



# Pharyngealization in Two Varieties of Toussian

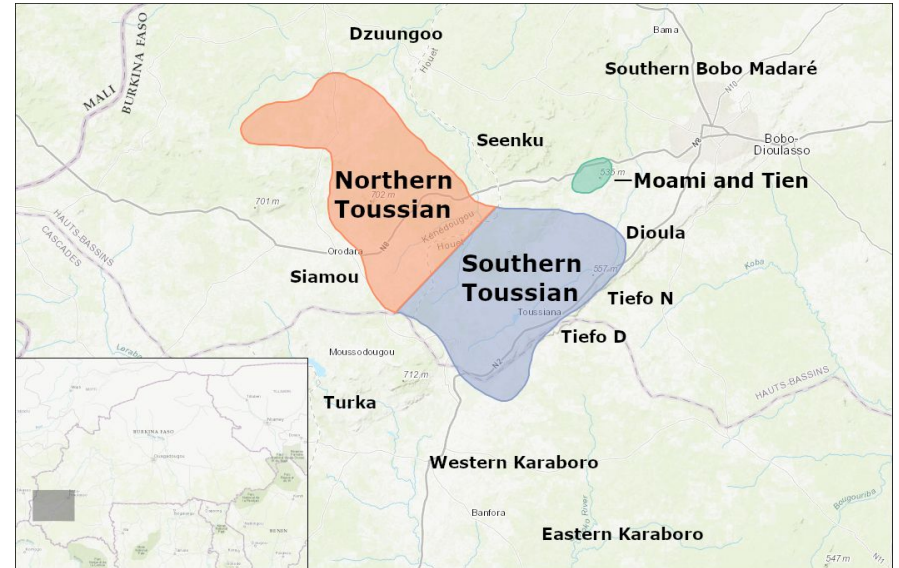
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# Toussian

- Minority languages spoken in southwest Burkina Faso
- Niger Congo, potentially Gur (Mabia)
- There are two, potentially three Toussian languages
  - Northern Toussian
  - Southern Toussian
  - A third variety spoken in Moami and Tien, either divergent dialect of ST or separate language
- Each has around 20,000 speakers (SIL 1995)





## Non-modal vowels

- In addition to modal and nasal vowels common to the region, they have a third type of vowel
  - “Glottalized vowels” (henceforth creaky) in Prost (1964)
  - “Pharyngeal vowels” by Wiesmann (reported in Winkelmann 2007) and Zaug-Coretti (2005)
  - There have been no prior phonetic studies of these vowels
- According to Prost, the creak/pharyngealization is stronger in Southern Toussian than Northern Toussian



# Aims of the study

1. Determine the phonetic properties of these vowels
  - Are they pharyngeal or creaky?
  - What acoustic correlates do these vowels have?
2. Compare the phonetic correlates across the languages
  - What makes Southern Tossian vowel perceptually 'stronger'?

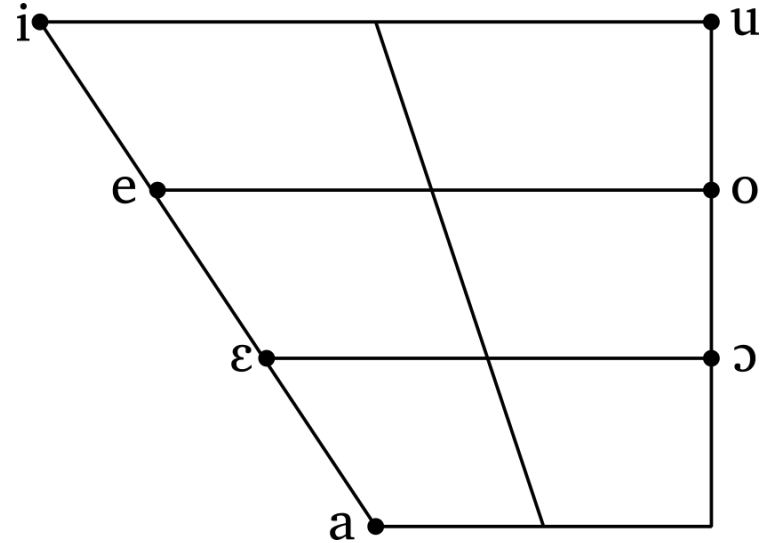


**Toussian**



## Toussian vowel system

- 8 vowel system—the vowels to the right and:
  - /ə/ in NT
  - /ɪ/ in ST
- Corresponding set of phonemic nasal vowels for the cardinal vowels











Shared vowels of Northern and Southern Toussian



# Toussian vowel system









- Non-modal vowels:
  - NT:  $a^s$ ,  $\tilde{a}^s$ ,  $\varepsilon^s$ ,  $\tilde{\varepsilon}^s$
  - ST:  $a^s$ ,  $\tilde{a}^s$ ,  $e^s$ ,  $\tilde{e}^s$ ,  $o^s$ ,  $\tilde{o}^s$
- Mid non-modal vowels are phonemic
- $[a^s]$  and  $[\tilde{a}^s]$  allophones of /a/ and /ã/
  - $[a^s]$  and  $[\tilde{a}^s]$  in open syllables, closed syllables with glide coda
  - $[a]$  and  $[\tilde{a}]$  in closed syllables with nasal or liquid coda (and  $\gamma$  in NT)

## Toussian vowel system—ST examples

<i>e</i>	<i>dê</i> 	‘enter’	<i>e˞</i>	<i>njē˞</i> 	‘cows’
<i>o</i>	<i>kǒ</i> 	‘plow (V)’	<i>o˞</i>	<i>kó˞</i> 	‘sew’
<i>a</i>	<i>dàl</i> 	‘millet beer’	<i>a˞</i>	<i>dā˞</i> 	‘shea tree’
<i>ɑ</i>	<i>jār</i> 	‘porridge (tô)’	<i>ɑ˞</i>	<i>já˞</i> 	‘four’



## Toussian vowel system—NT examples

ɛ	kɛ̃ 	'green monkey ( <i>Chlorocebus sabaeus</i> )'	ɛ˘	kɛ̃˘ 	'neighborhood'
ẽ	wjẽ̃ 	'cord'	ẽ˘	wjẽ̃˘ 	'hoe'
a	kā̃r 	'grass (sp.)'	a˘	kā̃˘ 	'surpass'
ã	jã̃r 	'nééré ( <i>Parkia biglobosa</i> )'	ã˘	jã̃˘ 	'heat up'

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# Creak and Pharyngealization



## Acoustic correlates of creak

- There are diverse creaky phonation types (Keating et al. 2015, Garellek 2019, Esposito and Khan 2020)
  - Tense/pressed, stiff, creaky, laryngealized, glottalized, aperiodic, period doubled
- In general
  - Lower pitch
    - lower  $f_0$
  - Higher noise
    - Lower harmonics to noise ratio (HNR)
    - Lower cepstral peak prominence (CPP)
  - Glottal constriction
    - Lower H1-H2/residual H1 (Chai and Garellek 2022)
      - Higher values reflect breathier vowels (this will be relevant later)

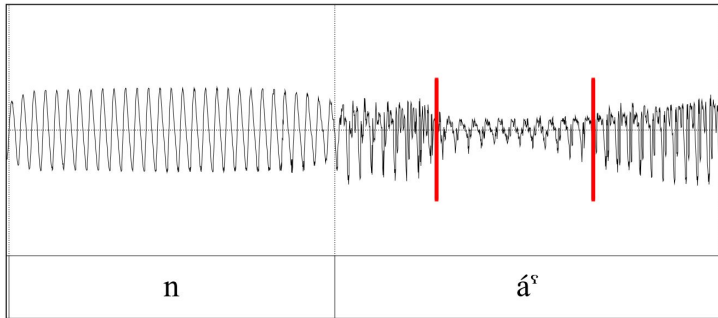


# Rearticulation

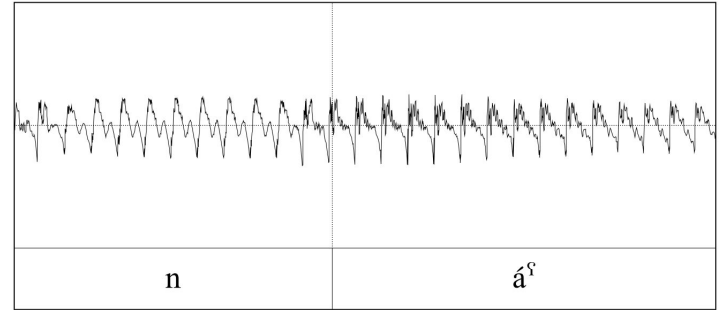
- ST non-modal vowels often exhibit some degree of rearticulation
  - Constriction during the vowel, approaching a consonantal gesture
- Not seen in NT
- Rearticulation judged by strength of excitation (SOE), measuring the strength of voicing (Chai et al. 2023)
  - Lower values reflect more rearticulation



## Visible rearticulation in waveform



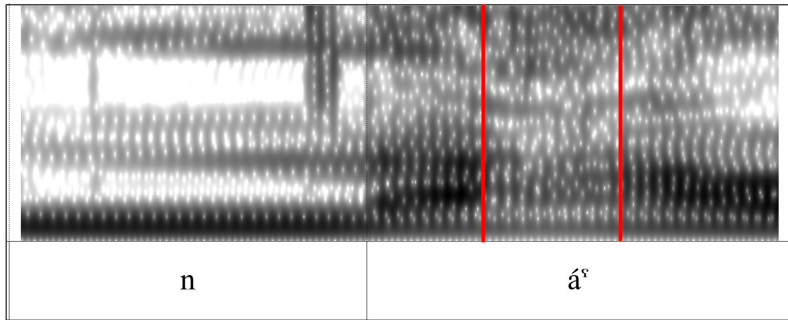
ST náʕ 'back (N)'



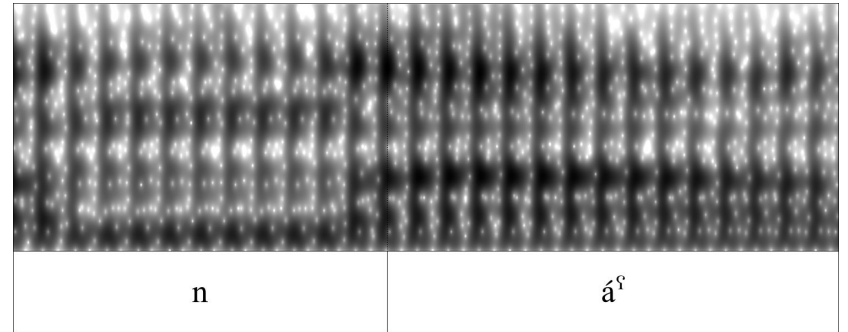
NT náʕ 'listen'



## Visible rearticulation in spectrogram



ST náʕ 'back (N)'



NT náʕ 'listen'



# Acoustic correlates to pharyngealization

- Pharyngeal vowels are produced with concomitant constriction in the pharyngeal cavity
  - Often involves lowering and retraction of the tongue
- Pharyngeal articulations are coupled with laryngeal activity (Esling 2005)
  - Raising of the larynx
  - Aryepiglottic constriction
  - This means pharyngeal and creaky vowels are expected to have overlap in articulation and acoustics
- Pharyngeal-specific correlates (Al-Tamimi 2017)
  - Raising of F1 (vowel lowering)
  - Lowering of F2 (vowel backing)
    - Though in some languages, pharyngeals centralized, e.g., Archi (Arkhipov 2015), Mundabli (Faytak 2024)
  - Changes in F3—higher for front vowels and lower for back vowels (Tamimi 2017, Chiu and Sun 2020)



## Summary of acoustic correlates

<b>Shared correlates (phonation)</b>	Lower spectral tilt	↓H1-H2/resH1
	Noisier	↓HNR/ CPP
	Reararticulation	↓SOE
<b>Pharyngealization-specific correlates (formant differences)</b>	Lower vowel	↑F1
	Retraction or centralization	R: ↓F2 C: ↓F2 for front vowels ↑F2 for back vowels
	F3 changes	↑F3 for front vowels, ↓F3 for back vowels



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# The study



# Methods and data

- Wordlist built to elicit all vowels
  - NT words selected from personal research
  - ST words chosen from published ST dictionary (Barro et al. 2004)
- Words placed phrase-medially in carrier phrase
- Data from five speakers
  - Two NT speakers from Djigouera
  - Three ST speakers
    - One from Wempéa
    - Two from Toussiana



## Methods and data

- Acoustic measurements made with VoiceSauce (Shue et al. 2011)
  - Measurements output every millisecond
  - For each token, averaged over the middle third of these measurements
- All measurements were standardized by speaker
- F1 and F2 outliers omitted by Mahalanobis distance (e.g., Riverin-Coutlée et al. 2023), F0 outliers also excluded
- Only oral vowels considered in this study due to difficulties collecting accurate measurements of nasal vowels



## Research question 1: are these vowels truly pharyngeals?

- If yes, we expect:
  - Formant differences from modal vowels
    - Higher F1
    - Lower F2
    - Differences in F3 (depending on vowel frontness)
  - Phonation differences from modal vowels
    - Lower HNR, CPP, residual H1\*
- If creaky but not pharyngeal:
  - Phonation changes without formant changes



## Research question 2: what makes ST vowels 'stronger'?

- Hypothesis 1: ST has the same acoustic correlates to creak/pharyngealization as NT and only contrast in their magnitude
  - Difference in magnitude of acoustic correlates to creak/pharyngealization between creaky/pharyngeal vowels and modal vowels is greater in ST than NT
- Hypothesis 2: creaky/pharyngeal vowels in ST and NT have different acoustic correlates

