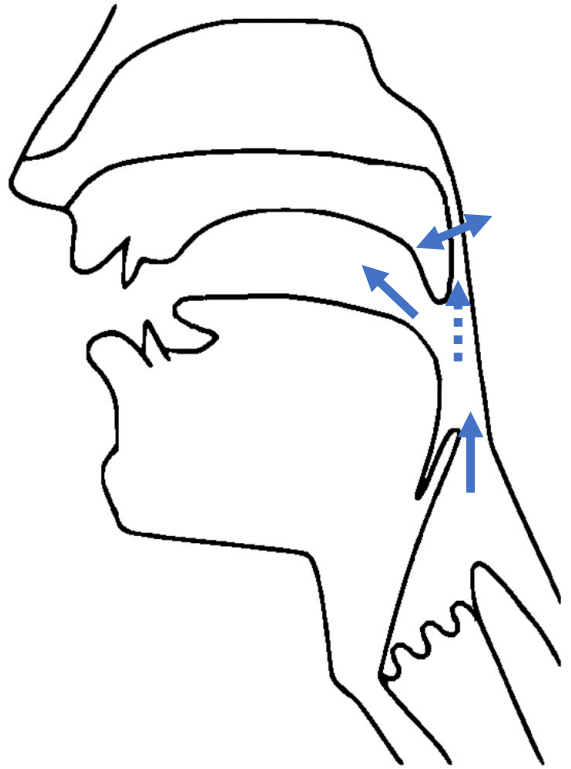
Articulation of the oral-nasal vowel contrast in Chaoshan Chinese

Changhe Chen and Jonathan Havenhill
Department of Linguistics, The University of Hong Kong

Oral-nasal vowel contrast

- Nasal/nasalization: lowered velum
- Phonemic nasal vowel [+nasal] vs. oral vowel

- "**Minimal difference**" assumption (Shosted, 2015): oral-nasal vowel pairs differ only in velopharyngeal opening



Adapted from http://smu-facweb.smu.ca/~s0949176/sammy/

“Minimal difference”?

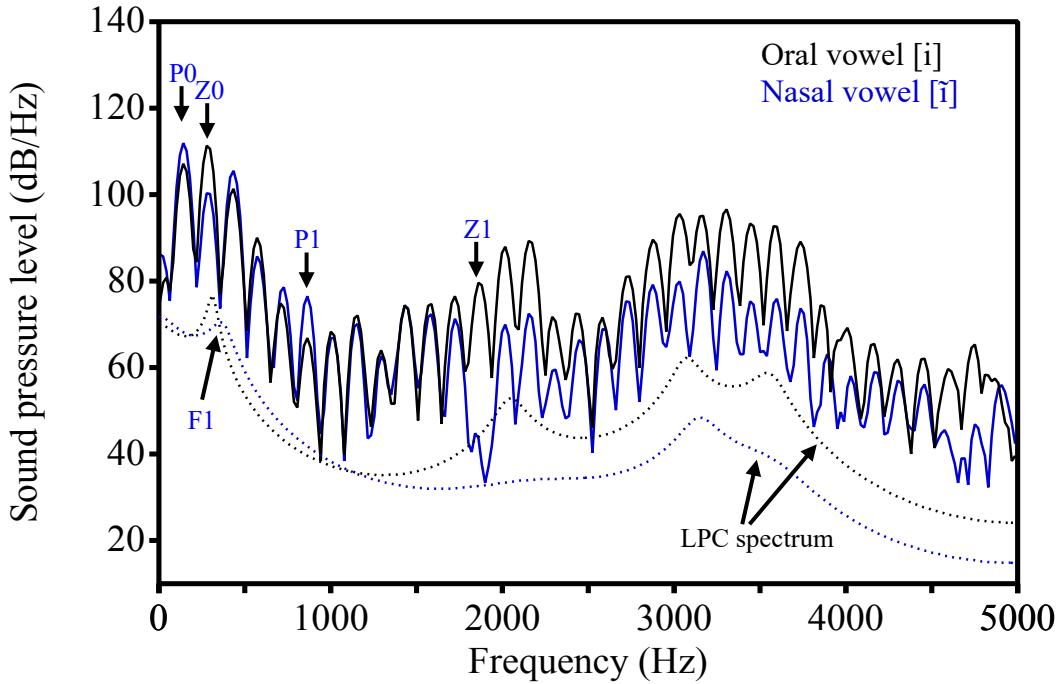
- Not well supported by studies on Indo-European languages

