Phonetic Realization of Vowel Length and Glottalization in Todos Santos Mam

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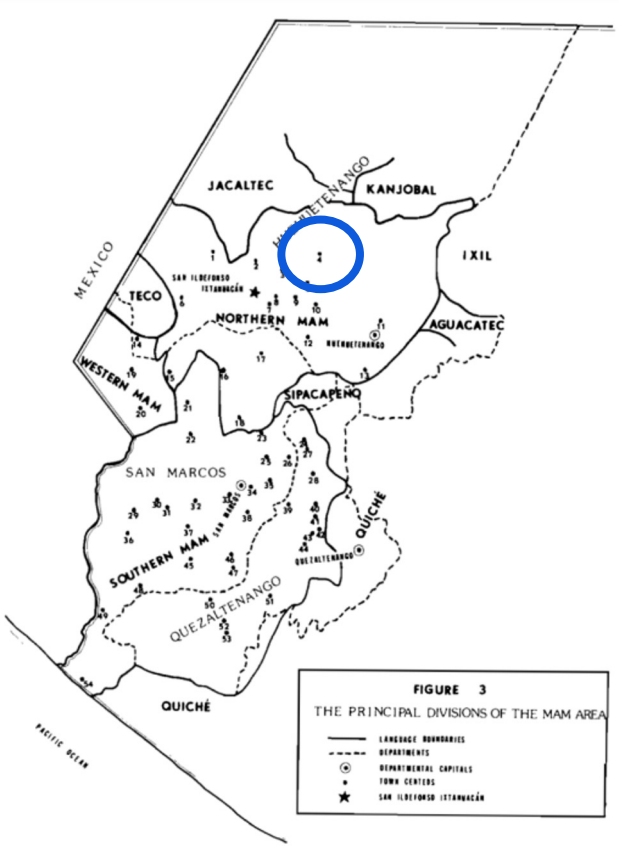
Language background

Mam is a Mamean-branch Mayan language of Western Guatemala (~600,000 speakers)

- high degree of inter-dialectal variation

Todos Santos Mam is an under-investigated dialect, that is highly divergent along phonetic, lexical, and syntactic dimensions (e.g. England 2017).



Language map of Guatemala (England 1983), Todos Santos is town #4

Background: vowel length

- Mam has a 5-vowel system (/a i e o u/)
- said to have a **length contrast**, which interacts with vowel quality (England 1983/2011)
- low functional load: few minimal pairs, not referenced in prescriptive grammars (Cristósomo et al. 2015)

Examples of vowel length contrast (England 1983)

/a/ vs. /aa/	q'a 'boy (masc. classifier)' q'aaj 'chair'	/e/ vs. /ee/	ab'éch 'flower' peetz 'duck'
/i/ vs. /ii/	tílb'el 'color' txiil 'cricket'	/o/ vs. /oo/	mox 'beetle' jooj 'crow'
/u/ vs. /uu/	tx'ut 'drop (of liquid)' xuux 'flute'		

Background: Mam /Vʔ/

- Mam also has /Vʔ/ sequences which supposedly interact with vowel length.
- According to England (1983/2011):
  - /Vʔ/ sequences are realized as **glottalized vowels**, with falling pitch, rather than as V-ʔ sequences.
  - Glottalized vowels are also lengthened relative to modal counterparts (England 1983/2011)
  - Vʔ sequences are also active in the phonology: they are heavier than other VC and attract stress
- No phonetic studies of either vowel length or glottalization in Mam.

Background: Mayan /Vʔ/ sequences

- Two views by Mayanists
  - View 1: /Vʔ/ is a ‘glottalized vowel’, where either the vowel is glottalized, or the /ʔ/ occurs in the middle of the vowel (e.g. Attinasi 1973:106, Coon 2004 on Chol; Lois and Vapnarsky 2003 on Yucatec Maya)
  - View 2: /Vʔ/ is a vowel followed by a glottal stop, not a glottalized vowel (Baird 2011).

- Acoustic analyses of glottal stops in Mayan languages are rare, with mixed results (Frazier 2009a, b; Baird 2011)

Goals of current study

Aim: to investigate the vowel length contrast and /Vʔ/ realization in Todos Santos Mam, using novel acoustic evidence

- **Vowel Length:** Is there a vowel length contrast supported by duration and/or vowel quality?
- **/Vʔ/:** What is the phonetic realization of /Vʔ/?
- Is there any interaction between vowel length and glottalization?