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# Results

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# Southern Toussian

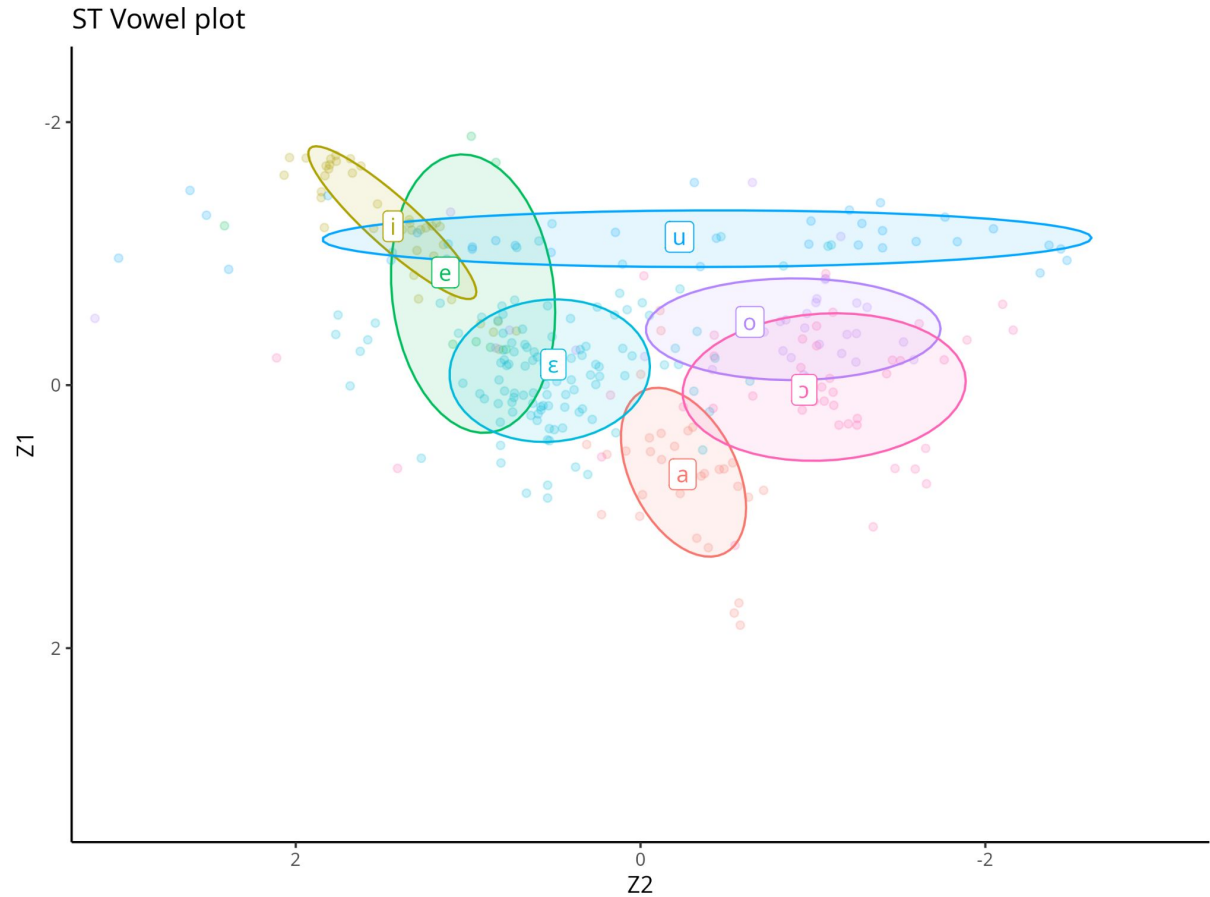


## One issue

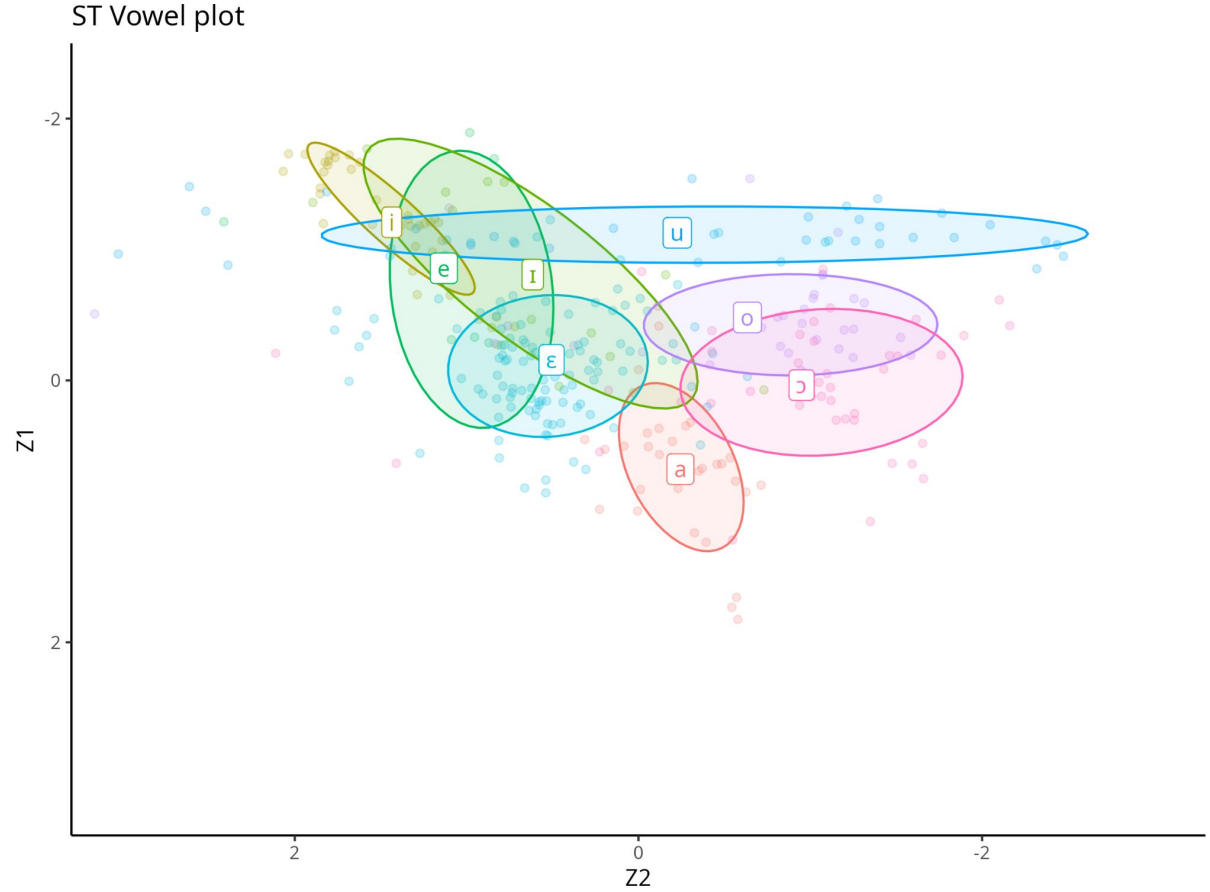
- There were few words with  $e^{\zeta}$  and  $o^{\zeta}$  in Wiesmann et al. (2004)'s dictionary
  - There are few tokens in the dataset, reducing statistical power
  - Because of this, there are some promising trends we see that are not statistically significant