- Breathier voice (Carignan, 2017)
- distinct labial/lingual gestures (e.g., Shosted, 2015; Carignan, 2014; Shosted et al., 2012; Barlaz et al., 2018)
- different pharyngeal configurations (Carignan et al., 2015; Barlaz et al., 2018)

- **speaker-, vowel- and language-specific adjustments** relative to the oral vowels

Oral-nasal vowel contrast (acoustics)

- The acoustic features of the nasal vowel (e.g., Arai, 2006; Chan, 1997; Fujimura & Lindquist, 1971; Stevens et al., 1987; Stevens, 2000; Styler, 2017):
  - Nasal formants (P0, P1…) and nasal zeros (Z0, Z1…) (pole-zero pairs)
  - Lowering of F1 amplitude and widening of F1 bandwidth (also breathy voice)
  - Increasing F1 frequency (F̃1)
  - Increasing spectral tilt



Overview

- Previous work: Articulatory adjustments to nasal vowels
- Current study: nasal vowels of Chaoshan Chinese
- Ultrasound and acoustic data
- EGG data
- Discussion and conclusion

Lingual gestures of nasal vowels

- For /ĩ/ (relative to /i/),
  - higher and more retracted tongue body and tongue root for European Portuguese (Martins et al., 2008)
  - higher tongue position and smaller lip aperture for Brazilian Portuguese (Shosted, 2015)
  - no labial or lingual difference for Hindi (Shosted et al., 2012)

Lingual gestures of nasal vowels

- For /ɛ̃/,
  - Lower and more retracted tongue position for Northern Metropolitan French (Carignan, 2014)
  - lower and more retracted tongue position for Belgian French (Delvaux et al., 2002)
  - higher and more advanced tongue position for Hindi (Shosted et al., 2012)