Method

- Recorded one male speaker of Todos Santos Mam reading a wordlist.
- speaker was asked to read each word at least three times in isolation.
- interview was conducted and recorded through Zoom.
    - Note: the use of a compressed file format may skew common vowel quality and phonation measures (Decker 2016; Pena et al. 2021).
- 128 items across the 5 vowel qualities (controlled for stress)

	short	**long**
/a/	19	10
/e/	12	7
/i/	15	15
/o/	13	10
/u/	11	16

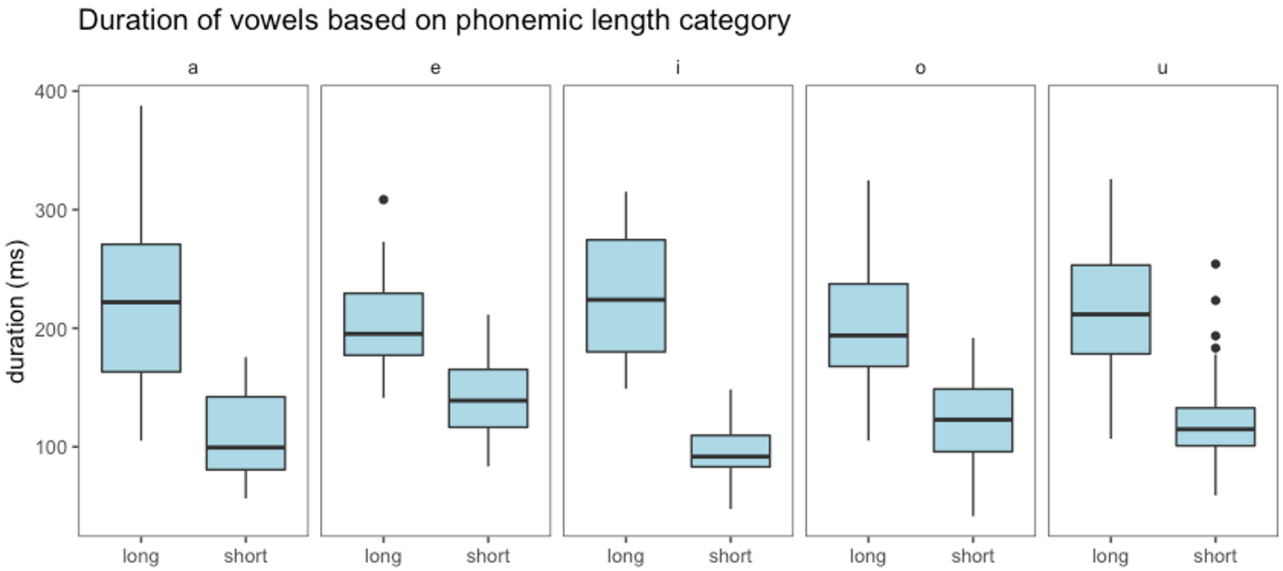
	glottalized	**modal**
/a/	9	20
/e/	7	12
/i/	10	20
/o/	5	18
/u/	15	12

Results: vowel length

Results: is vowel length phonemic?

- These results **exclude** /V?/ tokens.
- linear mixed effects models in R using the *lme4* package (Bates et al., 2015)
  - baseline model: **duration ~ vowel + OnsetPlace + CodaPlace + (1| stimulus item)**
  - Test for effect of **length** using likelihood ratio tests.
- There is a **significant effect of vowel length** (long vs. short) ($p<2.2e-16$)

Results: is vowel length phonemic?



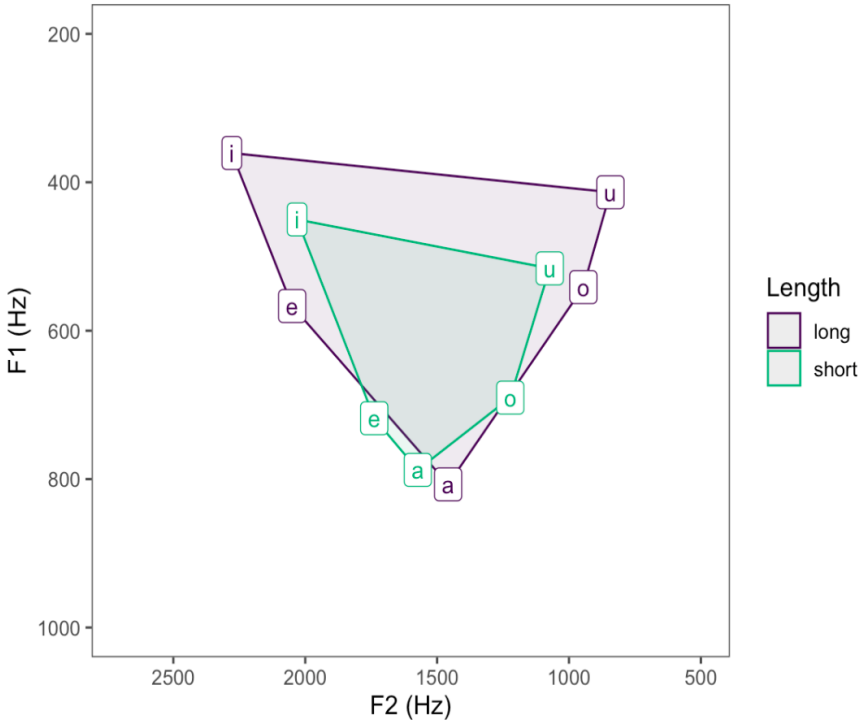
- clear length contrast across all five vowels
- more pronounced in peripheral vowels (/a/, /i/, /u/), although no significant interaction of vowel quality and length was found.

