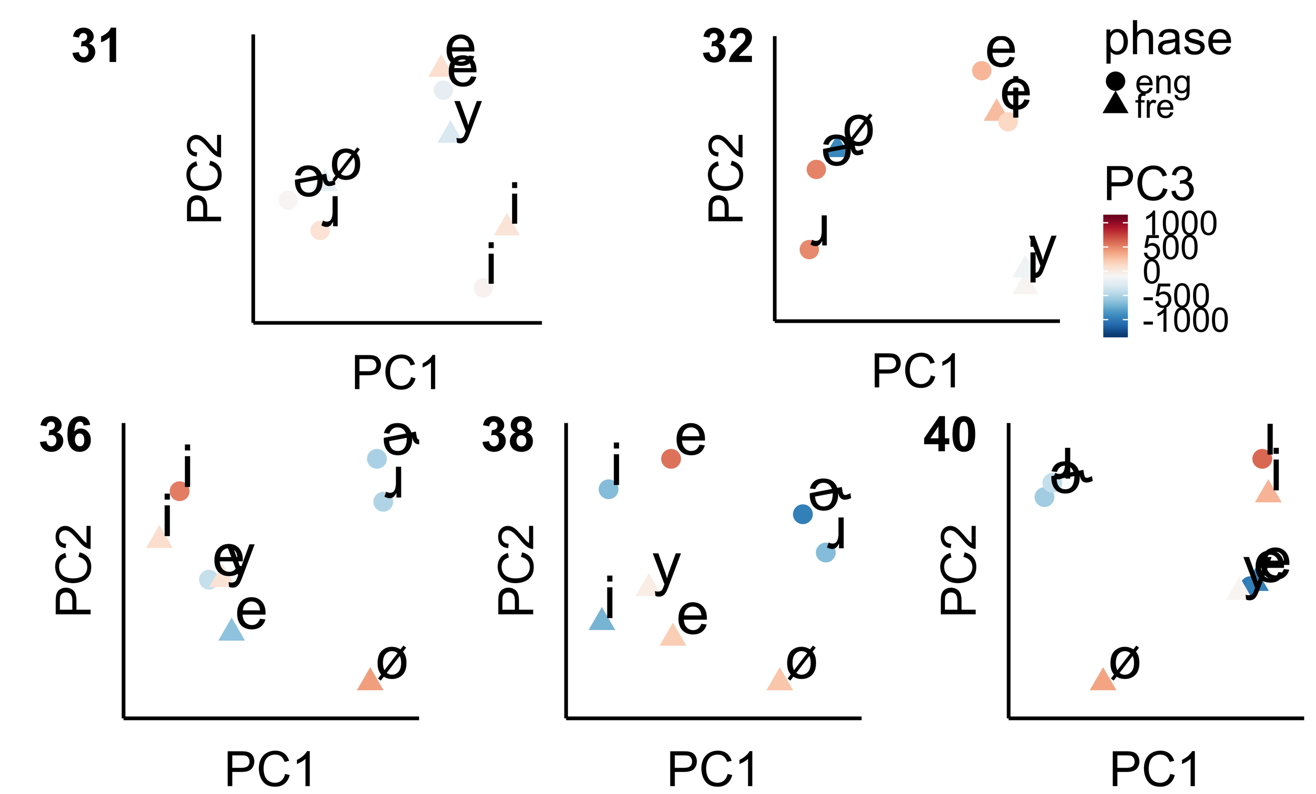
- "Back" rounded vowels are commonly fronted in California English, characteristic of most participants; similarity may merely reflect working with the acoustically most similar vowel
- **Caveat:** acoustics do not always directly relate to lingual PC space alone