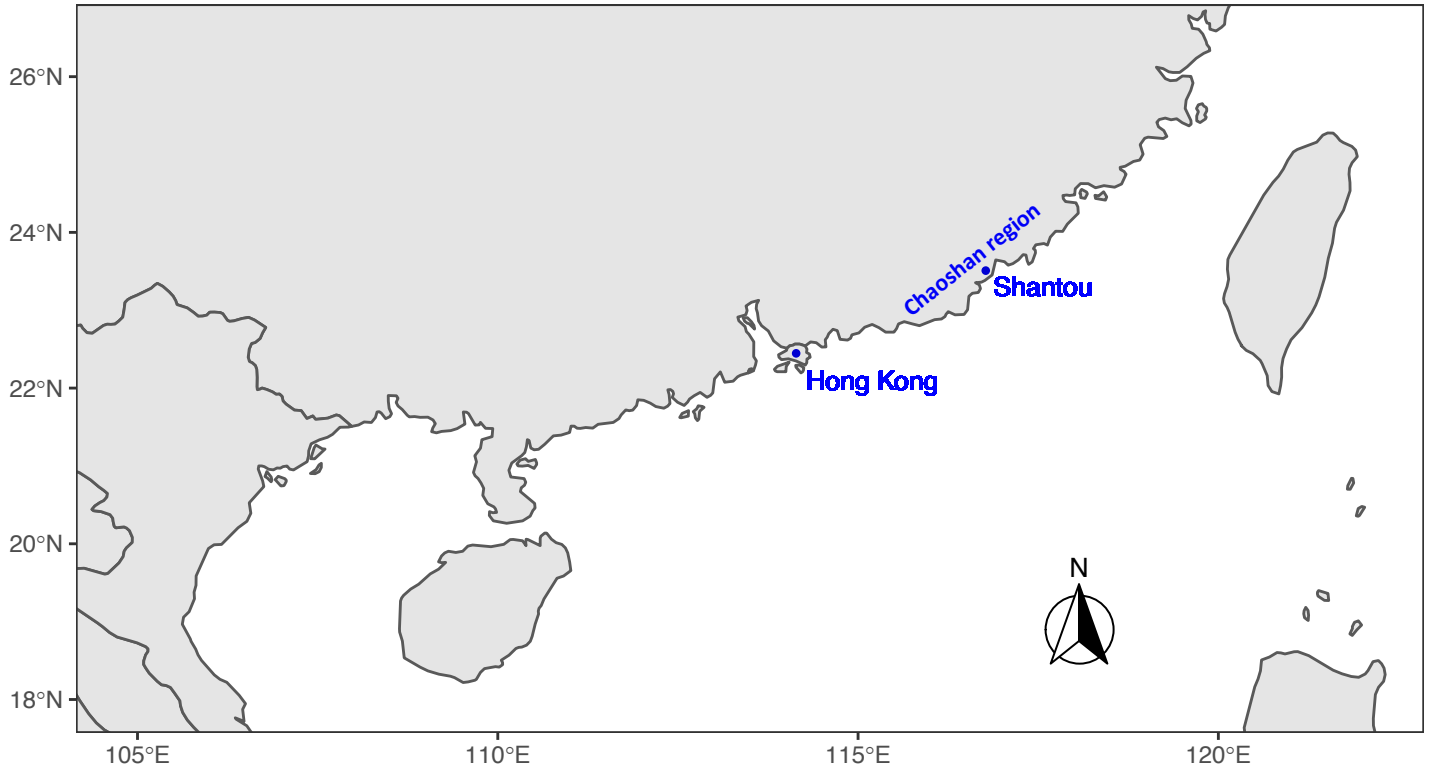
Lingual gestures of nasal vowels

- For /ɑ̃/ or /ɐ̃/,
  - higher and more advanced tongue position for European Portuguese (Martins et al., 2008)
  - higher tongue position for Brazilian Portuguese (Shosted, 2015)

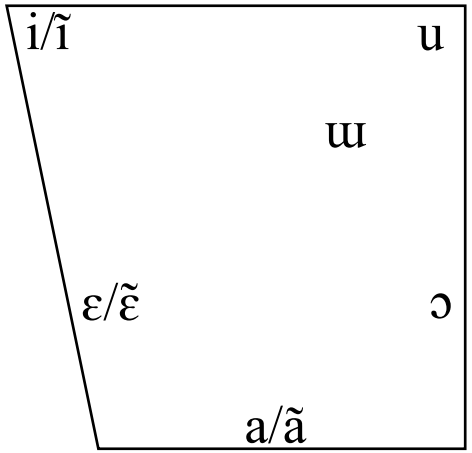
- For /ɑ̃/,
  - More retracted tongue position for Northern Metropolitan French (Carignan, 2014)
  - More advanced tongue position for Hindi (Shosted et al., 2012)

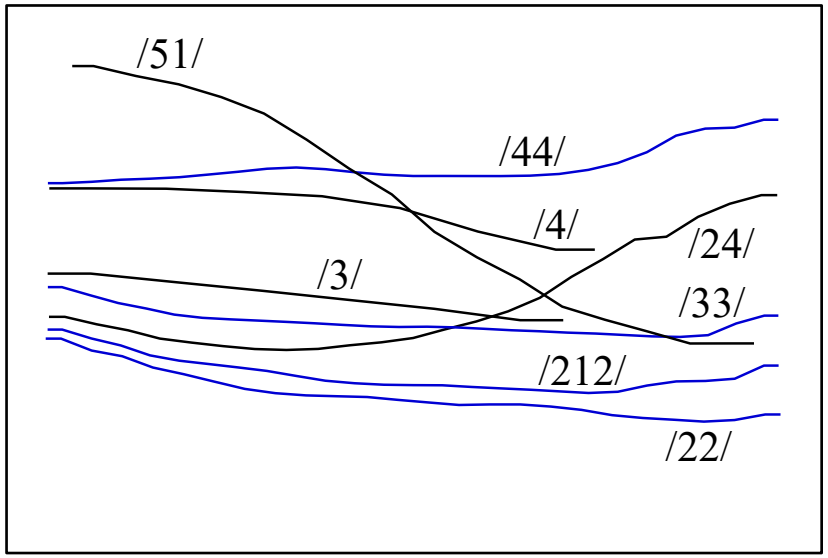
Current study on Chaoshan Chinese

- Articulatory study on nasal vowels in Sinitic languages is lacking
- 33 out of 86 Sinitic languages have nasal vowels (Zee & Lee, 2007)
- Chaoshan Chinese is a variety of Southern Min spoken in southern China