Results: is vowel quality predictable from length?

- Mixed effects models
  - 2 models (for F1 and F2 respectively)
  - DV: F1 and F2 (Hz; standard measure of vowel quality)
  - main effects of:
    - **duration** (gradient)
    - **length** (categorical, long vs. short)
    - vowel quality (categorical, /a, i, e, o, u/)
    - (Onset place, coda place)
  - interaction of vowel quality with duration and length.
- Results
  - For both F1 and F2, duration and length are non-significant
  - interaction of **length and vowel quality** is strongly significant.
  - suggests that vowel quality is predictable from **length**, and seems to be phonologized.

Results: is vowel quality predictable from length?

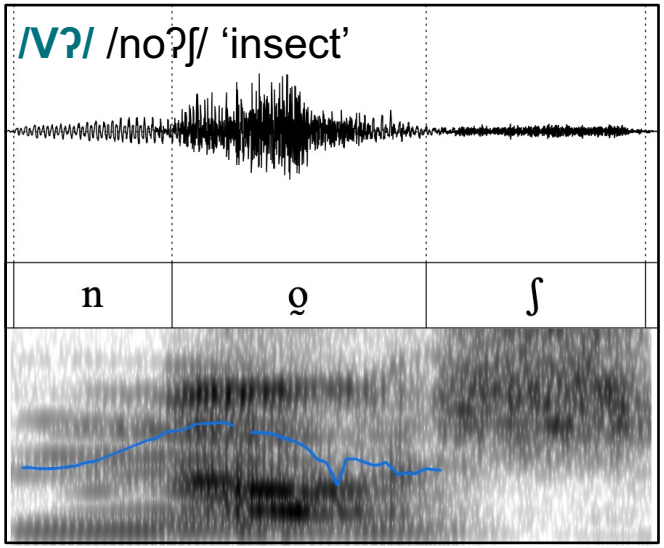
- Uniform lowering/ centralization across all vowels except /a/
- Note: /a/ not raising is unusual for a purely phonetic vowel reduction process.

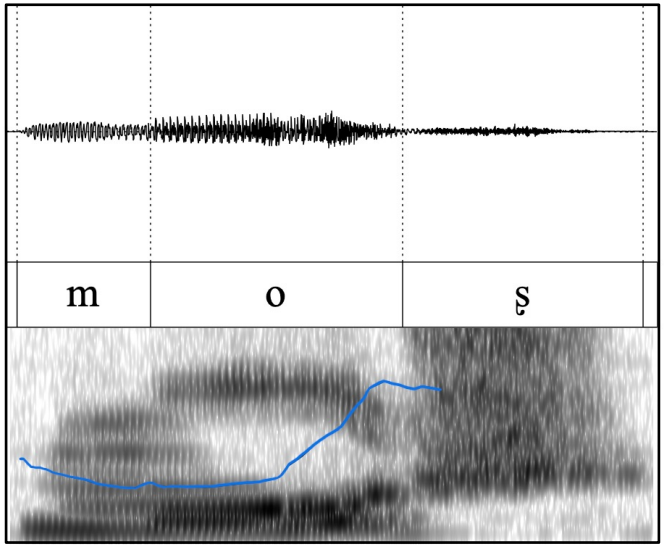


Results: realization of /VʔV/

Realization of /VʔV/

- Post-vocalic /ʔ/ seems to be realized primarily as a pitch contrast
  - /VʔV/ is falling, while /VV/ is level/rising
  - /VʔV/ also seems to be variably realized with creaky voice.