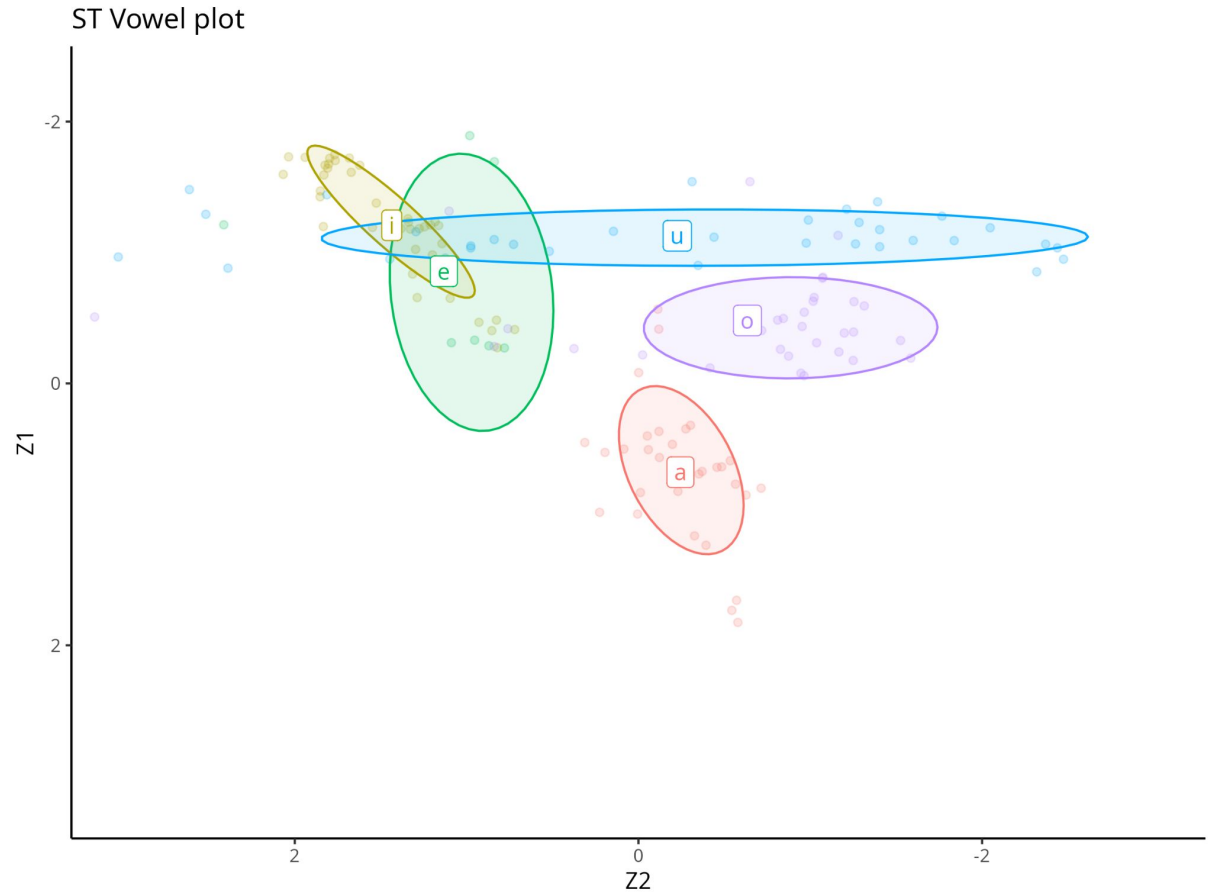
# Formant differences



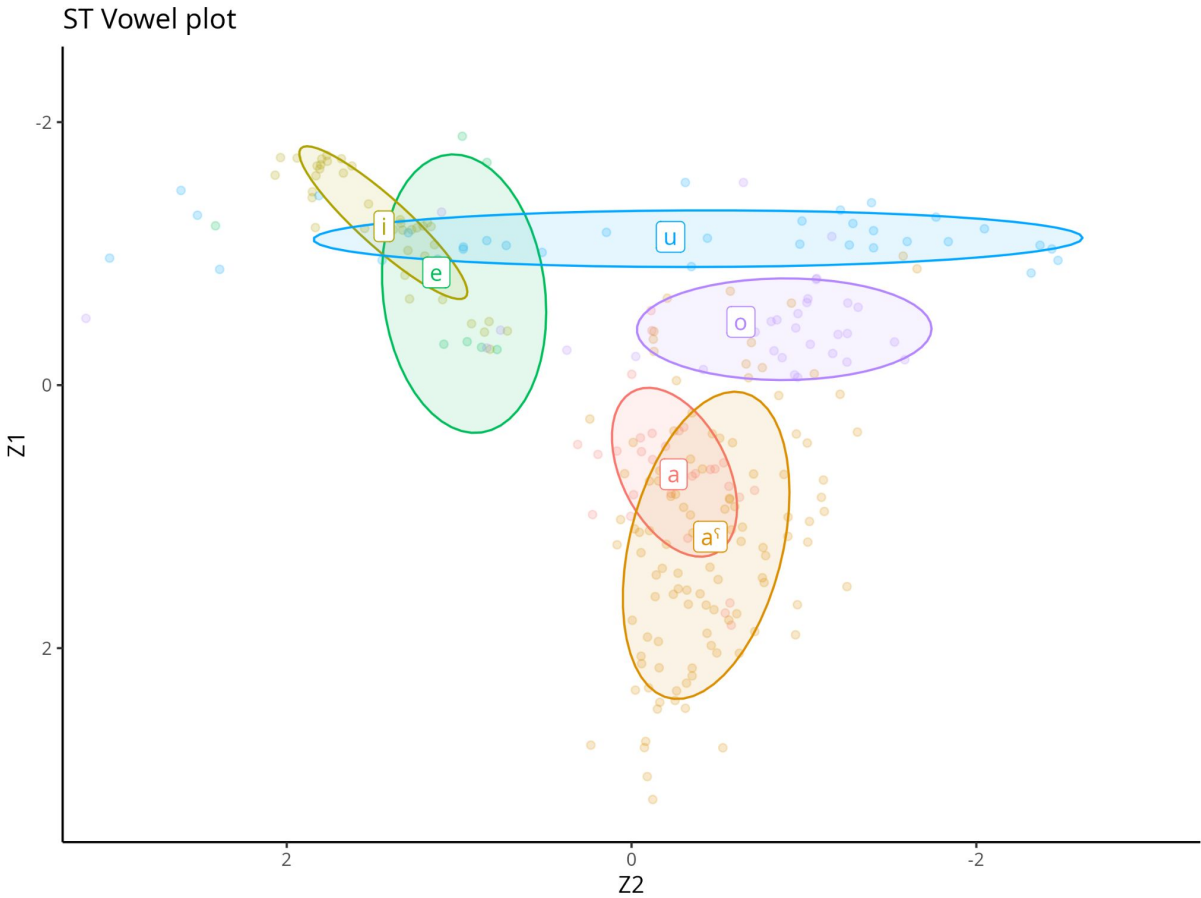
# Formant differences



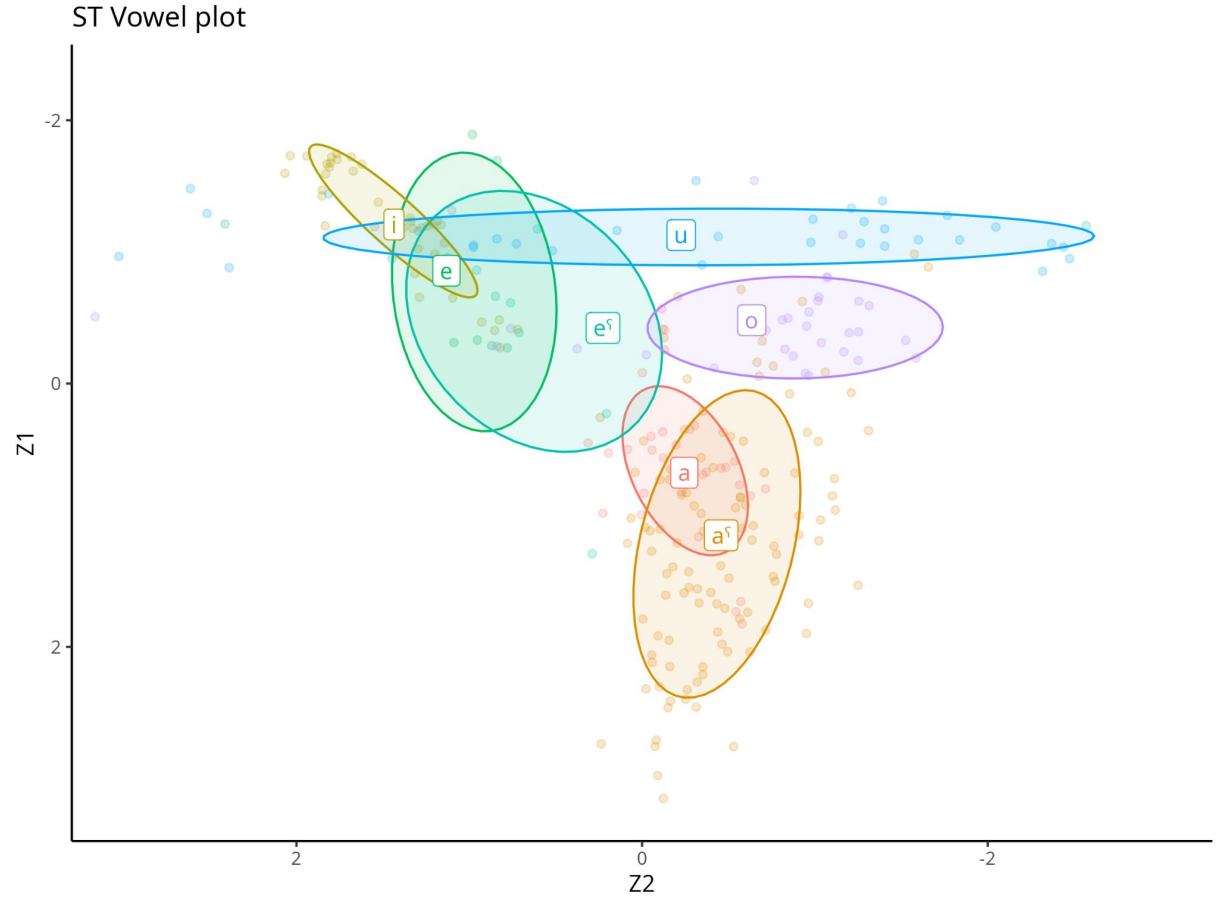
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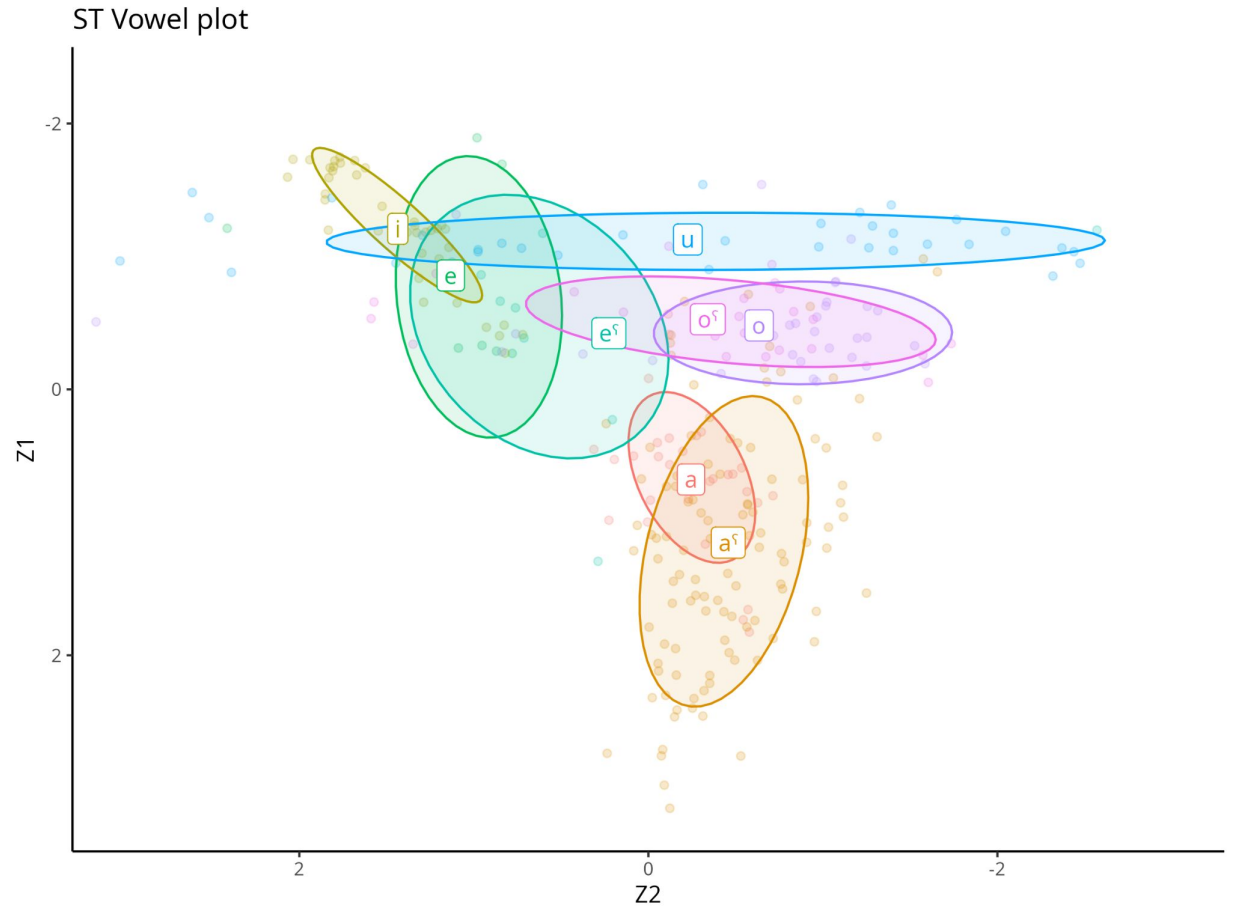
# Formant differences



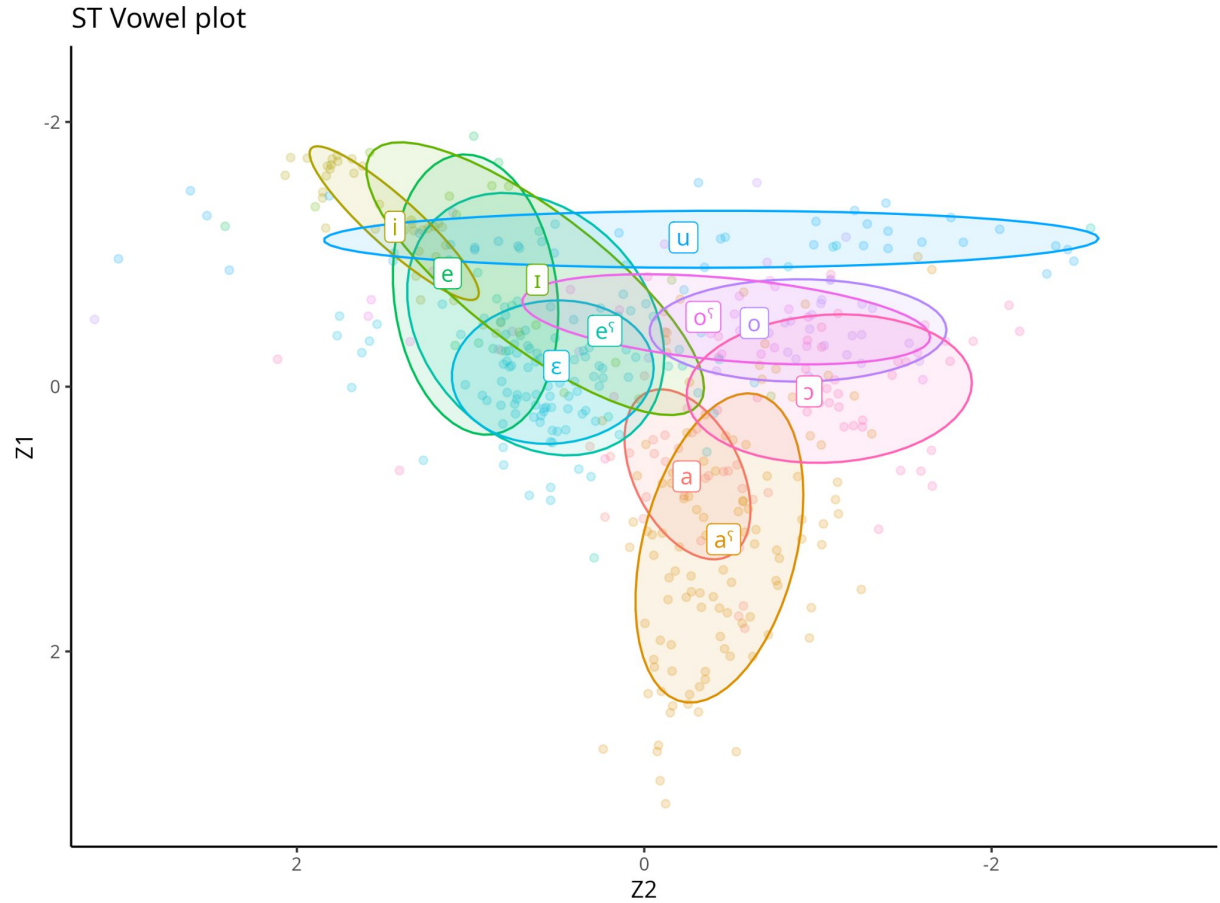
# Formant differences



# Formant differences



# Formant differences

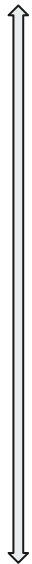


# ST F1

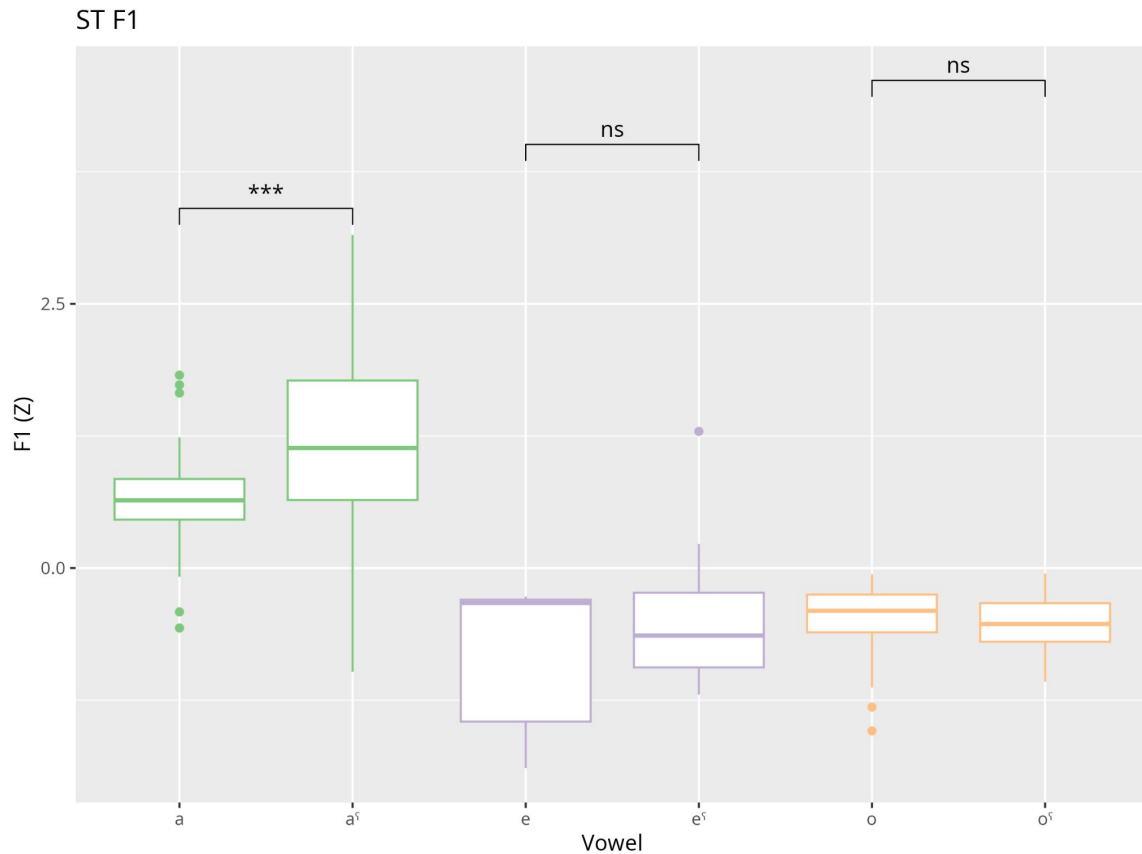


- Pharyngeal  $a^{\text{f}}$  higher F1 (lower)
- $e^{\text{f}}$  and  $o^{\text{f}}$  same F1 (height) as modal vowels

Lower vowel



Higher vowel





# ST F2

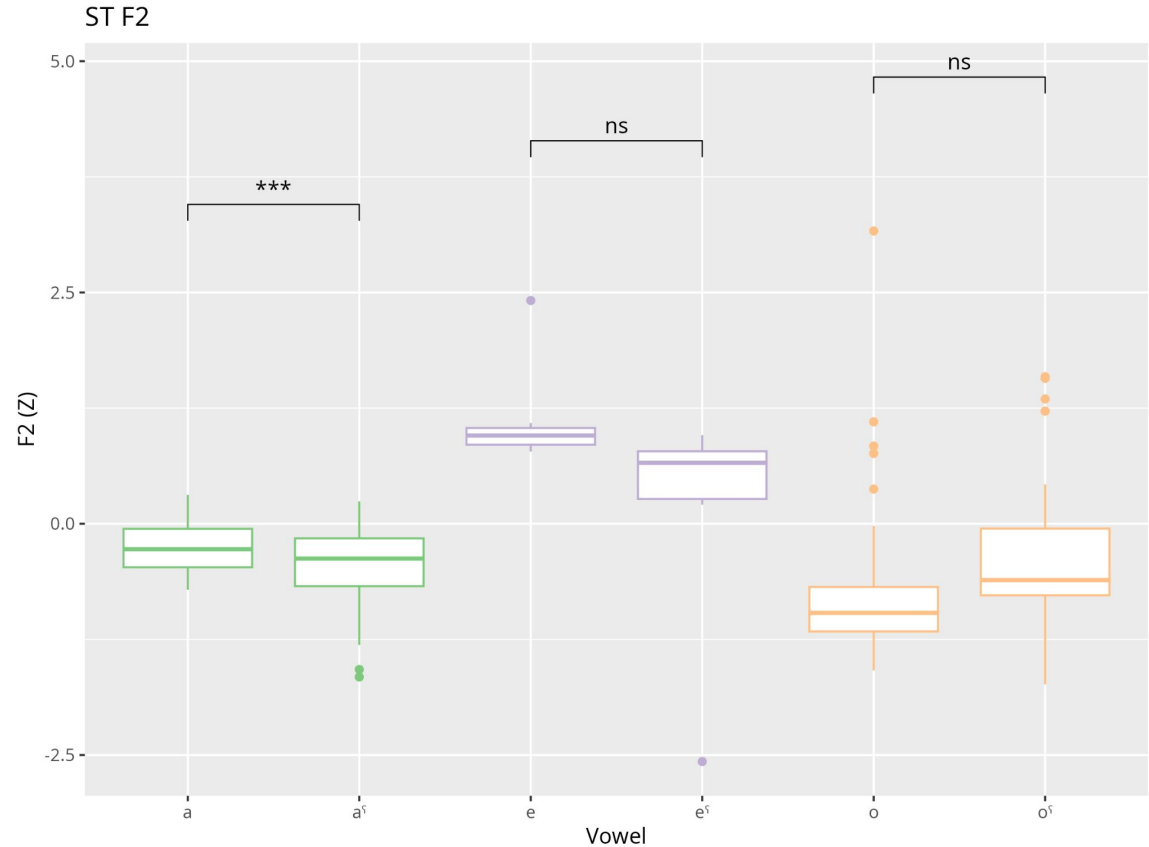


- $a^f$  has lower F2 (backer)
- $e^f$  has lower F2 (backer)
  - Not significant
- $o^f$  higher F2 (fronter)
  - Not significant
- A trend towards centralization of mid vowels