Shantou dialect (sound inventory)





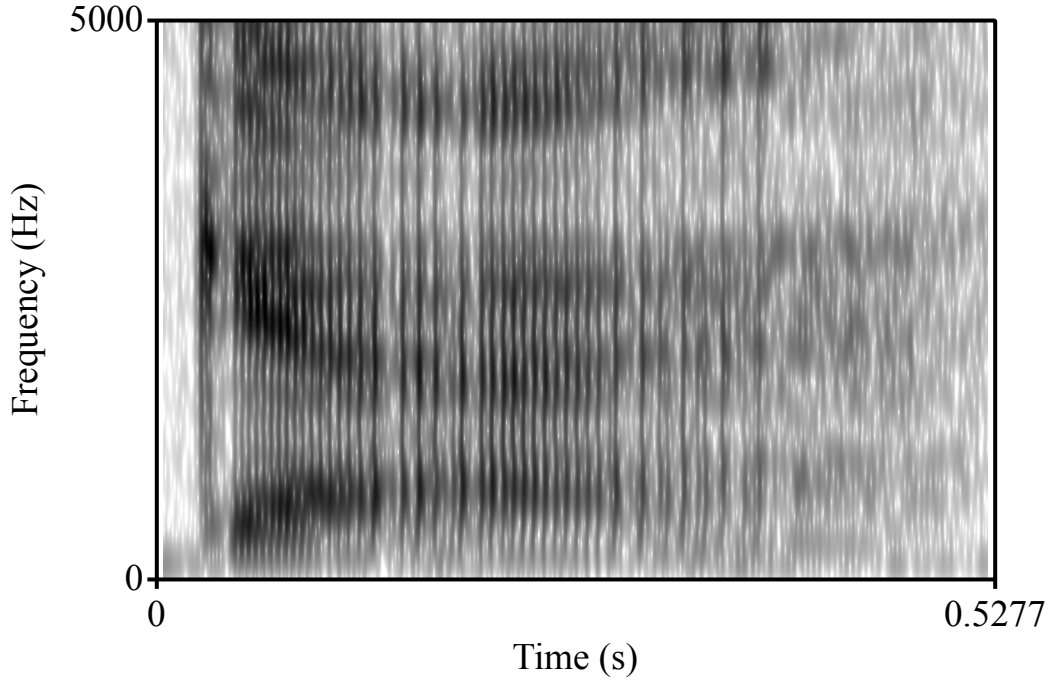
	Bilabial	Alveolar	Velar	Glottal
Plosive	p pʰ b	t tʰ	k kʰ g	ʔ
Fricative		s z		h
Affricate		ʦ ʦʰ		
Nasal	m	n	ŋ	
Approximant		l		