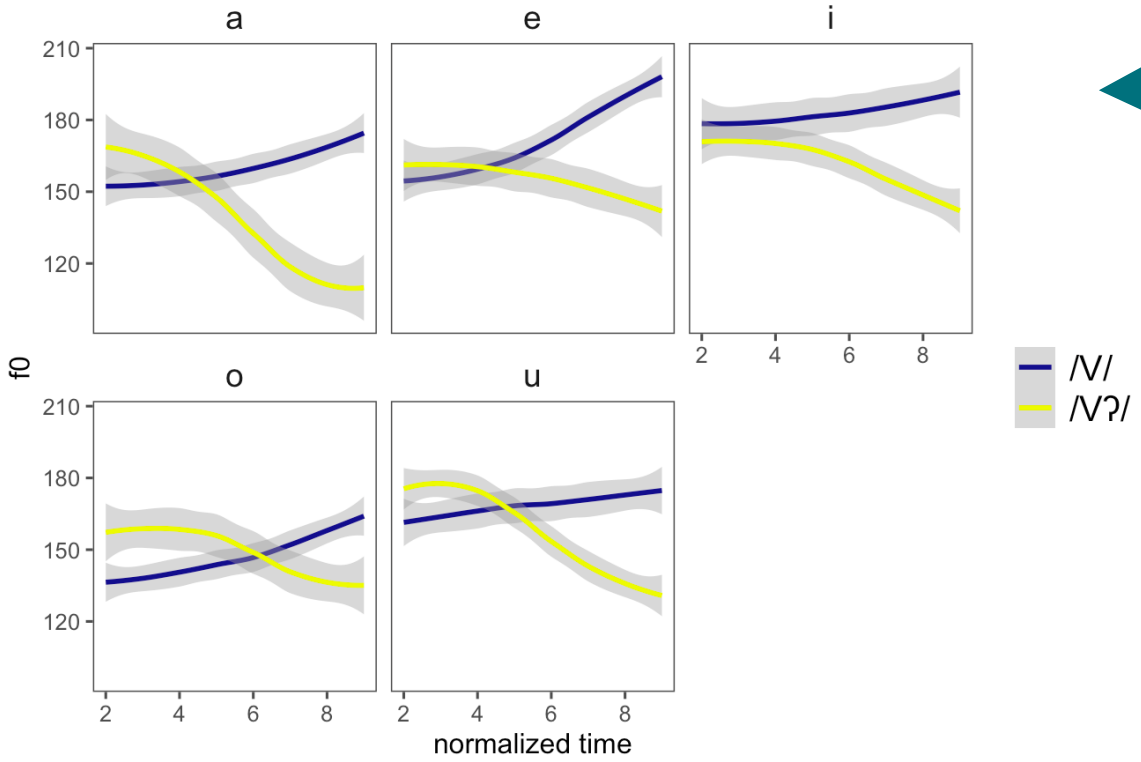


Realization of /V?/

- Measures of F0
  - across 10 normalized time points
  - T1 & T10 were omitted from analysis to minimize coarticulation and pitch tracking errors.
  - all data points where f0>300 were automatically excluded