Fronter vowel



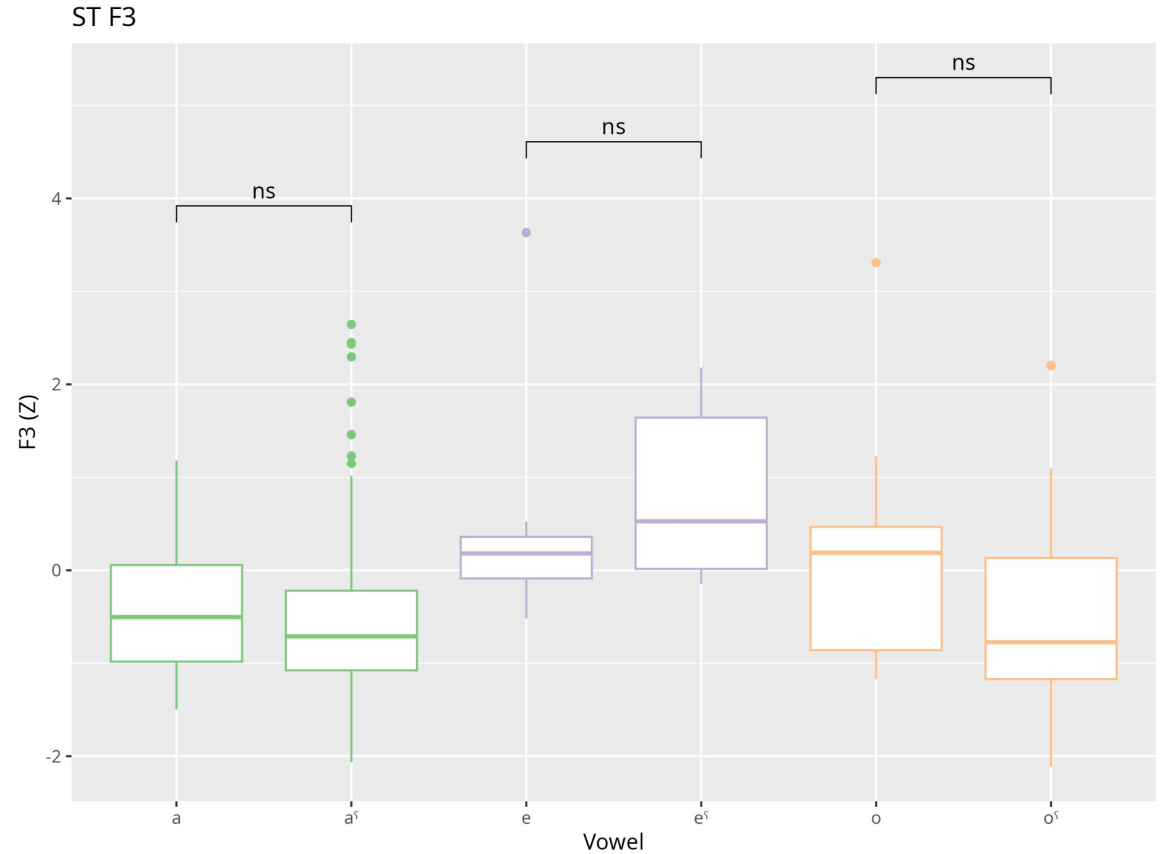
Backer vowel



# ST F3



- F3 higher for front vowels (not significant)
- F3 lower for back vowels (not significant)
- A trend expected for pharyngeal vowels

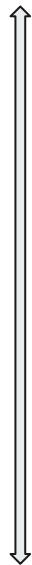


# ST HNR05

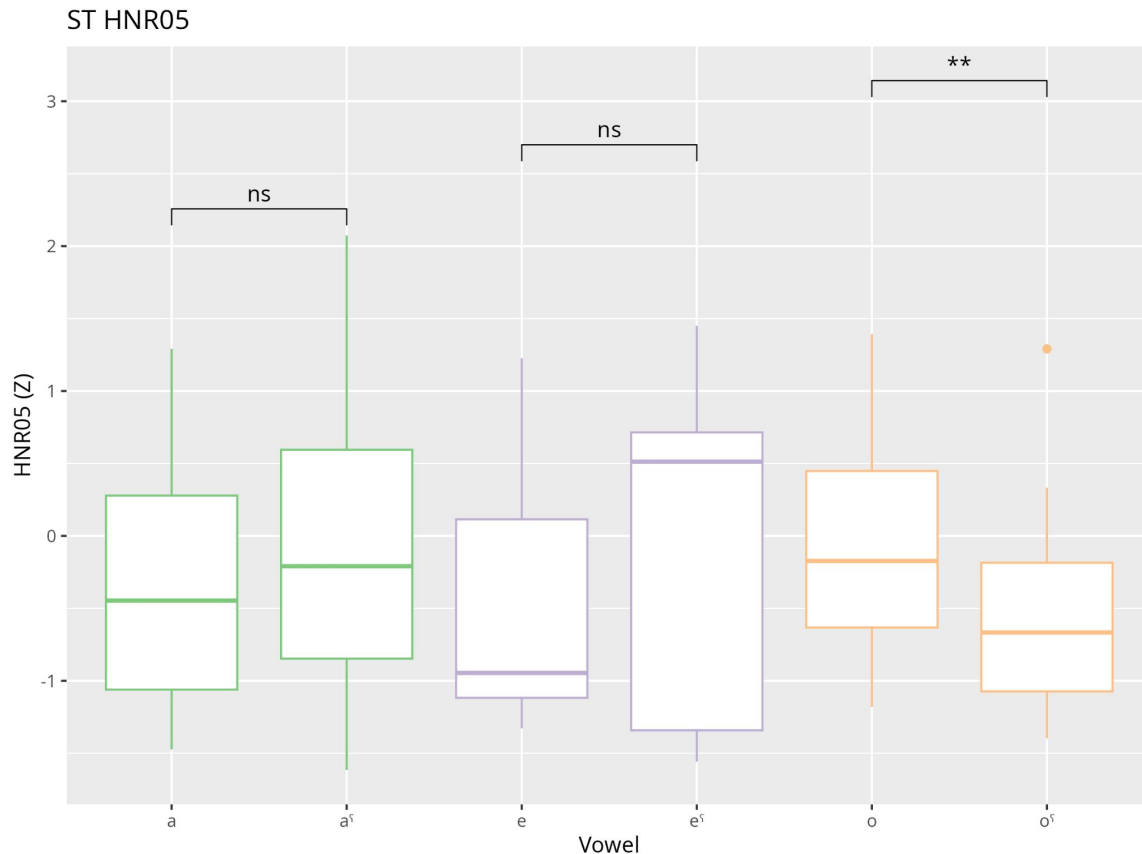


- $o^f$  has lower HNR05 (noisier)
  - Other vowels appear to have higher HNR05
- not significant

Less noise



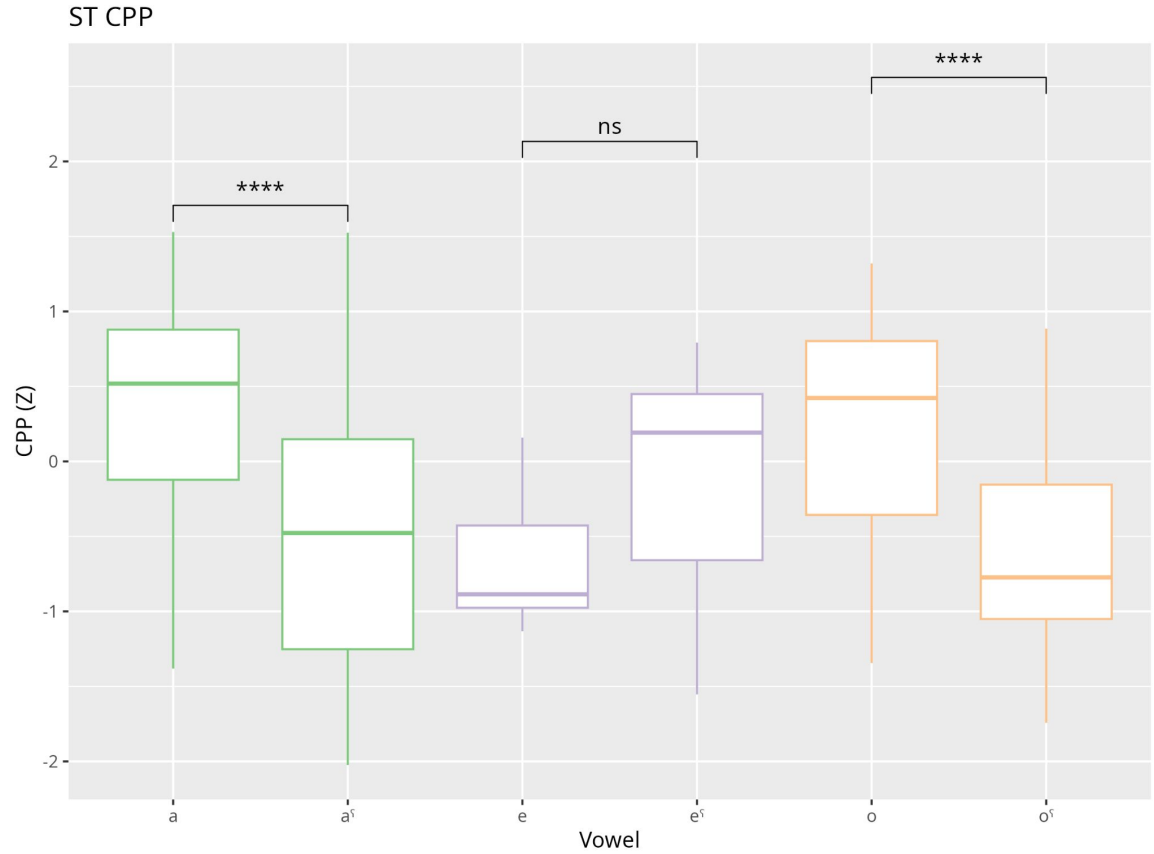
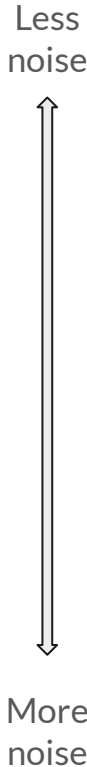
More noise



# ST CPP

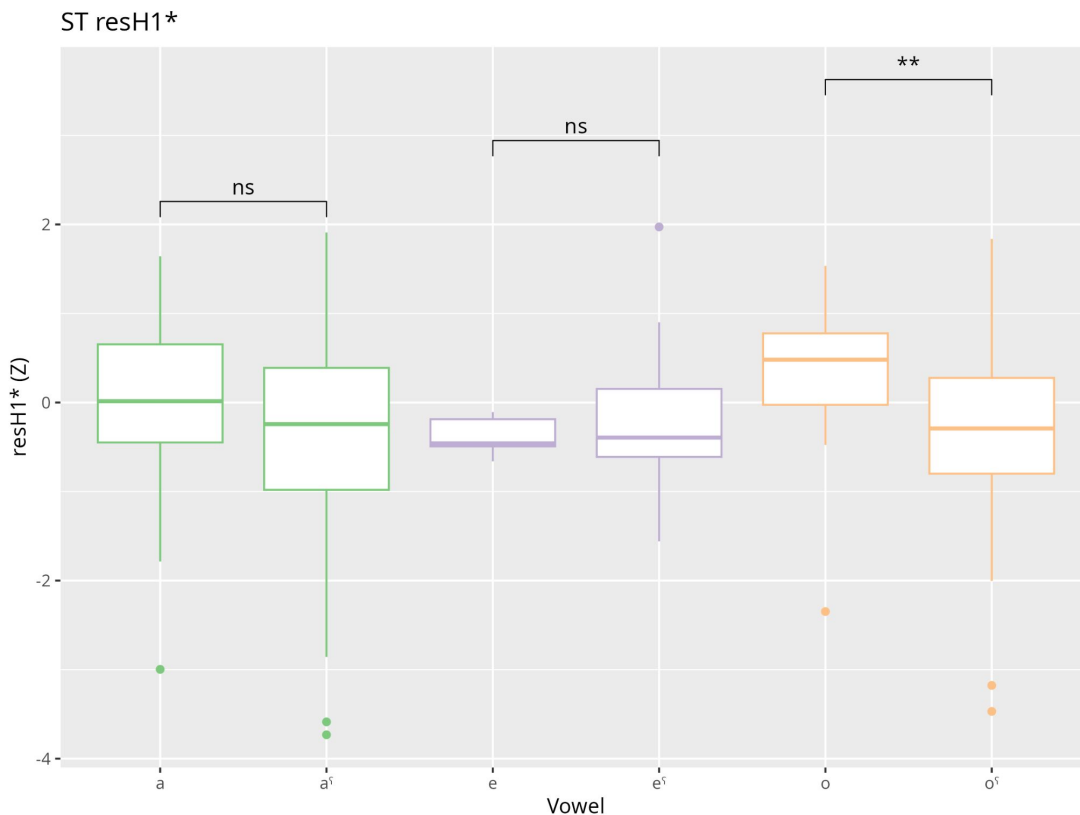
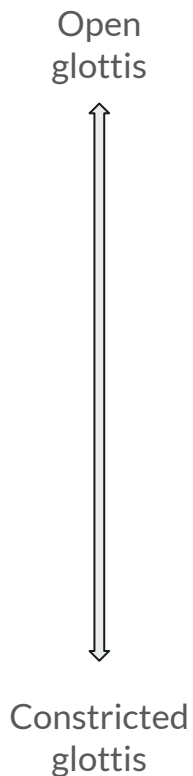