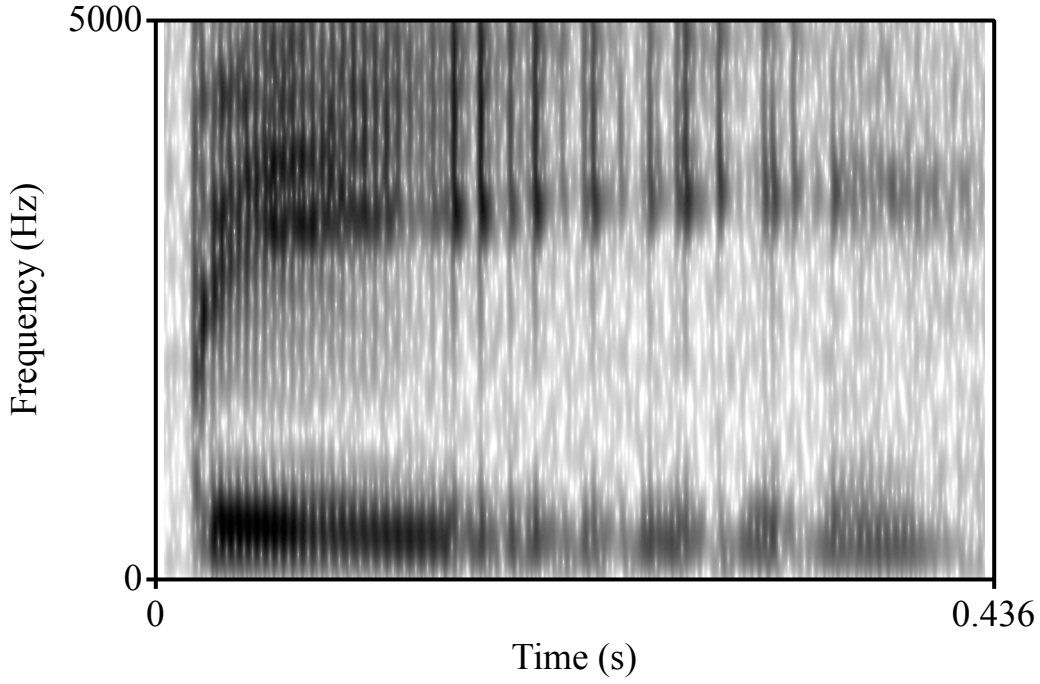
The oral-nasal vowel contrast

- Chaoshan oral-nasal vowel contrast:
  - /ĩ/ ([ĩ^{44}] 圓 “circle”) vs. /i/ ([i^{44}] 姨 “aunt”)
  - /ɛ̃/ ([pɛ̃^{44}] 棚 “shed”) vs. /ɛ/ ([pɛ^{44}] 爬 “crawl”)
  - /ã/ ([ã^{33}] 揜 “to cover”) vs. /a/ ([a^{33}] 亞 “Asia”)
  - Impressionistic studies of Chaoshan Chinese describe the articulation of the oral, but not the nasal, vowels (e.g., Li, 1994; Lin & Chen, 1996)
- The historical connection in Chaoshan Chinese (e.g., Li, 1994; Chang, 2012):
  - VN → Ṽ (N: nasal consonant)
  - HV → HṼ (H: high airflow consonant)
  - V → Ṽ (nasalization without specific reasons)
  - NṼ → HṼ

Shantou dialect (creaky dipping tone)

- Creaky voice
  - lower spectral tilt (e.g., Garellek, 2019; Keating et al. 2015)
  - possible narrower formant bandwidth (Gobl, 1989; Keating et al. 2015)
- How do creaky voice and nasality interact?



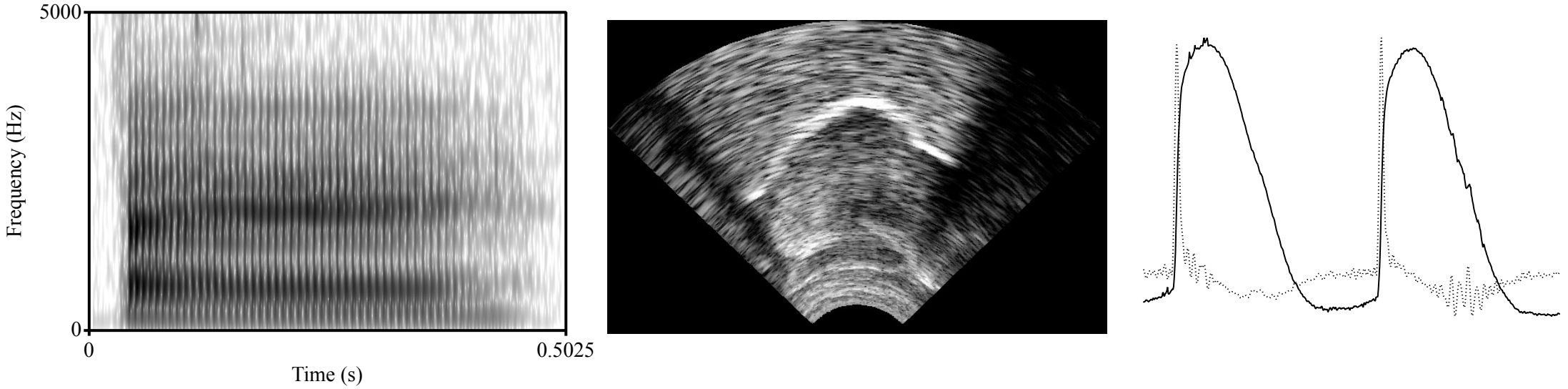


Purposes of this study

- To investigate the phonetic realization of the oral-nasal vowel contrast
- To explore the interaction between creaky voice and nasality (which can be enhanced by breathy voice)
- To find out which enhancing or compensatory gestures are used
- To test the "minimal difference" assumption

