# The Effects of Post-Velar Consonants on Vowels in Ditidaht*

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## Introduction

- The post-velar consonants are interesting to linguists for several reasons:
  - They are more difficult to observe than more anterior consonants,
  - Non-glottal post-velars (uvulars and pharyngeals) are cross-linguistically uncommon,
  - The post-velars are argued to function as a natural class, the GUTTURALS, in Semitic (Hayward and Hayward 1989; McCarthy 1994), and, without glottals, as the *faucal* class in Interior Salish (Bessell 1998).
- The effects of post-velars on vowels are an important aspect of justifying a GUTTURAL natural class.
- In pursuit of the larger question of whether the GUTTURAL natural class is innate, it is important to determine whether there is evidence for it in languages that have the relevant consonants, the post-velars.
- Ditidaht (Southern Wakashan) has uvulars, a pharyngeal, and glottals.
- This study provides the first instrumental phonetic investigation of the effects of Ditidaht's post-velar consonants on its vowels.
- I argue that evidence from the effects of post-velar consonants on vowels at both the phonological and phonetic levels in Ditidaht motivates a view under which uvulars are [+back] and the pharyngeal is [+low].
  - The featural representation is less important than the fact that backness and lowness are essential characteristics of uvulars and the pharyngeal, respectively.
- *Roadmap*:
  - First (§1), I review the phonemic inventory and allophony in Ditidaht as it relates to vowels and post-velar consonants.
  - Next (§2), I survey the phonological processes and constraints that involve post-velars.
  - Then, I present a phonetic study of the effects of post-velars on vowels.

## 1 Phonemic Inventory and Allophony

- The Ditidaht vowel inventory is roughly as follows:

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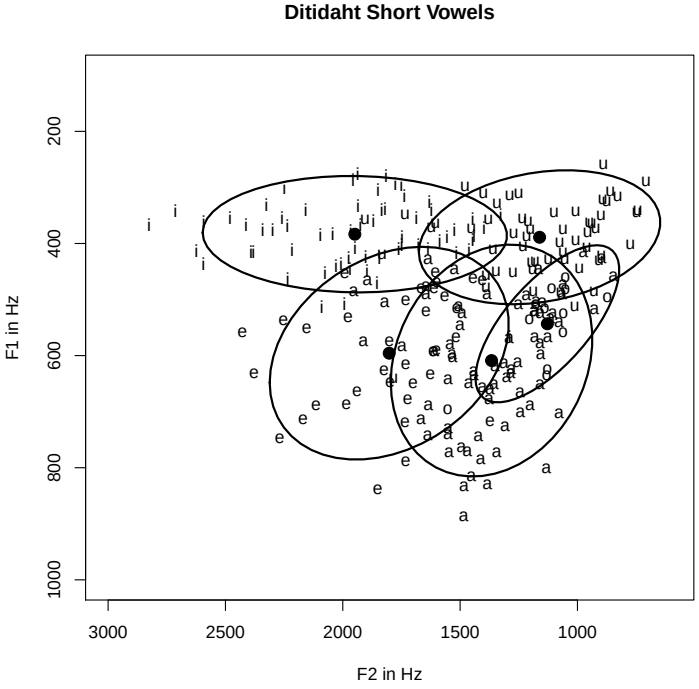
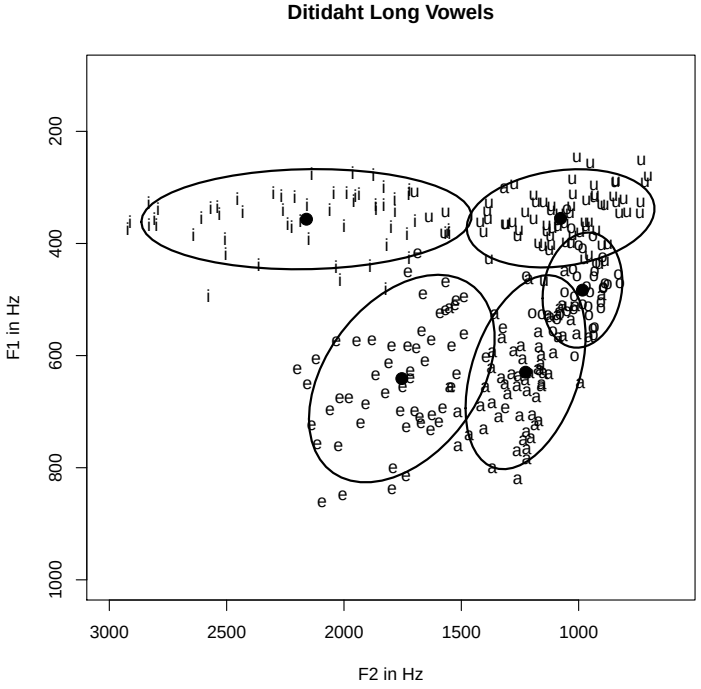
| Orthography | a | aa | e | ee | i | ii | o | oo | u | uu |
|---|---|---|---|---|---|---|---|---|---|---|
| IPA | ə∼ɑ | ɑː | ɛ∼æ | æː | ɪ∼i | iː | o∼ɔ | oː | ʊ∼u | uː |