- Voice quality
  - H1-H2 and H1-A2, at midpoint of vowel
  - Measured in Praat

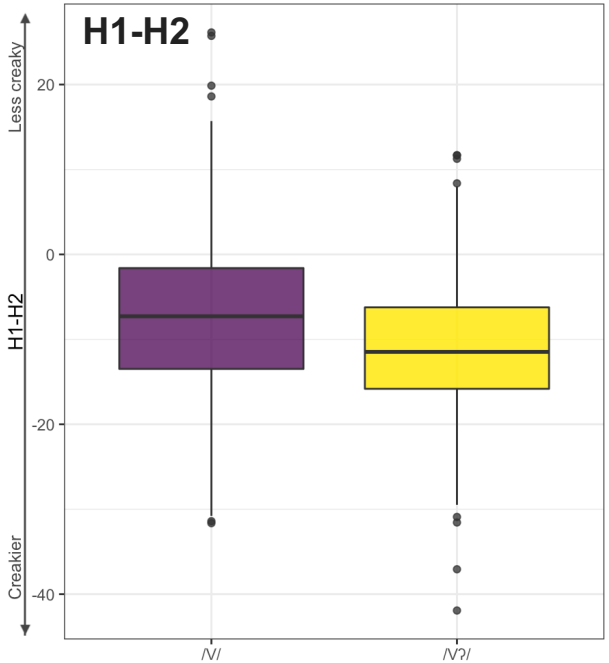
F0 of /V/ vs. /Vʔ/

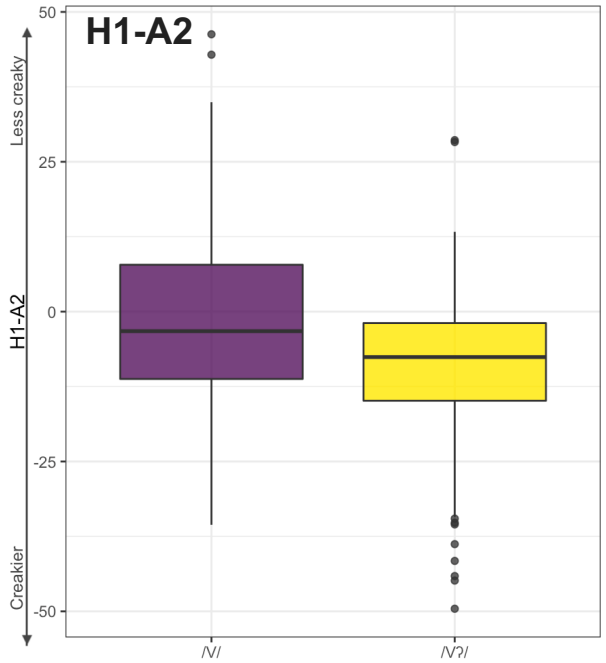


- Pitch tracks of /V/ vs. /Vʔ/, by vowel
  - contrast in pitch contour across all five vowels
  - This difference was also confirmed to be significant via SSANOVA.

Phonation measures /V/ vs. /Vʔ/

- Presence of post-vocalic /ʔ/ (**/Vʔ/** vs **/V/**) was a significant predictor of both H1-H2 ($p < 0.001$) and H1-A2 ($p < 2.23e-09$)

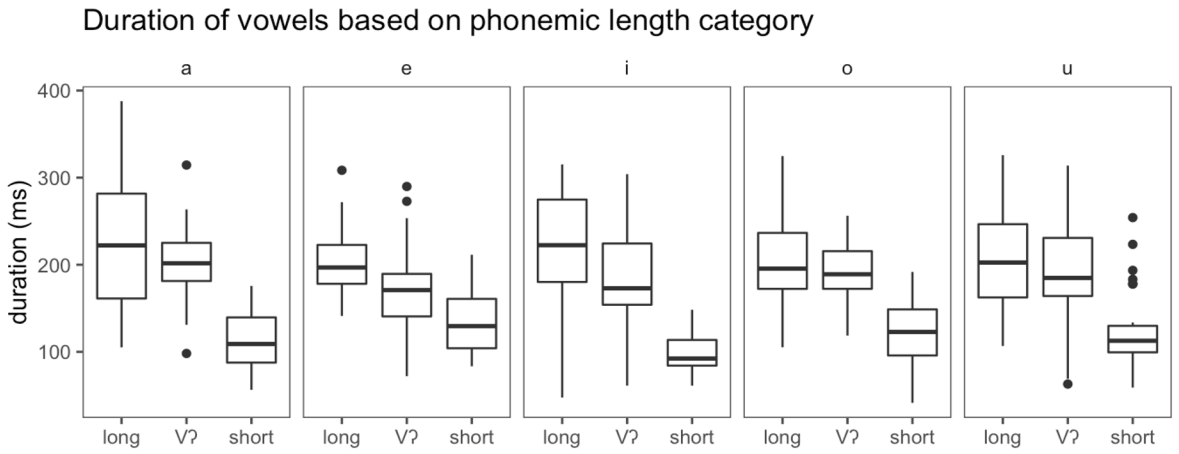




▷ tested using mixed effects models, with **vowel, onset place, & coda place** as baseline predictors, and **stimulus** as a random intercept

Results: do glottalized vowels lengthen?

- Recall: glottalized vowels are described as being lengthened
- seems to be true for **short glottalized vowels**
  - difficult to tell for long glottalized vowels because there are very few words with long glottalized vowels



Conclusion & Discussion

- Mam has a phonemic vowel length contrast, reflected in both vowel duration and quality
- Phonetic realization of /Vʔ/ is consistent with England's description:
  - lengthened
  - falling pitch, and glottalized
- Typologically unusual
  - /Vʔ/ sequences are commonly realized as short checked vowels, opposite of the lengthening effect found in Mam.
    - **Checked /Vʔ/:** Hupa (Gordon & Luna 2004), Min (Pan 2017), Ngalakgan (Baker 2008), Capanahua (Loos 1967)
    - **Lengthened /Vʔ/:** Cahuilla (Seiler 1965) and Huehuelta Tepehua (Kung 2007)