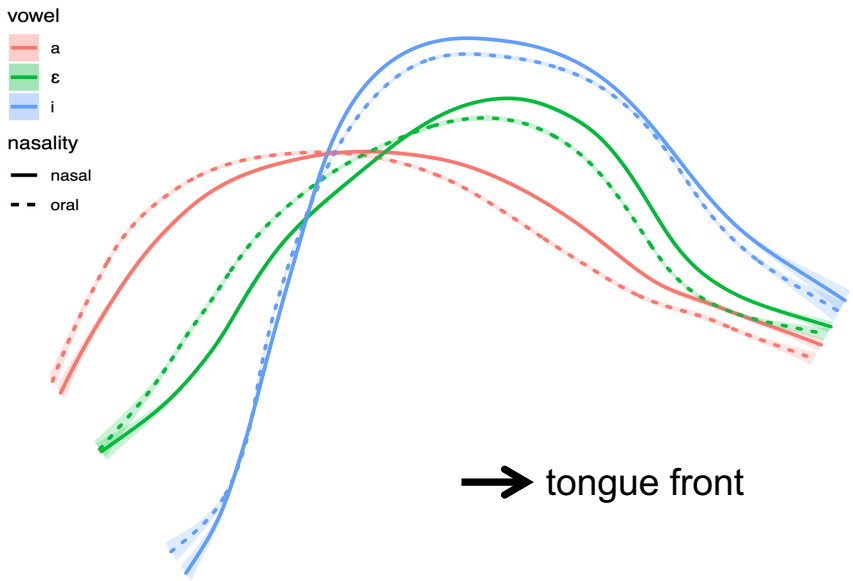
Methodology

- Thirteen native speakers of Chaoshan Chinese
- Three successive repetitions of each word in isolation
- Synchronized audio, lip video, and ultrasound tongue images in AAA along with electroglottograph (EGG) recordings