- The range of variation in the quality of short vowels is greater than that of long vowels.
- The realization of the vowels is as below (the ellipses cover 80% of the tokens of each vowel quality):




- The post-velar phonemic inventory of Ditidaht is as follows:

| | Uvular | Pharyngeal | Glottal |
|---|---|---|---|
| Orthography | q $q^w$ q̓ $q̓^w$ x̣ $x̣^w$ | ʕ | ʔ h |
| IPA | q $q^w$ q’ $q^w$’ χ $χ^w$ | ʕ | ʔ h |

- The pharyngeal is realized as an epiglottal stop [ʔ] in onset position, but as a pharyngeal glide [ʕ] in post-vocalic coda position (Werle 2007:75).
  - /ħ/ occurs in one word, *maħmu* ‘seashell,’ which is *maxmu* for some speakers (but never **baxbu*).
- Similarly, glottal stop is realized as the stop [ʔ] in onset position, but as a post-vocalic coda, it is realized as laryngealization or creakiness on the preceding vowel.

## 2 Phonological Processes and Constraints Involving Post-Velar Consonants

1. High vowels are phonologically lowered before a coda pharyngeal:

   (1) a. *ciciqt* ‘talk to someone,’ root is something like *ci-*

   b. *ce̲ʕqaƛ* ‘(public) speaker’

   (2) a. *duduuk* ‘to sing,’ root is something like *duu-*

   b. *do̲ʕqaƛ* ‘singer, person entrusted with remembering the songs of many families’

2. /h/ cannot occur in coda position.

3. Historically, *q̓, *q̓$^{w}$ > ʕ (Jacobsen 1969)
    - Synchronically, this still occurs as a result of the Hardening process. When Hardened:
    - post-consonantal /q/ becomes /q̓/,
    - but post-vocalic /q/ becomes /ʕ/ (Werle 2007:81-82).
    - There is variation according to whether the Hardener is a suffix or clitic, as well as individual variation.

4. It has been claimed that /a/ and /o/ have merged before coda /ʕ/ (Werle, p.c.).

5. It has also been claimed that short vowels "are tenser (more peripheral) preceding glides /y, w/, voiced glottalized continuants /b̓, d̓, m̓, n̓, l̓, y̓, w̓/, and the non-oral stops /ʔ, ʕ/" (Werle 2007:76).

# 3 Phonetic Investigation of Effects of Post-Velar Consonants on Adjacent Vowels

- The main study addresses the general effects of different places of articulation on vowels in Ditidaht.
- The main study was motivated by:
    - The claim that the GUTTURAL natural class is innate and possibly universal,
    - The lowering of high vowels before a coda pharyngeal,
    - The possible merger of /a/ and /o/ before a coda pharyngeal,
    - The rarity of mid-vowels before uvulars, especially when the uvulars are in coda position, and
    - generally, the fact that Ditidaht has uvulars, a pharyngeal, and glottals.
- Two smaller studies tested the claims that:
    - /a/ and /o/ are merged before coda /ʕ/
    - vowels are tensed before coda glottalization, specifically before word-final glottal stops, where I perceived the effect to be greatest
- NB: 'Coda' here refers to a vowel-adjacent segment in coda position, and excludes consonants that are phonologically codas but are not vowel adjacent.