- Lower CPP (noisier)



# ST ResH1\*

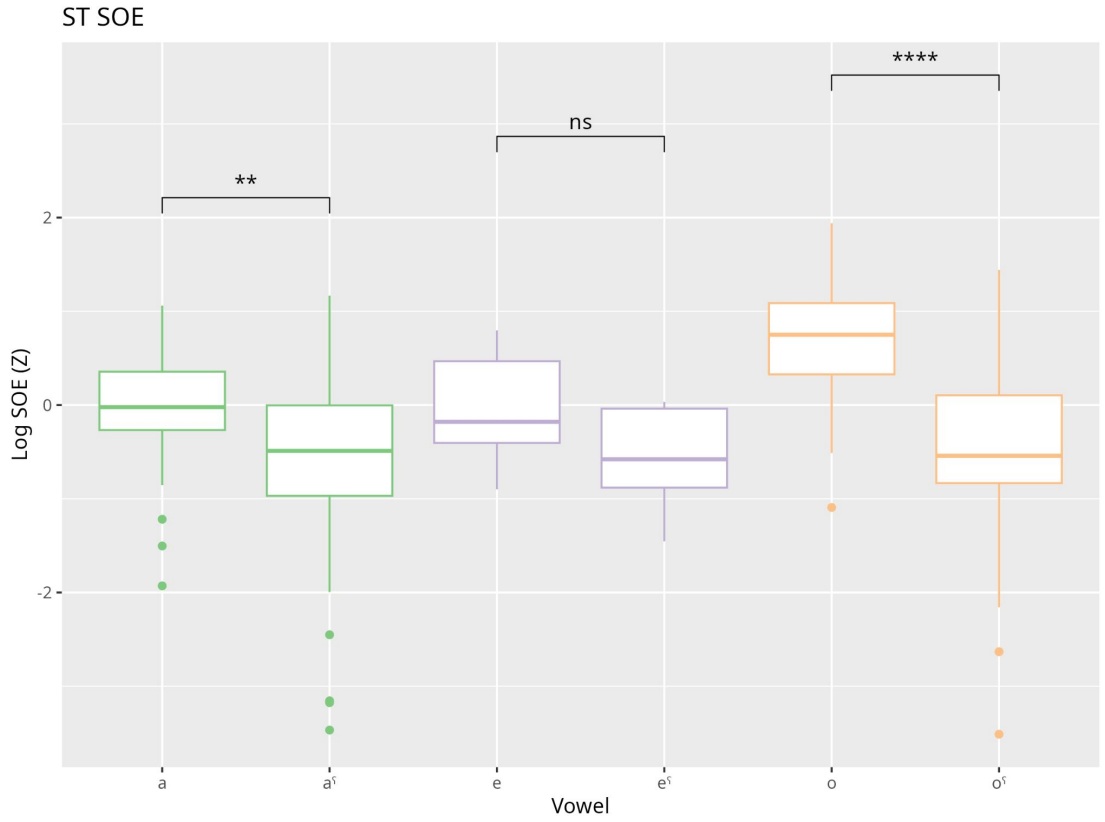
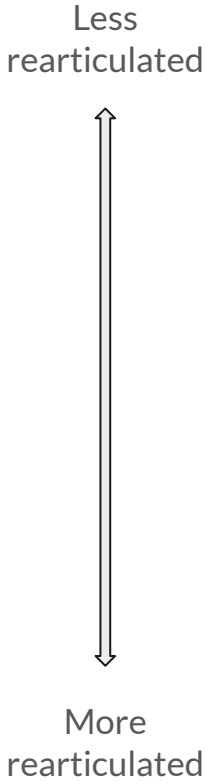
- $o^{\text{r}}$  has lower resH1\* (which, together with noise, suggests more creak)
- Not significant for other qualities



# ST SOE



- Lower SOE (more rearticulated)





## ST Summary

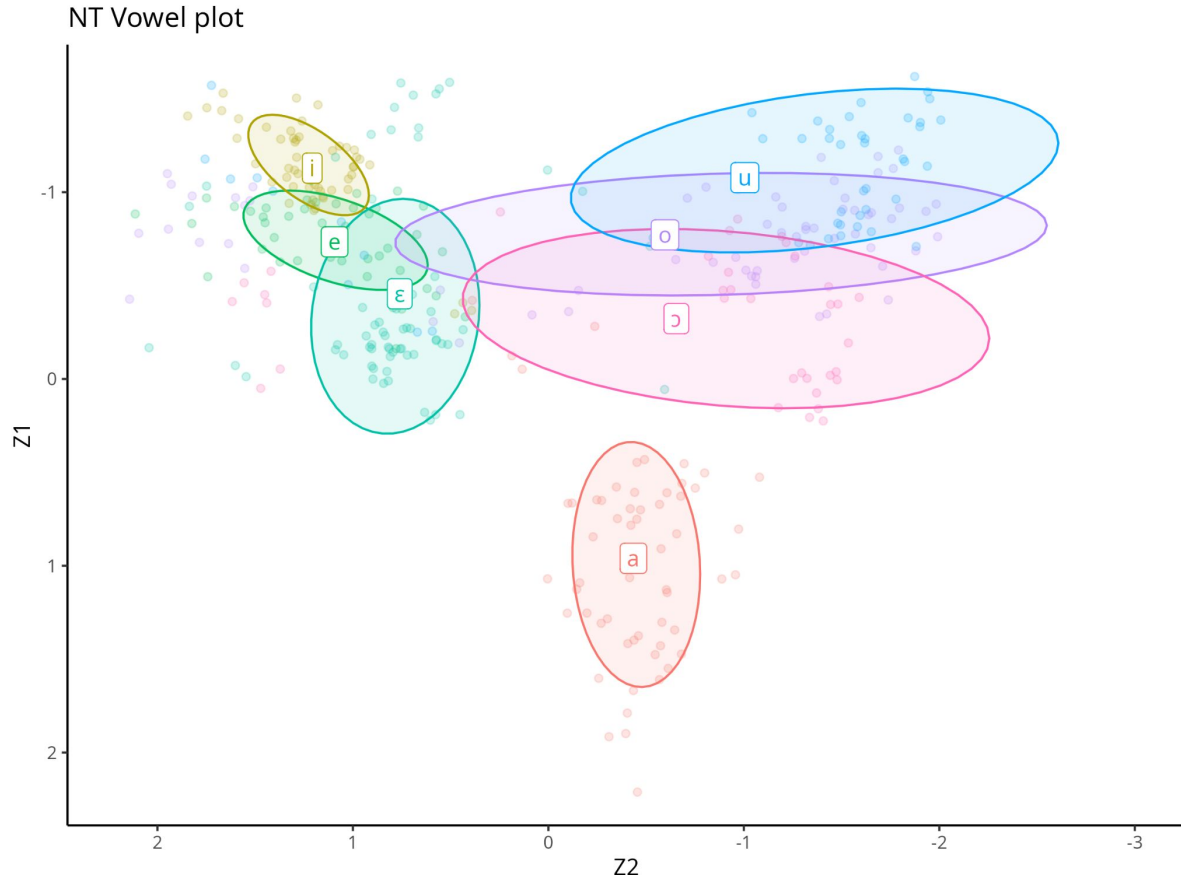
- Non-modal vowels characterized by:
  - More noise (lower CPP and HNR05)
  - More creak (lower resH1\* + lower CPP and HNR05)
  - Retraction and lower of  $a^{\text{r}}$  (higher F1 + lower F2)
  - Rearticulation (lower SOE)
- Promising—but not significant—trends:
  - Centralization of mid vowels
  - Raising of F3 for front vowels and lowering of F3 for back vowels

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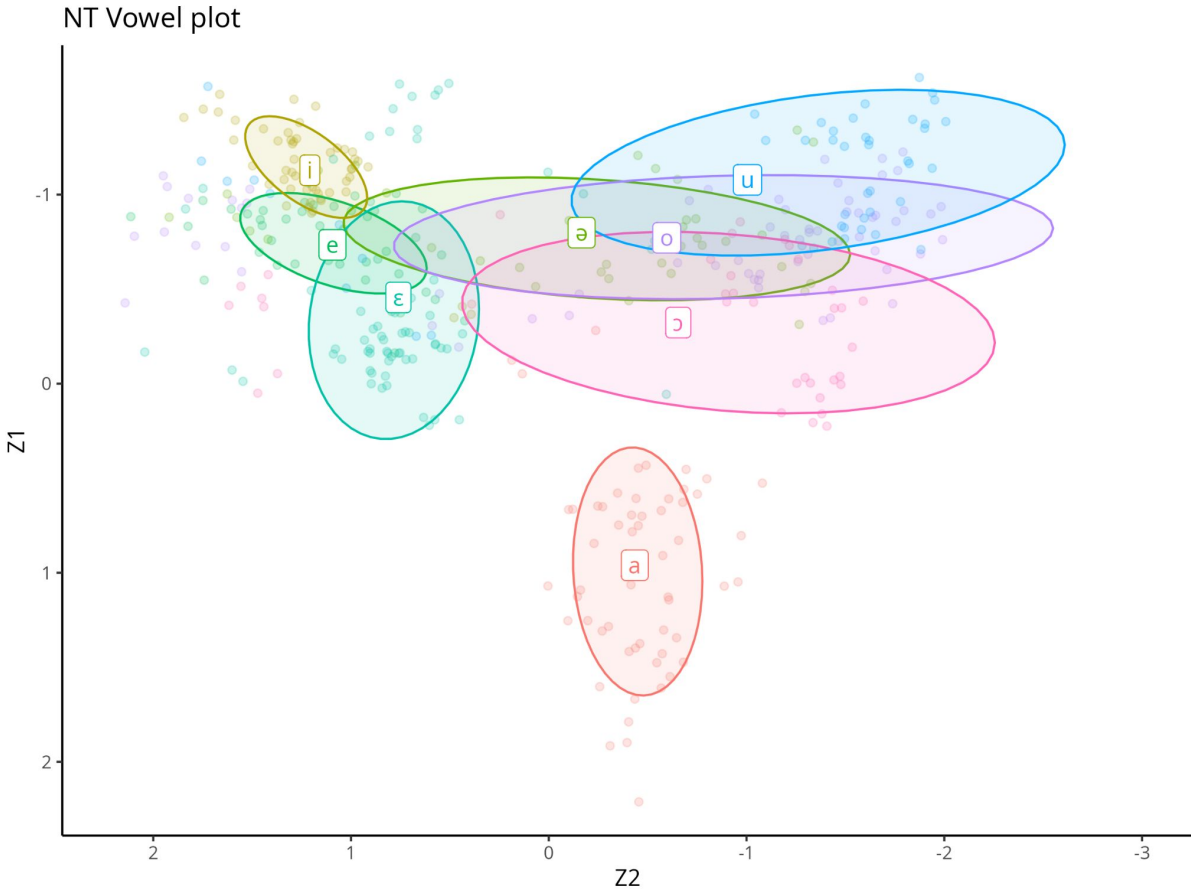
# Northern Toussian