Acknowledgements

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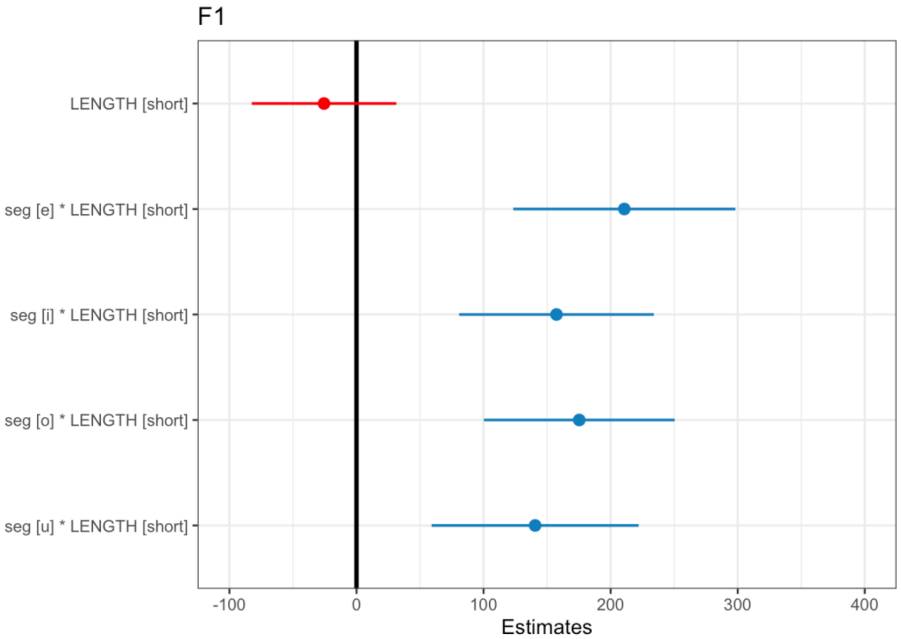
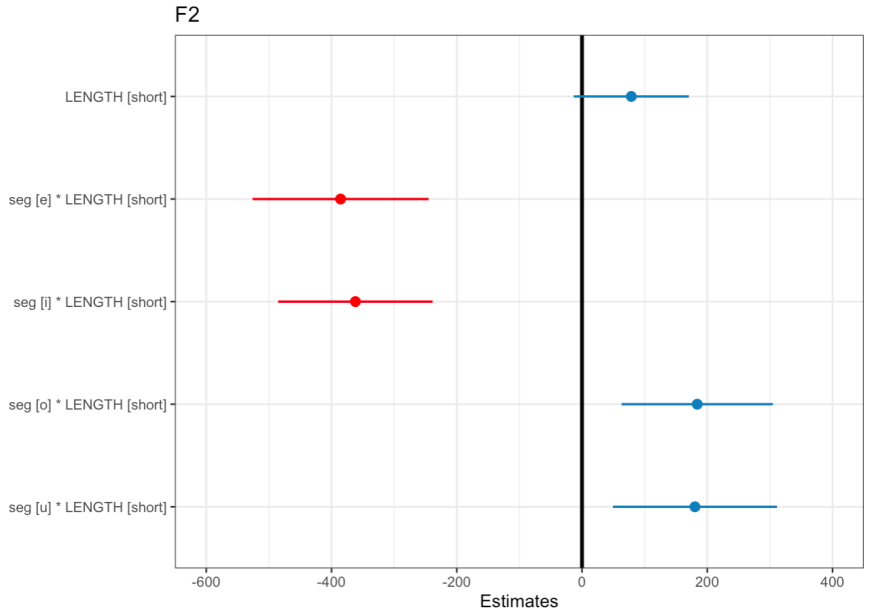
Extras

F1/F2 model results (LENGTH * vowel)