## 3.1 Main Study

### 3.1.1 Speakers, Data Collection, and Methods

- Purpose was to investigate the effect that place of articulation has on the realization of vowels.
- Data were elicited from 4 speakers of Ditidaht in Nitinaht Lake (Malachan 11), BC, in the early summers of 2012 and 2013. Speakers were recorded in quiet places using a Zoom Handy H4N digital recorder and either a lapel (2012) or head-mounted (2013) microphone.
- For the labial, coronal, palatal, and velar places, data were elicited to get one token per speaker of each vowel quality in stressed position in contact with the consonant place of interest.
    - Wherever possible, given the lexicon, tokens which sandwiched the vowel between consonants with the same place of articulation were elicited for each vowel quality.
    - The next best tokens were those in which the consonant of interest was in coda position.
    - If those two options were unavailable, a token with the consonant of interest in onset position was chosen.
- For the post-velar places, uvular, pharyngeal, and glottal, data were elicited to get one token per speaker of each vowel quality in stressed position (if possible).

  - For each consonant, not just each place, the wordlist was constructed to try to get a token of each vowel quality adjacent to the consonant in onset position and one token adjacent to it in coda position
  - Also used were tokens of each vowel quality sandwiched between each post-velar place of articulation.
- The velar data and the tokens of each vowel quality sandwiched between a post-velar were generally from 2012, and so were not said in a carrier phrase.
- However, impressionistically, the speech rate did not differ between the small amount of 2012 data and the majority of the data (from 2013), which was said in the carrier phrase: *ƛaʔúu wáa* ____ "Say ____ again."
- Token counts for places of articulation (all speakers):

| | Labial | | | | Coronal | | | | Palatal | | | | Velar | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 62 | | | | 50 | | | | 57 | | | | 51 | | | |
| σ Pos. | Surr | | Coda | | Ons | | Surr | | Coda | | Ons | | Surr | | Coda | | Ons | |
| | 22 | | 20 | | 20 | | 36 | | 0 | | 14 | | 31 | | 4 | | 22 | | 27 | | 16 | | 8 | |
| Stress | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v |
| | 18 | 4 | 14 | 6 | 12 | 8 | 34 | 2 | — | — | 14 | 0 | 20 | 11 | 0 | 4 | 22 | 0 | 16 | 11 | 10 | 6 | 5 | 3 |

| | Uvular | | | | Pharyngeal | | | | Glottal | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 145 | | | | 55 | | | | 116 | | | |
| σ Pos. | Surr | | Coda | | Ons | | Surr | | Coda | | Ons | |
| | 15 | | 49 | | 81 | | 8 | | 21 | | 26 | | 26 | | 37 | | 53 | |
| Stress | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v | ́ | v |
| | 12 | 3 | 48 | 1 | 68 | 13 | 0 | 8 | 11 | 10 | 22 | 4 | 12 | 14 | 30 | 7 | 48 | 5 |

- This may bias the mean formant measurements toward those of vowels adjacent to uvulars and glottals, but deviations from the mean are still apparent, even for those places of articulation.

### 3.1.2 Results and Discussion

- The following table shows the difference between the formants of vowels in contact with certain places of articulation and the mean formant values for the vowels calculated from all the data (including that place of articulation).
  - It cannot be assumed that glottals are neutral, since they affect vowels in Semitic: Comparison to the mean allows the effects of glottals to be observed, if there are any.
- Changes greater than (or equal to) 50 Hz are shaded (in each table).