Case 2: rhotic /ø/

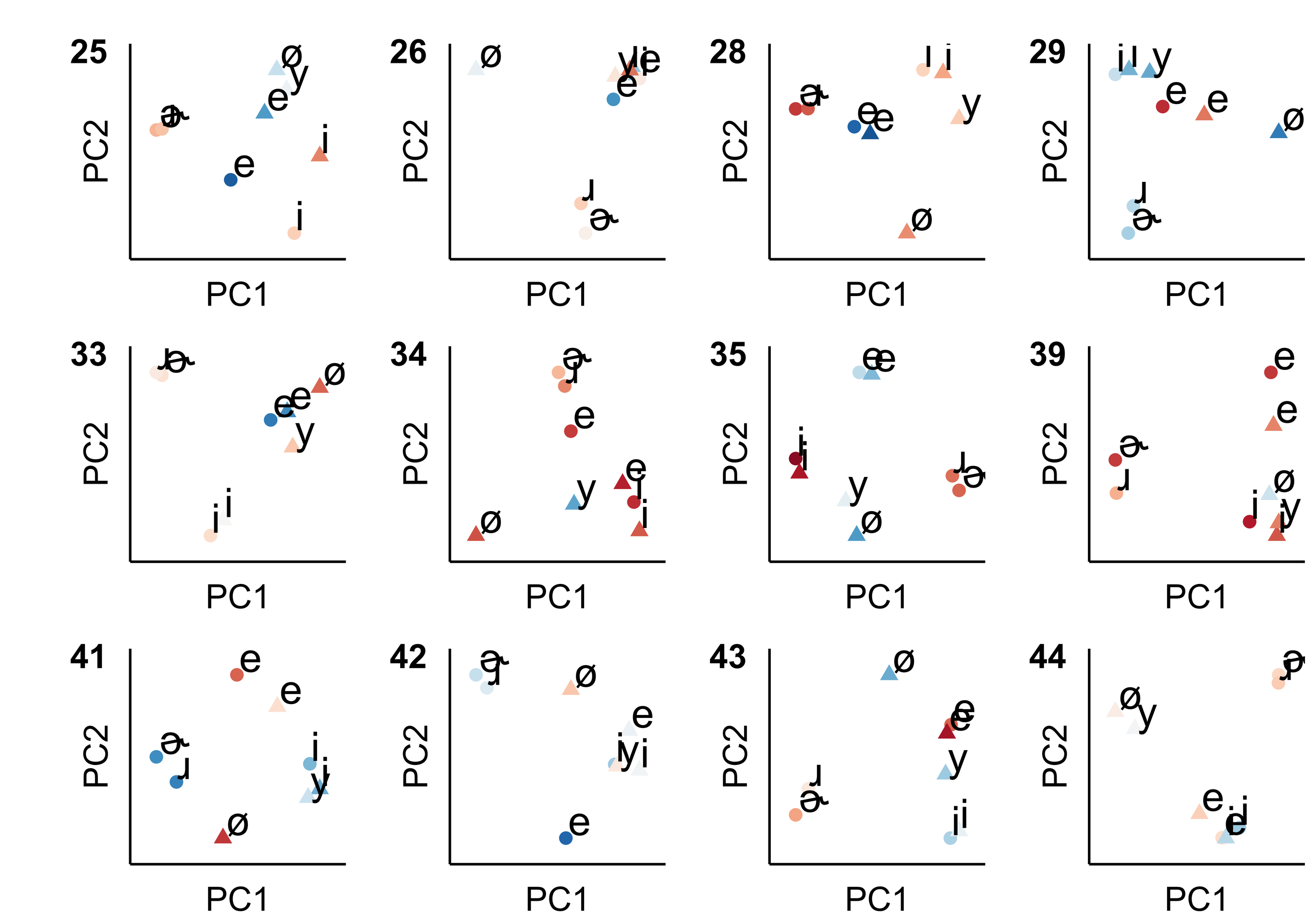
Front rounded vowels and rhotics have been observed to be interchangeable and confusable; both articulatory maneuvers lower F3 (Mielke, 2011)

PCA over subset of Eng/Fre front unrounded V /i, e/, Eng rhotics /ɚ, ɹ/ and Fre front rounded vowels /y, ø/, to pull concavity–convexity into low-numbered PC

A few speakers cluster /ø/ with English rhotic(s):



Rest of data: /ø/, all other vowels distinct from rhotics:



Thanks & references

Heather Fergus, Qiu Ting Liu, and Kana Lopez (data processing); Keith Johnson, Susan Lin and Sarah Bakst (general); Ronald Sprouse and Jeff Mielke (technical help). Supported by ASA's **Stetson Scholarship in Phonetics and Speech Science**.

Harshman, R., Ladefoged, P., and Goldstein, L. (1977). Factor analysis of tongue shapes. *JASA*, 62(3):693–707.

Loeb, G. E. (2012). Optimal isn't good enough. *Biological cybernetics*, 106(11-12):757–765.

Mielke, J. (2011). An articulatory study of rhotic vowels in Canadian French. *Canadian Acoustics*, 39(3):164–165.

Mielke, J., Baker, A., and Archangeli, D. (2016). Individual-level contact limits phonological complexity: Evidence from bunched and retroflex /ɾ/. *Language*, 92(1):101–140.

Nix, D. A., Papcun, G., Hogden, J., and Zlokarnik, I. (1996). Two cross-linguistic factors underlying tongue shapes for vowels. *JASA*, 99(6):3707–3717.

Wilson, I. and Gick, B. (2014). Bilinguals use language-specific articulatory settings. *JSLHR*, 57(2):361–373.

Wood, S. (1986). The acoustical significance of tongue, lip, and larynx maneuvers in rounded palatal vowels. *JASA*, 80(2):391–401.