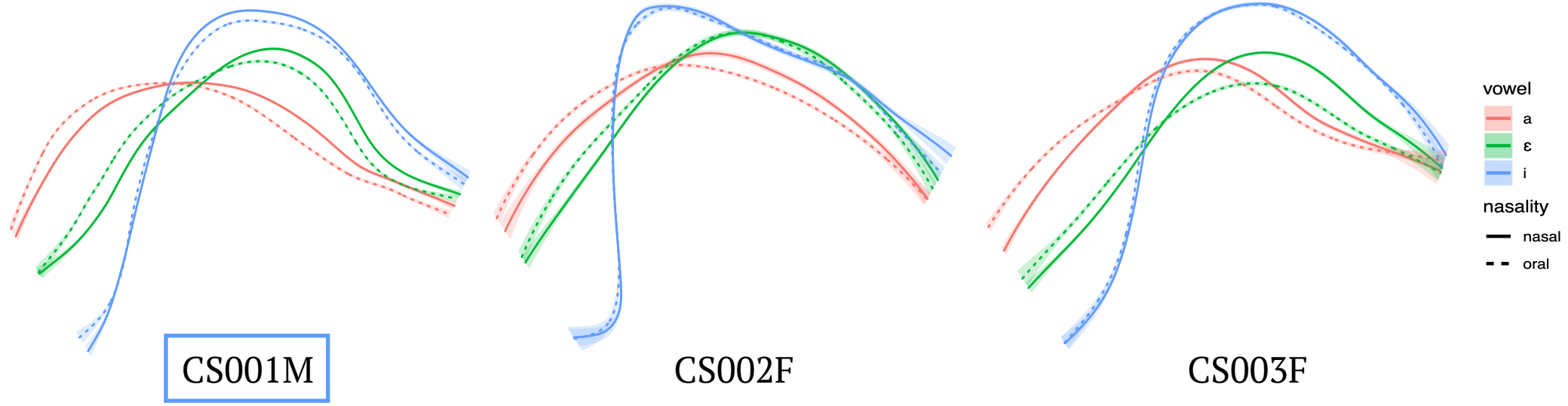


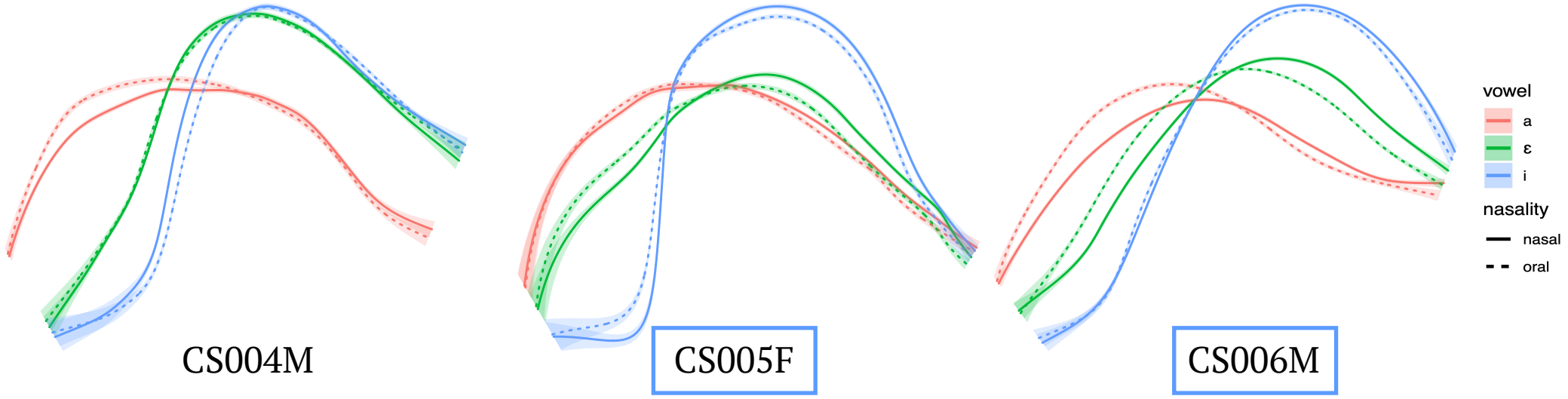
Methodology (ultrasound)

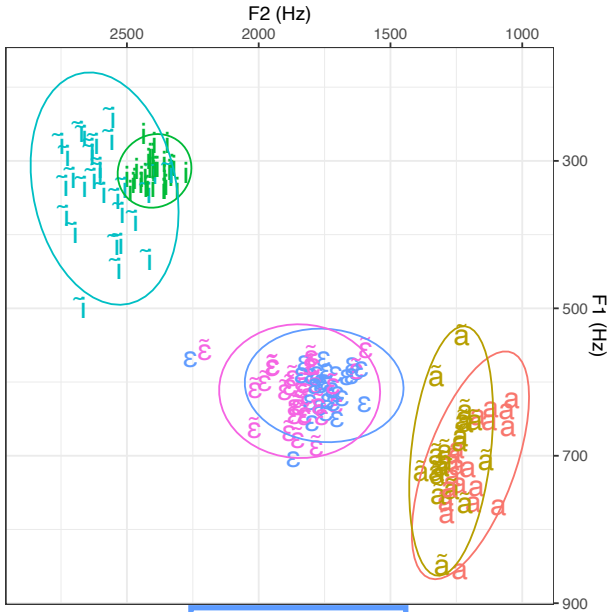
- 30 (near) minimal pairs of oral and nasal vowels carrying tones /44 33 22 212/:
  - 11 pairs for /i/-/ĩ/, 12 pairs for /ɛ/-/ɛ̃/, and 7 pairs for /a/-/ã/
- Tongue contour at a single point during the steady state portion of the vowel
- Statistical analysis: polar SS ANOVA (Mielke, 2015)



Results (ultrasound)







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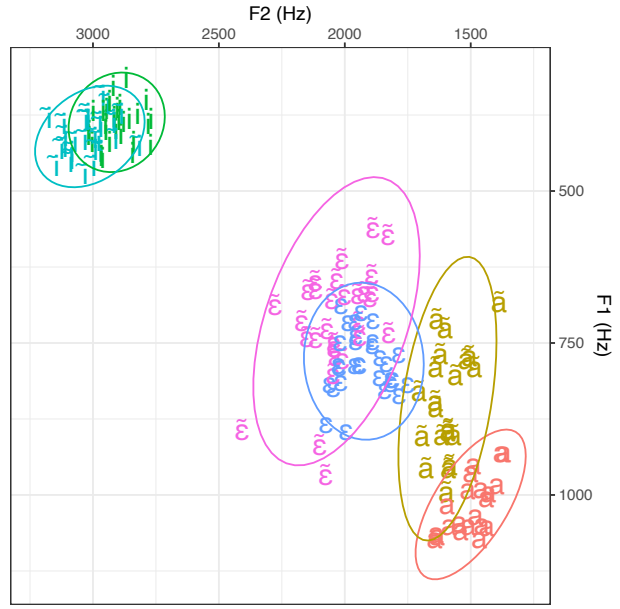