| | MEAN | | Labial | | Coronal | | Palatal | | Velar | | Uvular | | Phar | | Glottal | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F1 | F2 | F1 | F2 | F1 | F2 | F1 | F2 | F1 | F2 | F1 | F2 | F1 | F2 | F1 | F2 |
| a | 609 | 1366 | -103 | -372 | -82 | 173 | -109 | 199 | -62 | -302 | 45 | -58 | 111 | 9 | 88 | 50 |
| aa | 630 | 1226 | -67 | -162 | 46 | 104 | -129 | 218 | 28 | 127 | 25 | -20 | 18 | 91 | 19 | -47 |
| e | 596 | 1802 | -102 | 18 | — | — | -91 | 58 | -10 | 195 | -39 | -129 | 111 | -145 | 6 | -9 |
| ee | 641 | 1753 | -32 | 57 | -57 | 132 | -82 | 41 | -102 | 219 | 14 | -61 | 74 | -163 | 9 | 20 |
| i | 383 | 1949 | -2 | -171 | -8 | 92 | -53 | 90 | 19 | -215 | 31 | -150 | 31 | 35 | -42 | 310 |
| ii | 357 | 2160 | -15 | 172 | -33 | 11 | -38 | 5 | -5 | -44 | 49 | -150 | -24 | -23 | 13 | 412 |
| o | 543 | 1128 | — | — | — | — | -55 | -33 | — | — | — | — | 44 | 136 | 2 | -53 |
| oo | 483 | 984 | -38 | -40 | 34 | 92 | -50 | 45 | 28 | -47 | 3 | -68 | — | — | 27 | 1 |
| u | 389 | 1161 | -44 | -203 | -10 | 443 | -5 | 215 | 28 | -72 | 9 | -197 | -9 | -96 | -3 | -42 |
| uu | 355 | 1077 | -18 | -80 | -7 | 257 | -24 | 101 | 8 | 62 | 43 | -77 | 6 | 195 | -5 | -70 |

Table 1: Formant measurements for vowels in contact with each place of articulation relative to the mean of all vowel tokens

- An increase in F1 corresponds to vowel *lowering*; A decrease in F2 corresponds to vowel *backing*
- Labials show backing of /a, aa/, and /u, uu/. There is also raising of low /a, aa/ and low∼mid /e, ee/ (IPA /æ(ː)/.
- Coronals show fronting of all vowel qualities, except high, front /ii/.
- Palatals raise all vowel qualities and front most vowels.
- Velars do not affect vowels greatly, except for fronting /e, ee/.
- Uvulars back all vowels. This is consistent with the effects of uvulars in other languages (e.g. Arabic).
- The pharyngeal fronts long /aa/ and back /e, ee/. Given that /e/ here is IPA /æ/, one would expect merger between /a/ and /e/, at least in some cases.
  - Impressionistically, the realization of /a/ and /e/ before coda /ʕ/ does sometimes seem to be very similar.
  - However, the phonology seems to show that a pharyngeal in coda position heavily reduces the vowel oppositions such that only a backness distinction (no height) is relevant in that position. It is possible that this prevents complete merger.
- Finally, glottals heavily front /i, ii/, and lightly back /u, uu/: This likely contributes to the impression of tensing (vowel peripheralization).

| | Velar | | Uvular | |
|---|---|---|---|---|
| | Vel F1 | Vel F2 | Uvul F1 | Uvul F2 |
| a | 547 | 1064 | 106 | 245 |
| aa | 658 | 1353 | -3 | -147 |
| e | 586 | 1997 | -29 | -324 |
| ee | 539 | 1973 | 116 | -280 |
| i | 402 | 1734 | 12 | 65 |
| ii | 352 | 2116 | 54 | -107 |
| o | — | — | — | — |
| oo | 511 | 937 | -25 | -21 |
| u | 417 | 1090 | -20 | -126 |
| uu | 363 | 1138 | 35 | -139 |

Table 2: Formant measurements for vowels in contact with uvulars relative to those in contact with velars

- In comparison to velars, uvulars generally back vowels (with the exception of /a/ and /i/).
  - This is consistent with the view of uvulars as "back dorsals."
  - The fact that uvulars consistently lower F2 (backing vowels) points to that being a perceptual cue, which may be why uvular consonants are often quite variably articulated, possibly without even actually involving the uvula: The target may be perceptual rather than articulatory.
- Uvulars also lower /a/ and /ee/: This can be viewed as phonetic enhancement since these vowels are already low.

| | Uvular | | Pharyngeal | |
|---|---|---|---|---|
| | F1 | F2 | F1 | F2 |
| a | 653 | 1308 | 66 | 67 |
| aa | 655 | 1206 | -7 | 111 |
| e | 557 | 1673 | 150 | -16 |
| ee | 655 | 1693 | 60 | -103 |
| i | 414 | 1799 | 0 | 185 |
| ii | 406 | 2010 | -73 | 127 |
| o | — | — | — | — |
| oo | 486 | 916 | — | — |
| u | 398 | 964 | -18 | 101 |
| uu | 398 | 999 | -37 | 273 |

Table 3: Formant measurements for vowels in contact with the pharyngeal relative to those in contact with uvulars

- The pharyngeal lowers /a/ and /e, ee/ to an even greater extent than uvulars, but does not back vowels like uvulars do (with the exception of /e, ee/)
  - This can be seen as evidence that the most important/diagnostic feature of the pharyngeal is lowness while that of uvulars is backness.
  - Other supporting evidence: /ʕ/ fronts /a/ in Arabic while uvulars and emphatics back it (Watson 2002:272).