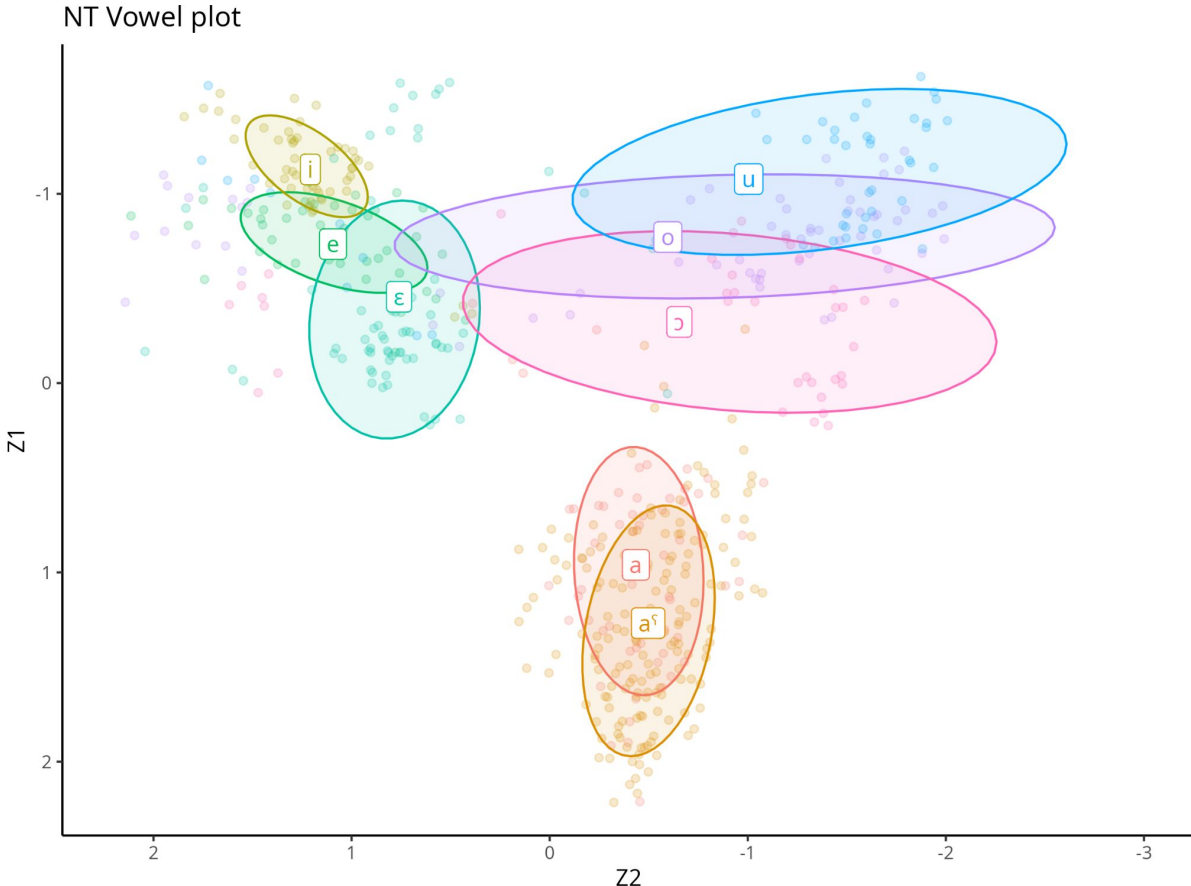
# Formant differences



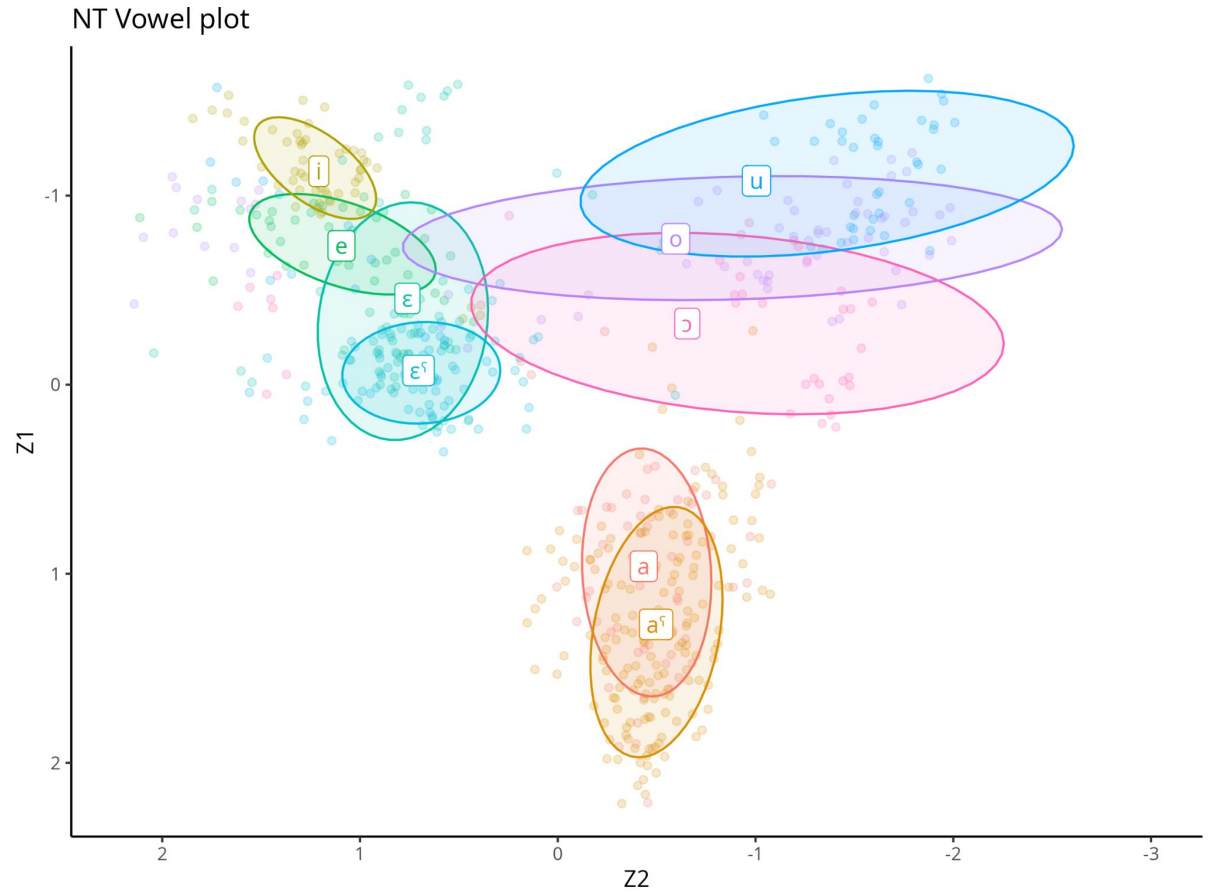
# Formant differences



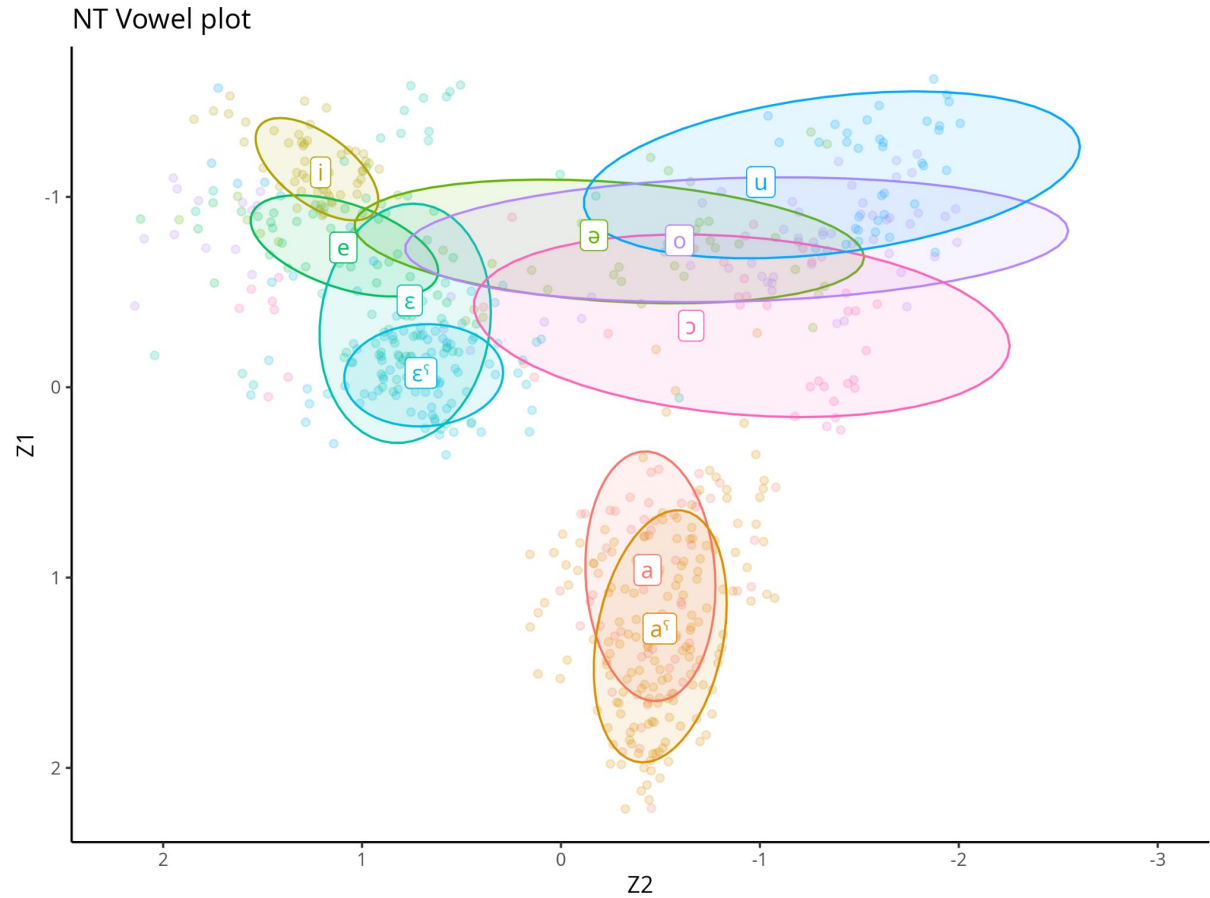
# Formant differences



# Formant differences



# Formant differences



# NT F1

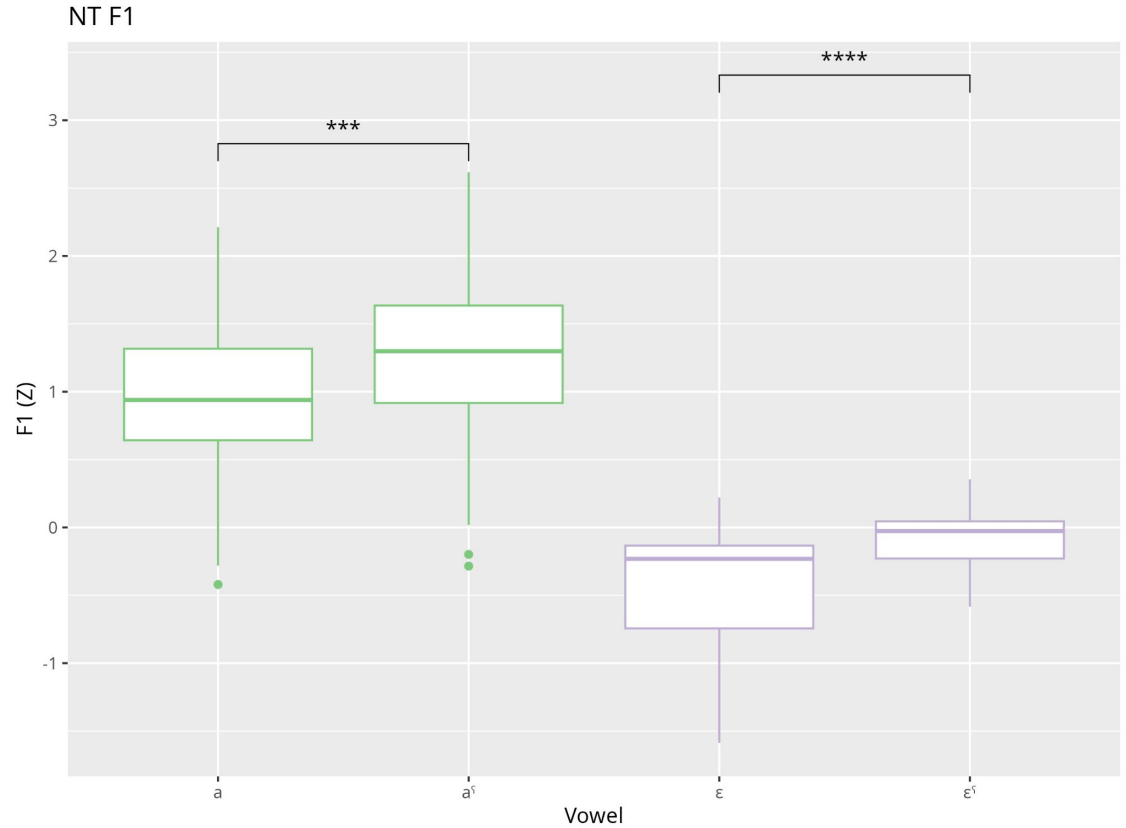


- Non-modal vowels have higher F1 (lower)