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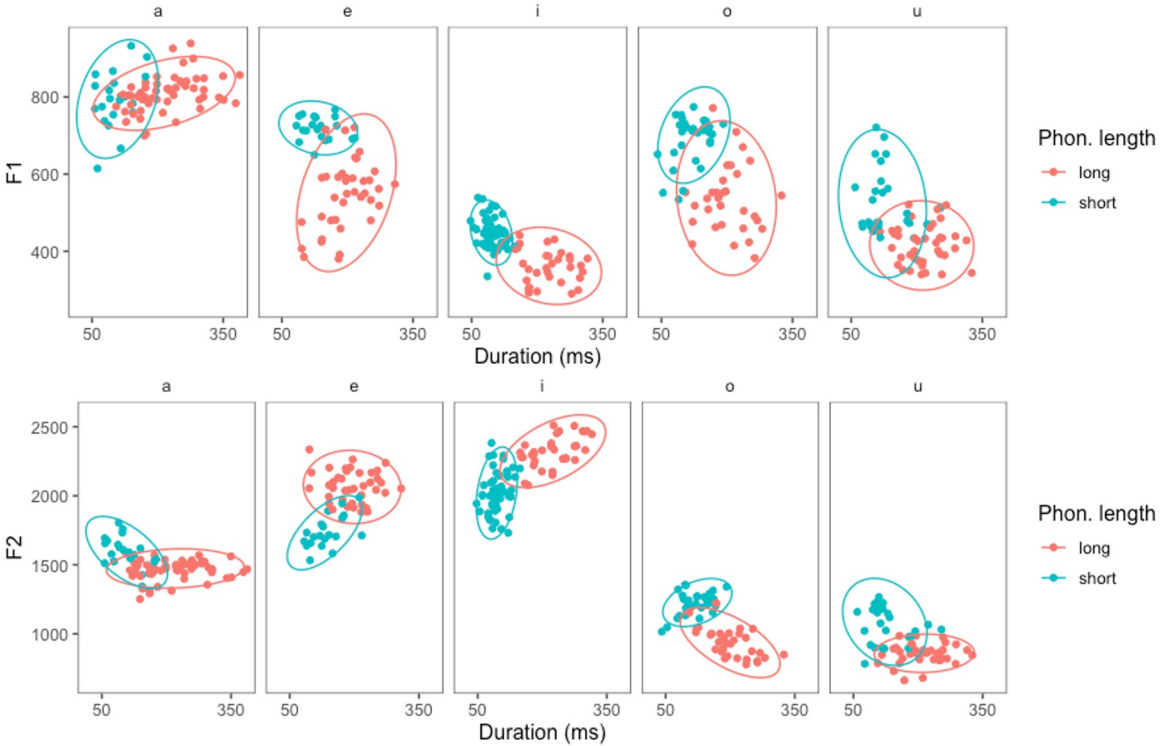
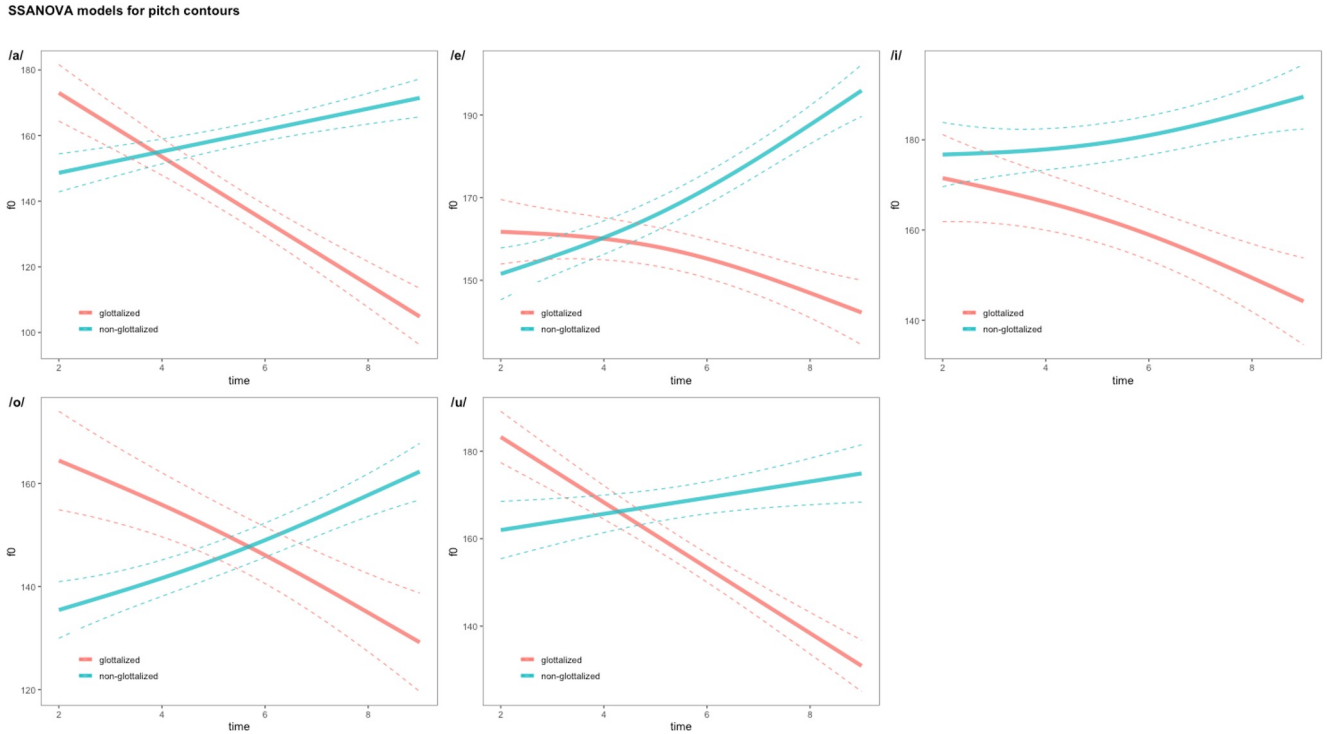