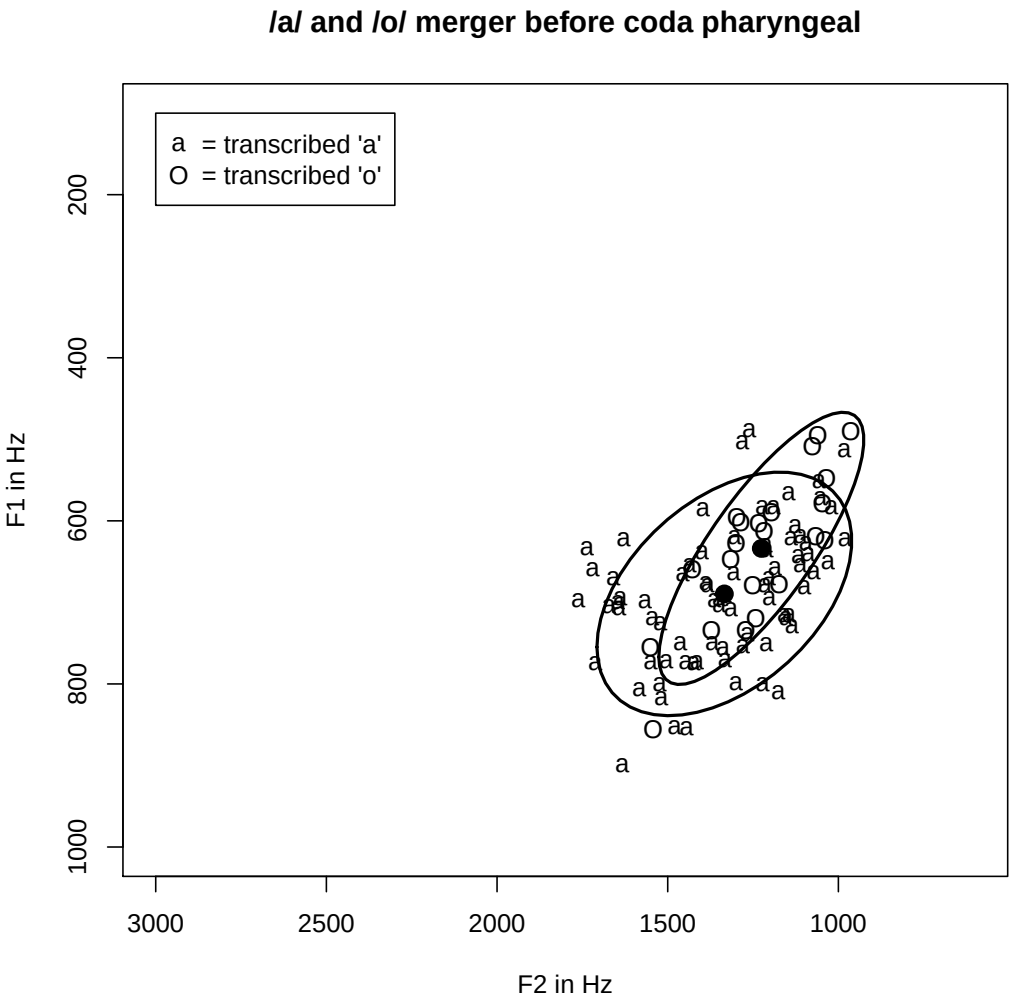
| | Glottal | | Pharyngeal | |
|---|---|---|---|---|
| | F1 | F2 | F1 | F2 |
| a | 653 | 1308 | 66 | 67 |
| aa | 655 | 1206 | -7 | 111 |
| e | 557 | 1673 | 150 | -16 |
| ee | 655 | 1693 | 60 | -103 |
| i | 414 | 1799 | 0 | 185 |
| ii | 406 | 2010 | -73 | 127 |
| o | — | — | — | — |
| oo | 486 | 916 | — | — |
| u | 398 | 964 | -18 | 101 |
| uu | 398 | 999 | -37 | 273 |

Table 4: Formant measurements for vowels in contact with the pharyngeal relative to those in contact with glottals

- Relative to glottals, the pharyngeal appears to centralize vowels with respect to backness.
- In the Northeast Caucasus, vowel centralization (also involving height) is reported as a characteristic of pharyngealized vowels in Udi (Catford 1994).