Lower vowel



Higher vowel



# NT F2

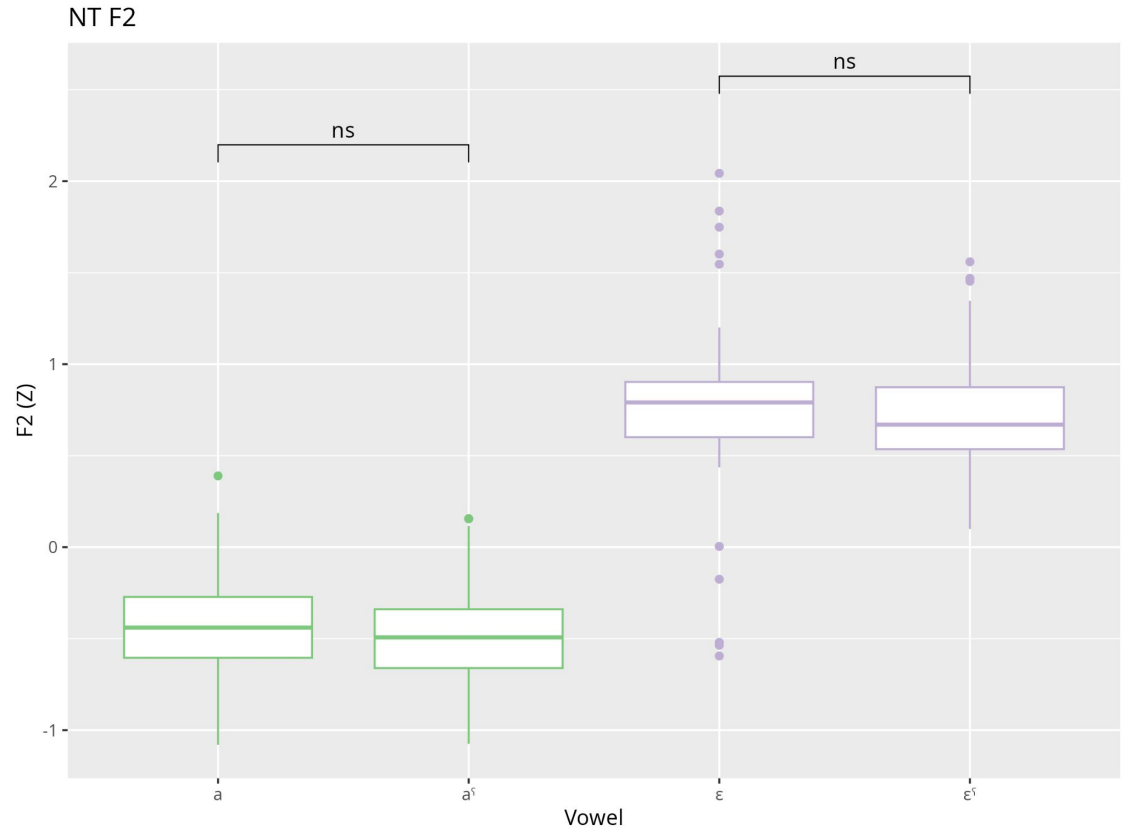


- No difference in backness

Fronter vowel



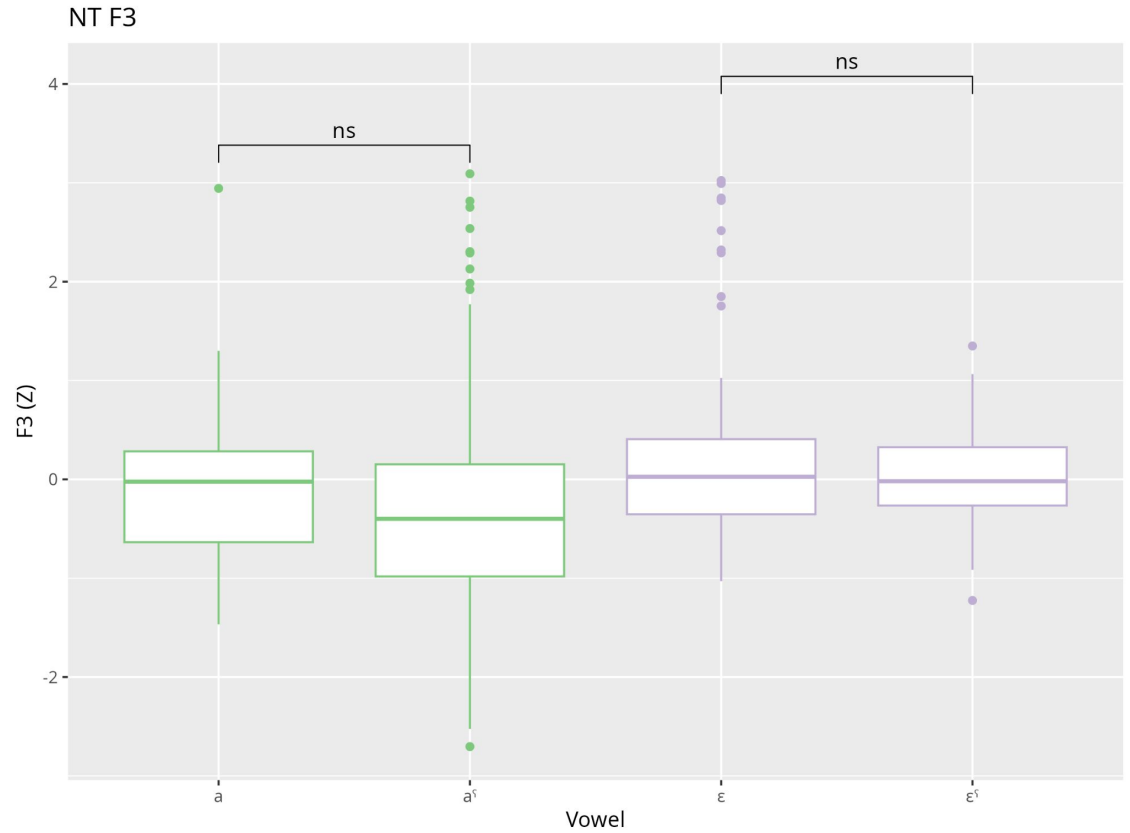
Backer vowel



# NT F3



- No difference in F3





# NT HNR05

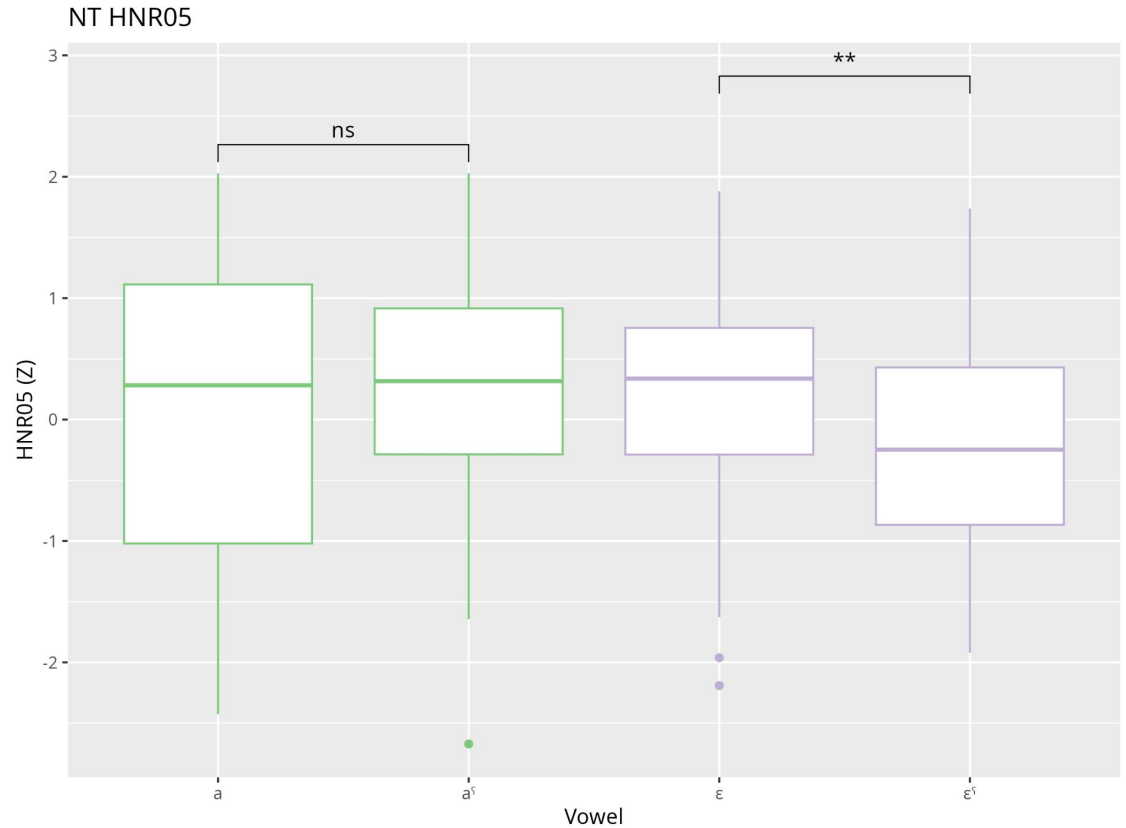


- $\varepsilon^f$  has lower HNR05 (more noise)
- No significant difference between  $a^f$  and  $a$

Less noise



More noise



# NT CPP

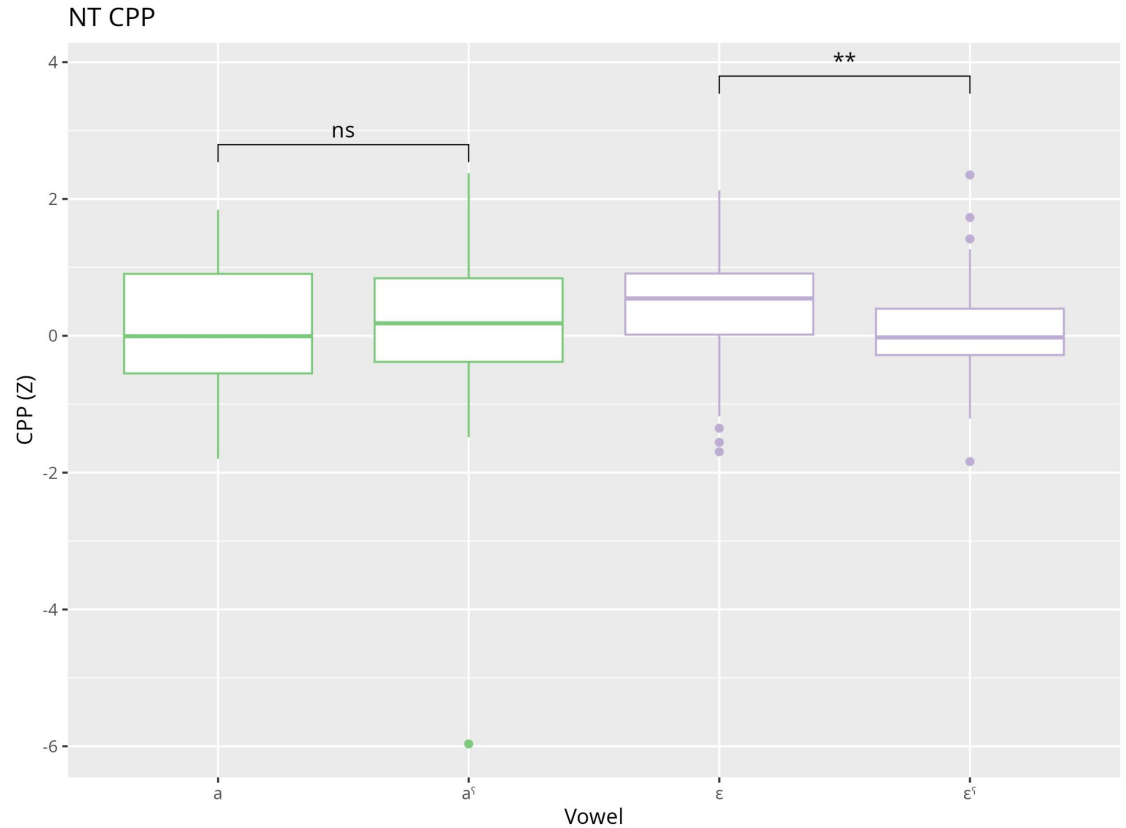


- $\varepsilon^f$  has lower CPP (more noise)
- No significant difference between  $a^f$  and  $a$

Less noise



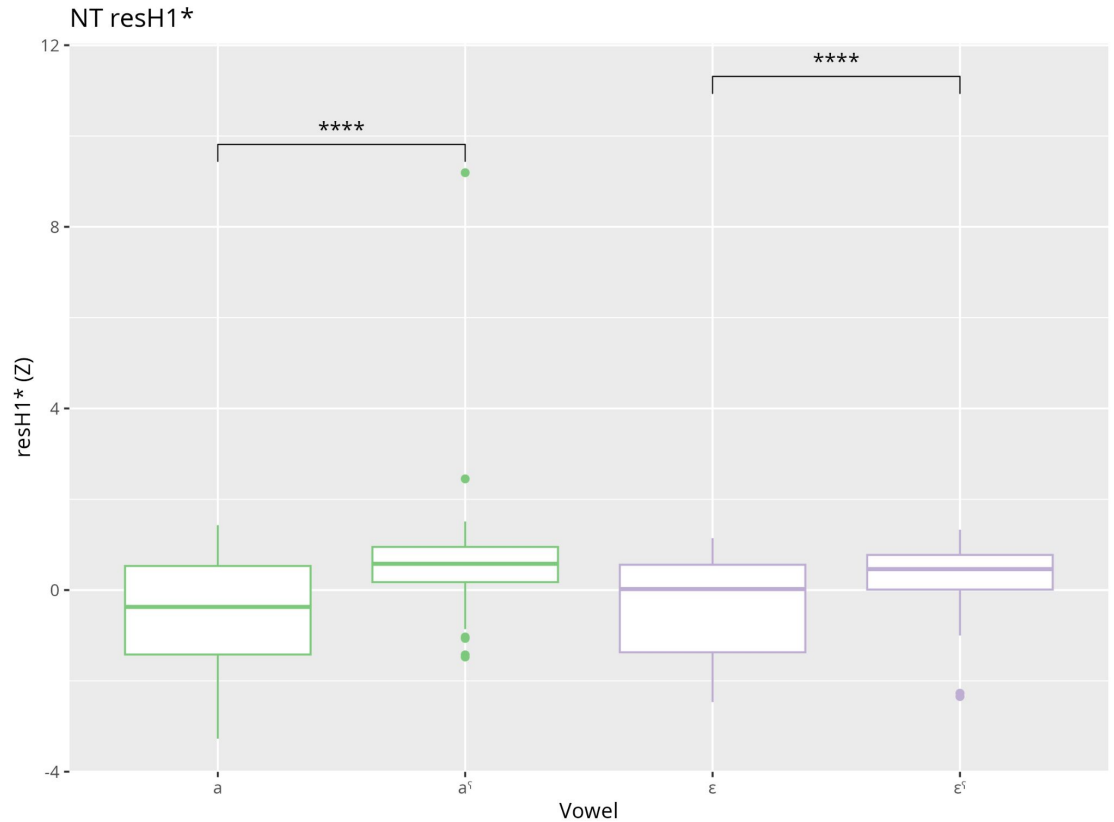
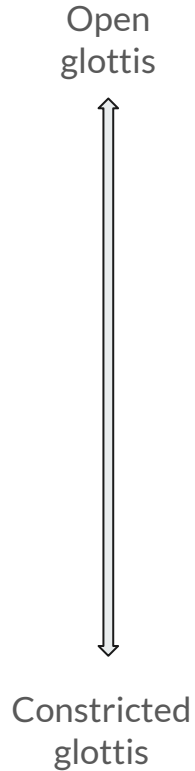
More noise



# NT resH1\*



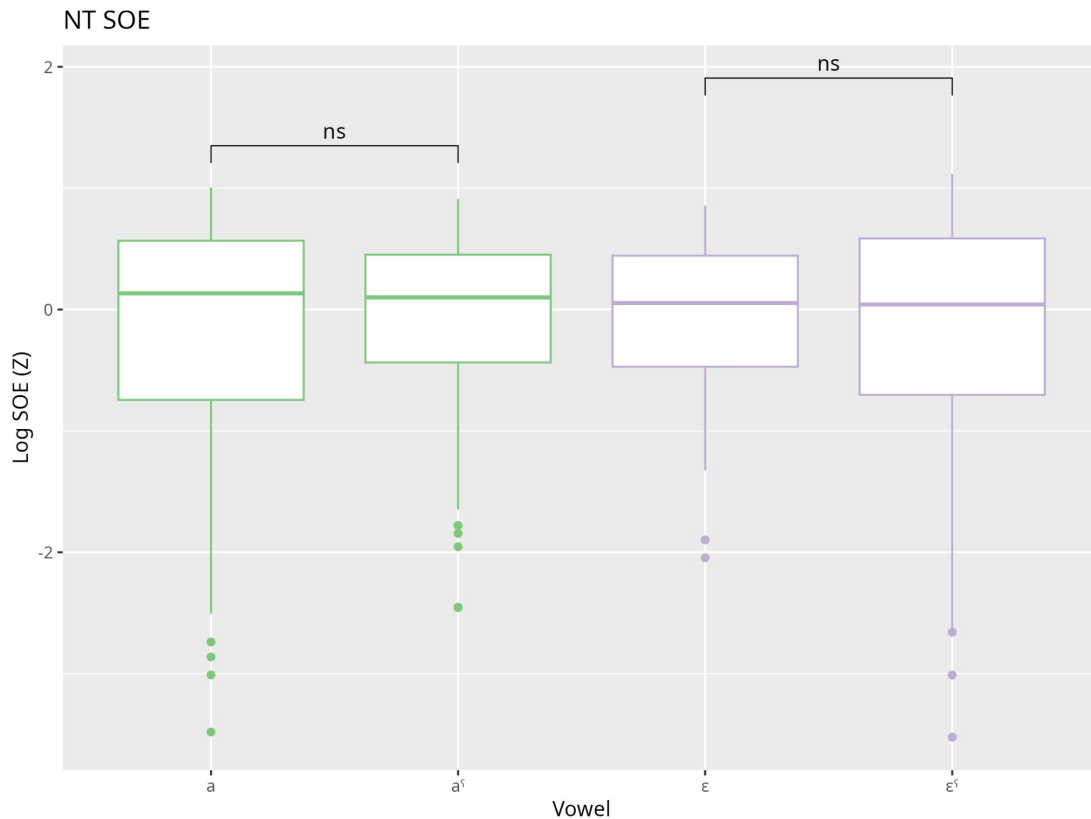
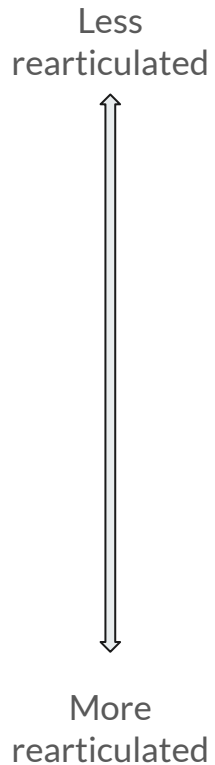
- Higher resH1\* (breathier, when considering the noise)



# NT SOE



- No difference in SOE (no rearticulation)