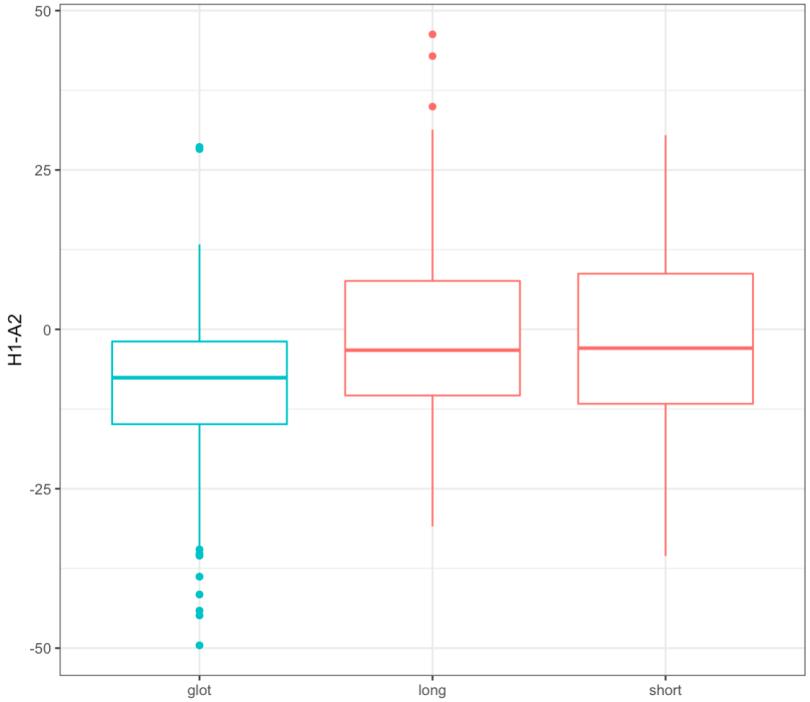
- vowel F1/F2 seems to be clustered by length category, and not just predictable by duration

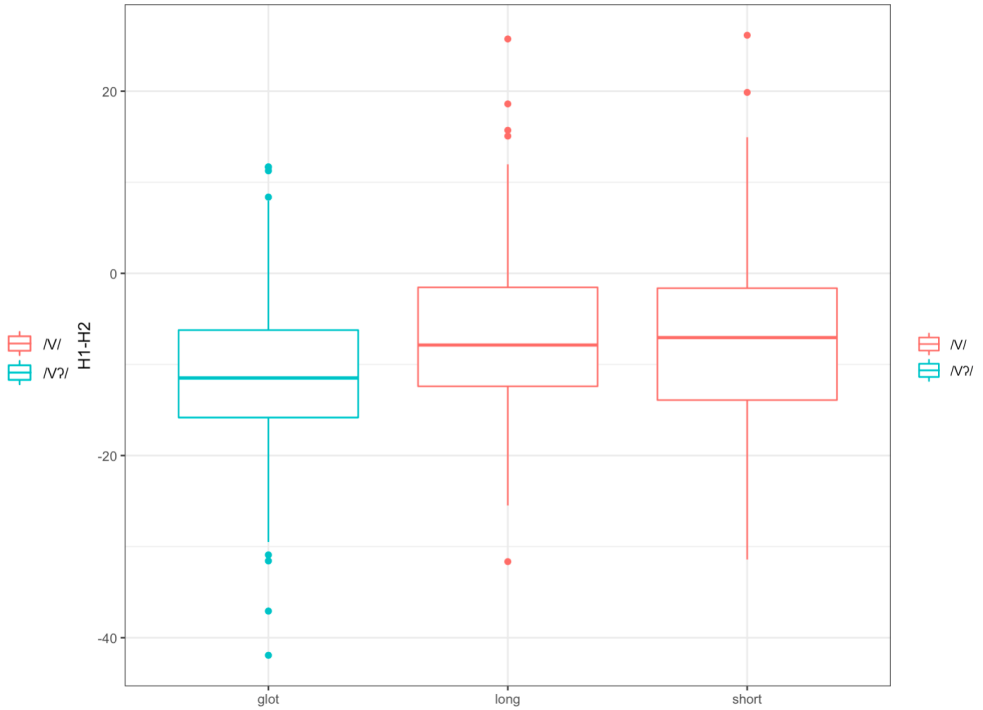
Realization of /V?/



- SSANOVA
- dotted lines show confidence interval)

Phonation measures with vowel length included





/Vʔ/ as glottalized vowel vs. full glottal stop

- /Vʔ/ sequences are only realized with falling pitch if non-final.
  - e.g. /t͡siʔɓ/ ‘writing’
- final /Vʔ/ is realized as a modal vowel followed by a full glottal stop ([ʔ] is sometimes deleted in fast speech)
  - e.g. /ʂiʔ/ ‘bug’
- suggests that glottalization is an allophonic realization of /ʔ/.