### 3.2 Merger of /a/ ∼ /o/ Before Coda /ʕ/

- Purpose was to gather acoustic evidence to test whether /a/ and /o/ have in fact merged before coda /ʕ/.
- Data are from 2013 from 4 speakers and were elicited in the carrier phrase.
- Wordlist included all words in the working dictionary transcribed with the sequences 'aʕ' and 'oʕ'.
- 99 total tokens from all speakers (77 = 'aʕ', 22 = 'oʕ').

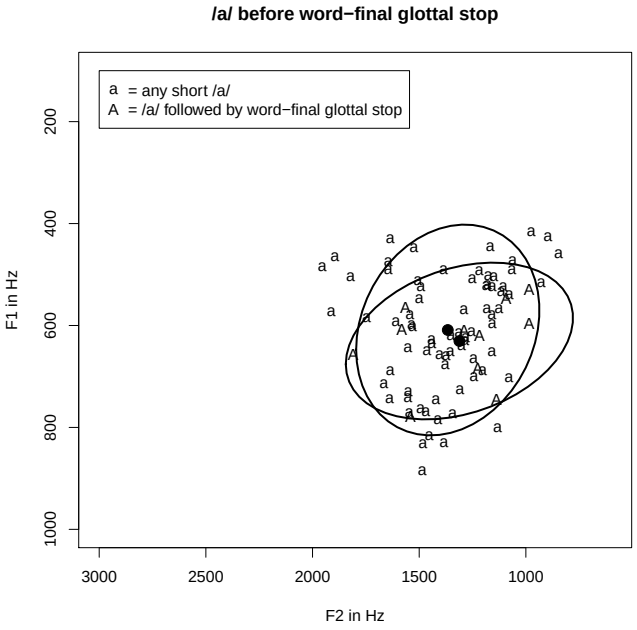


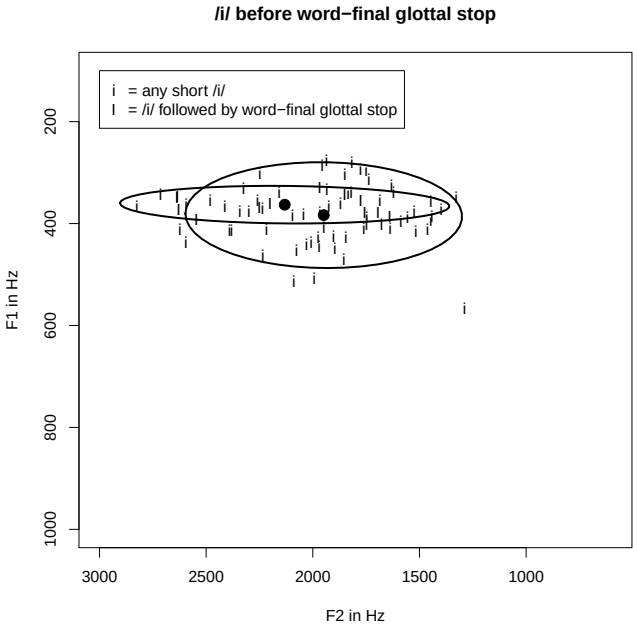

- In the image, the ellipses encompass approximately 80% of the tokens for each category.
- The image shows nearly complete overlap of tokens transcribed with 'a' (the lower, rounder ellipse) and those transcribed with 'o' (the upper, more oval-like ellipse).
- The overlap of the tokens suggests a complete merger, while the ellipses suggest a *near-merger*, in which speakers have different productions for the categories, but perceive no category difference.