## NT summary

- Non-modal vowels characterized by:
  - More noise (lower CPP and HNR05)
  - Breathier (higher  $\text{resH1}^*$  + lower CPP and HNR05)
  - Lowering (higher F1)



## Discussion

- RQ1: Are these pharyngeal vowels?
  - Higher F1 in  $a^{\text{f}}$  and  $\varepsilon^{\text{f}}$  in NT, only  $a^{\text{f}}$  in ST
  - ST centralization and F3 changes consistent with pharyngealization, but are not significant
  - Phonation differences appear to be the most reliable correlates to these vowels
    - Most significantly the differences in noise
- ST vowels more canonically pharyngeal—there appear to be differences in F1, F2, and F3 consistent with pharyngealization, as well as phonation changes
- The only formant correlates in NT are the differences in F1—all other correlates are phonation differences



## Discussion

- RQ2: What makes ST non-modal vowels sound ‘stronger’ than NT?
  - Hypothesis 1: ST has the same acoustic correlates to creak/pharyngealization as NT
  - Hypothesis 2: creaky/pharyngeal vowels in ST and NT have different acoustic correlates
- Hypothesis 2 holds—NT vowels characterized by breathiness, not creakiness, and are not rearticulated



## Conclusion

- The Southern Toussian non-modal vowels appear to be pharyngeal
- Less clear for Northern Toussian
- Their phonetic correlates vary by language, but they involve both formant and phonation changes
  - NT has lower, noisier, and breathier vowels
  - ST has noisier and creakier vowels that are often rearticulated, which appear to have formant changes consistent for pharyngeal vowels



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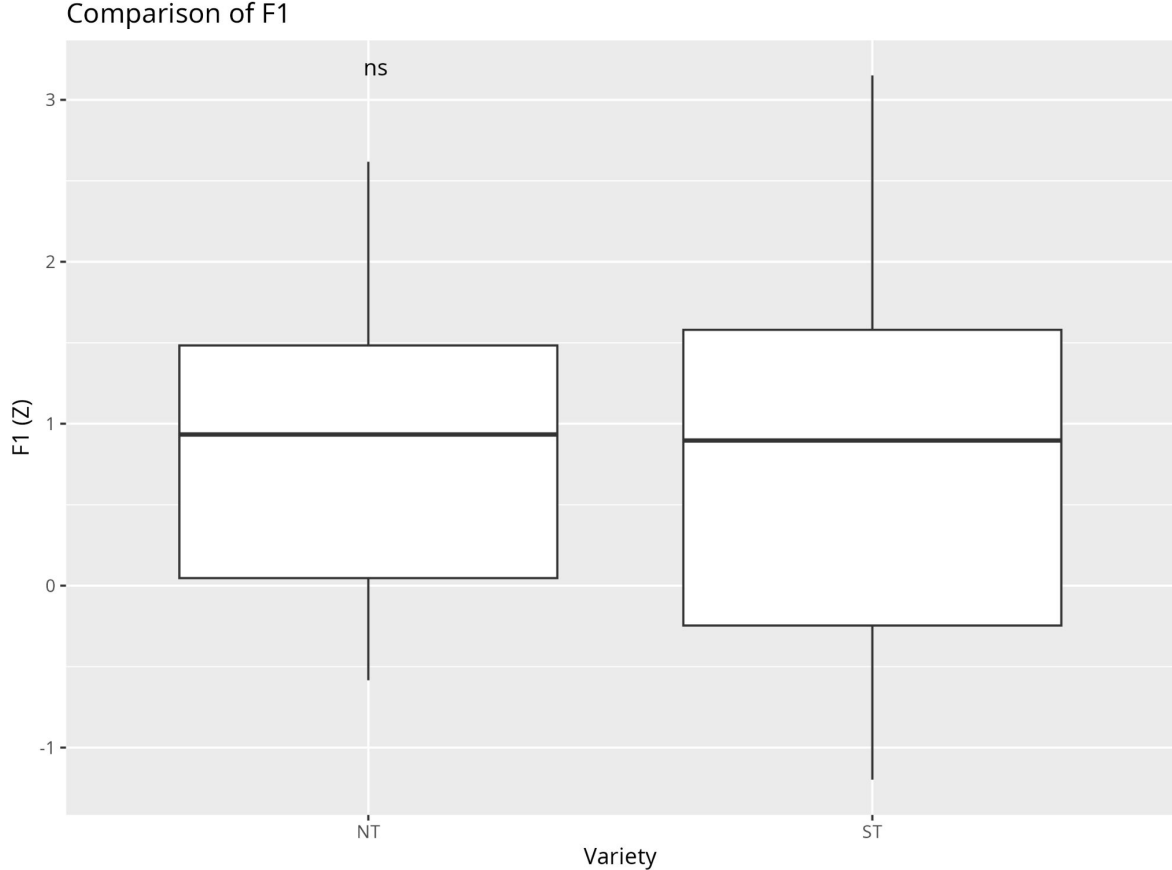
## Comparison

**What makes ST non-modal vowels sound 'stronger' than NT?**

# Comparison of F1



- No significant difference in F1 between NT and ST pharyngeal vowels

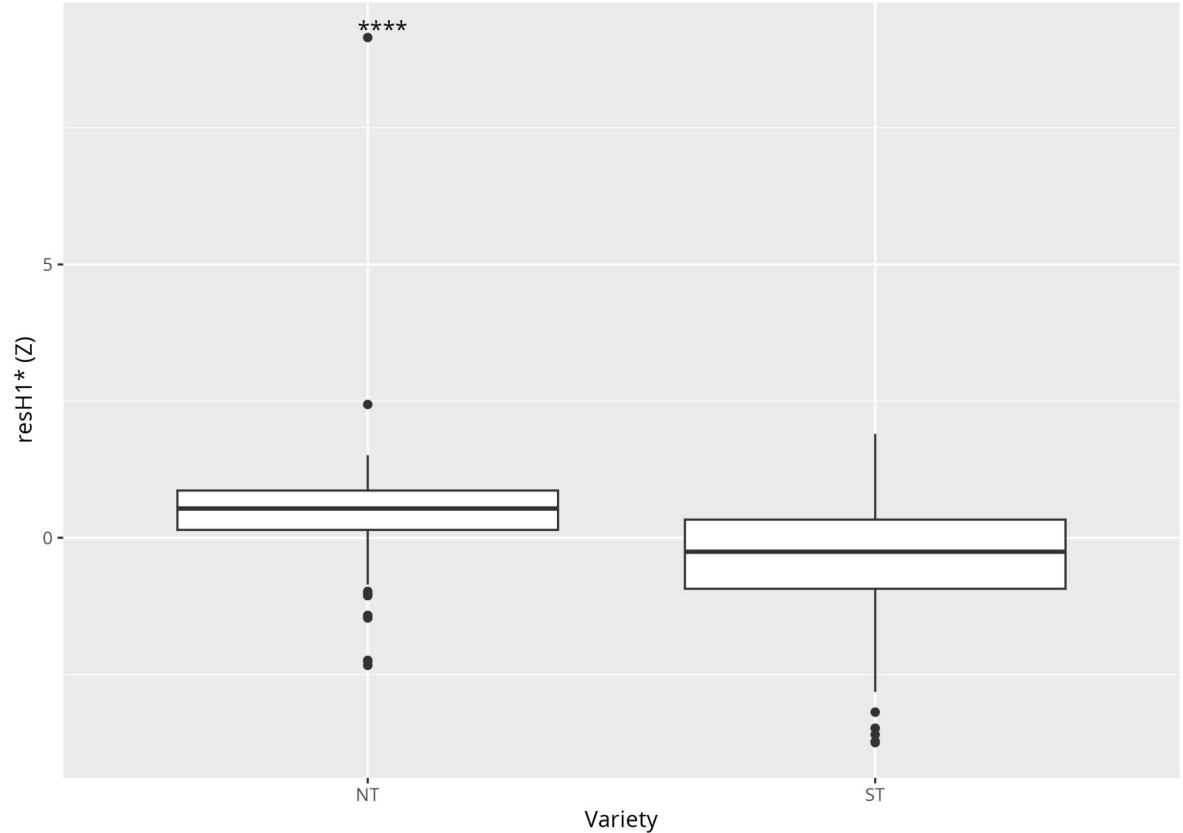


# Comparison of resH1\*



- NT has higher resH1\* (is breathier)

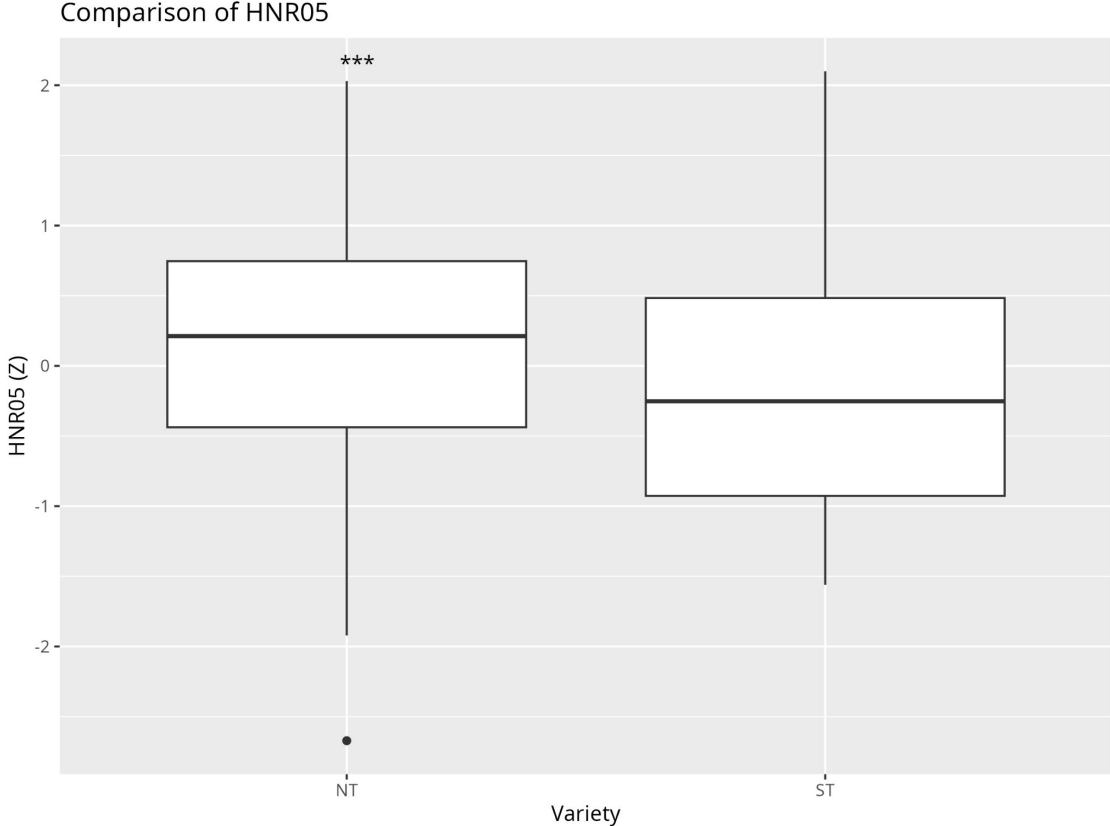
Comparison of resH1\*



# Comparison of HNR05

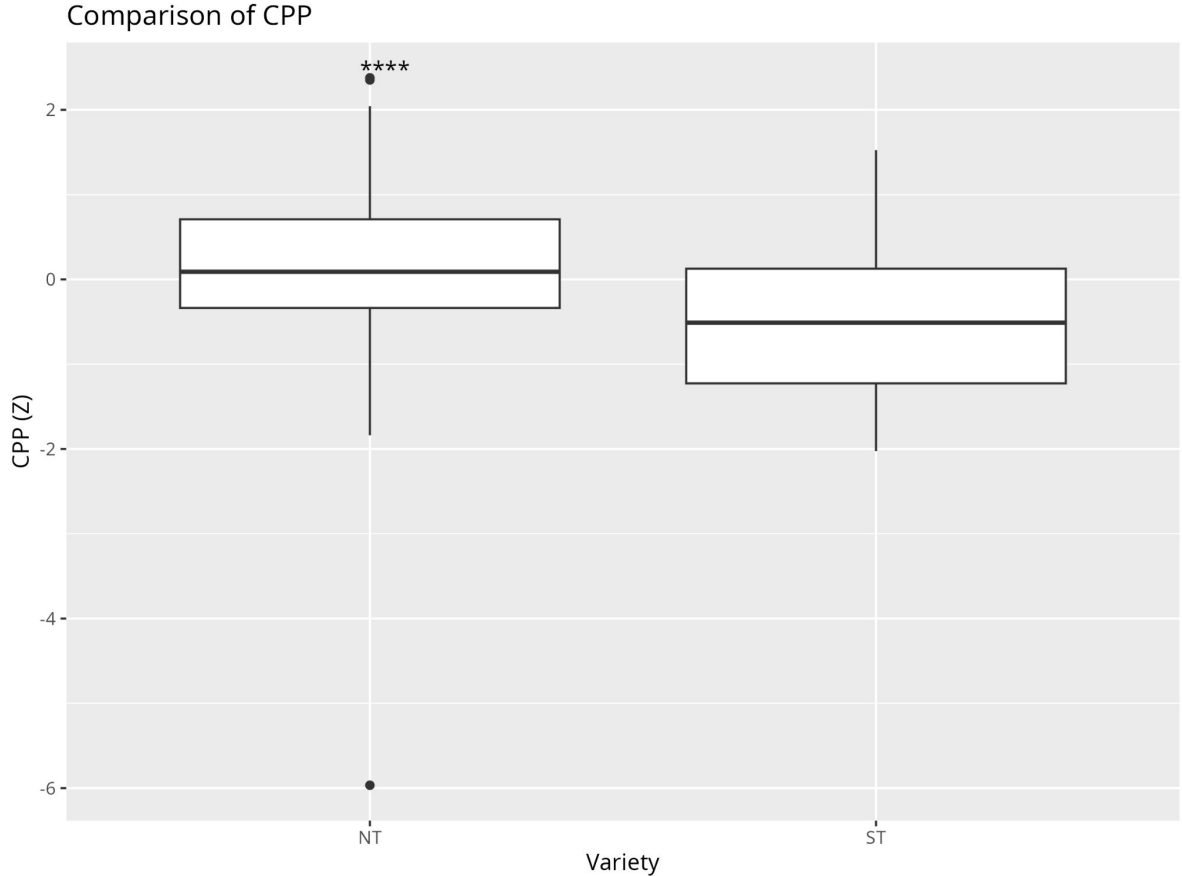


- ST has lower HNR05 (noisier)



# Comparison of CPP

- ST has lower CPP (noisier)



# Comparison of SOE



- ST has lower SOE (more rearticulation)