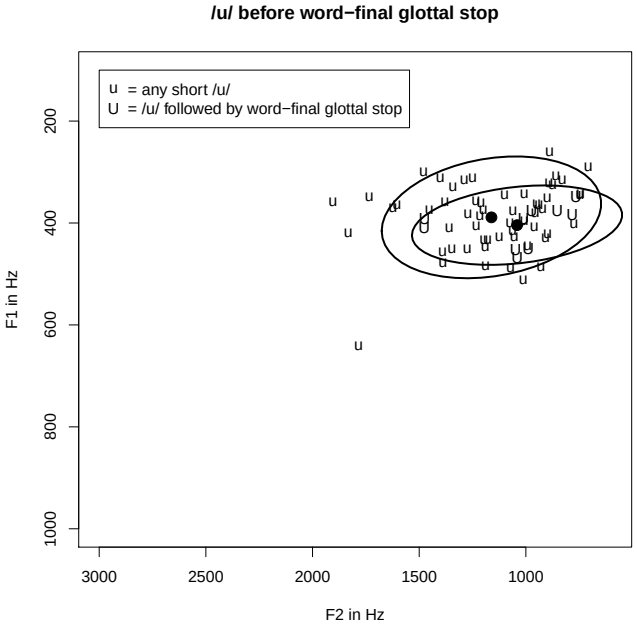
## 3.3 Word-Final Glottal Stop

- Purpose was to determine whether word-final glottal stops cause "tensing" of the vowel.
  - I perceived the tensing effect to be greatest in this position, but the original claim is that short vowels "are tenser (more peripheral) preceding glides /y, w/, voiced glottalized continuants /b̰, d̰, m̰, n̰, l̰, y̰, w̰/, and the non-oral stops /ʔ, ʕ/" (Werle 2007:76).
- Data are from 2013 from 4 speakers and were elicited in the carrier phrase.
- Token counts by vowel quality before the glottal stop (all speakers):

| a | i | u |
|---|---|---|
| 11 | 12 | 10 |




- These three figures show that vowels before word-final glottal stop show less variation in height (F1), but more in backness (F2), than comparable vowels outside of that position.

## Conclusion

- Very little phonological evidence in Ditidaht hints at the representation for uvulars, but phonetic evidence shows that backing is a robust characteristic.
- Uvulars also lower low vowels, possibly as an enhancement effect.
- Phonetically, the pharyngeal lowers vowels to a greater extent than uvulars, and shows few backing effects.
  - The lowering tendency of uvulars, which appears to be an enhancing feature, may have historically become a distinctive feature for the pharyngeal.
- These facts, combined with the phonological lowering of high vowels before a coda pharyngeal, point to the pharyngeal being [+low], with lowering of already low vowels serving as a phonetic enhancement feature.
  - Given the merger of /a/ and /o/ before coda /ʕ/, only low∼mid /e/ (=[æ]) and /a/ can appear before a coda pharyngeal.
  - Either only low vowels are allowed before a coda low consonant, or the vowel distinction between /a/ and /e/ is not simply [-back] vs. [+back].
- Whatever phonological representation is chosen, the backness of uvulars and lowness of the pharyngeal should be part of that representation due to its potential value in promoting perceptual contrast:
  - The backing of vowels adjacent to uvulars can be used to distinguish uvulars from velars
  - The lowering of vowels adjacent to the pharyngeal can be used to distinguish the pharyngeal from glottals

**References**


BESSELL, NICOLA J. 1998. Local and non-local consonant-vowel interaction in Interior Salish. *Phonology* 15:1–40.

CATFORD, JOHN C. 1994. Vowel systems of Caucasian languages. *Non-Slavic Languages of the USSR*, edited by Howard I. Aronson, Columbus, OH: Slavica, 44–60.

HAYWARD, K. M. and RICHARD J. HAYWARD. 1989. 'Guttural': Arguments for a new distinctive feature. *Transactions of the Philological Society* 87(2):179–193.

JACOBSEN, WILLIAM H. 1969. Origin of the Nootka pharyngeals. *International Journal of American Linguistics* 35(2):125–153.

MCCARTHY, JOHN J. 1994. The phonetics and phonology of Semitic pharyngeals. *Phonological Structure and Phonetic Form, Papers in Laboratory Phonology III*, edited by Patricia A. Keating, Cambridge, UK: Cambridge University Press, 191–233.

WATSON, JANET C. E. 2002. *The Phonology and Morphology of Arabic*. Oxford University Press.

WERLE, ADAM. 2007. Ditidaht vowel alternations and prosody. *The Canadian Journal of Linguistics* 52(1/2):71–104.



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