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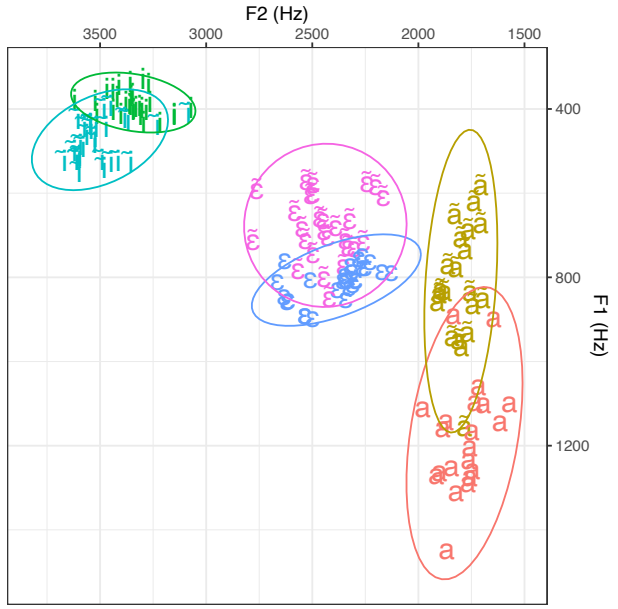

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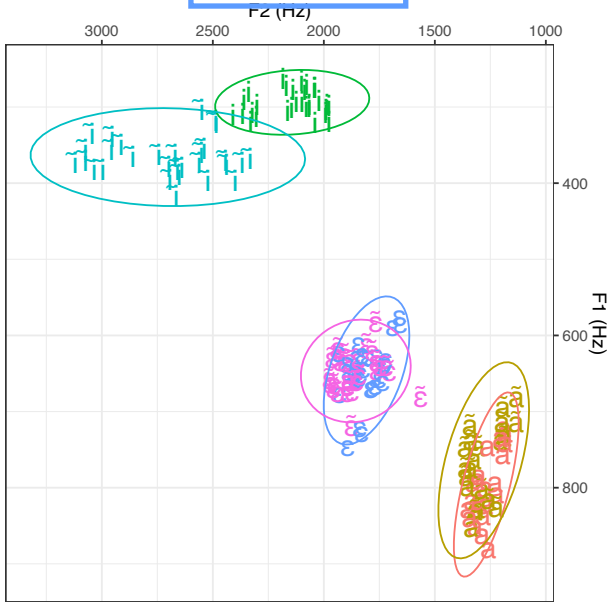

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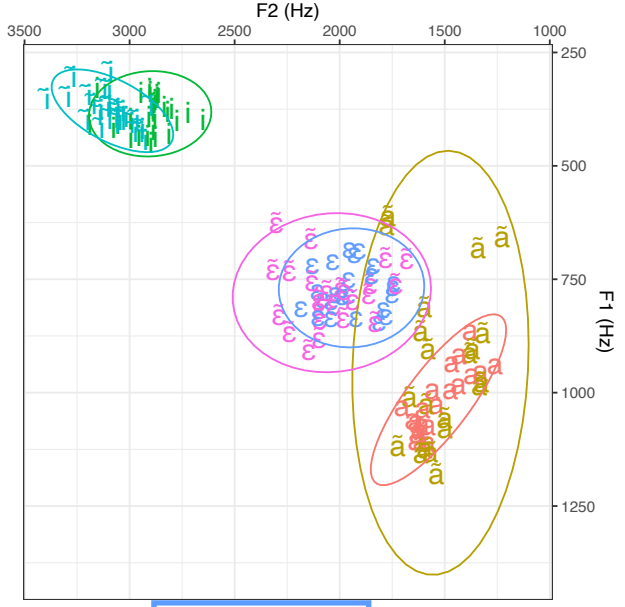

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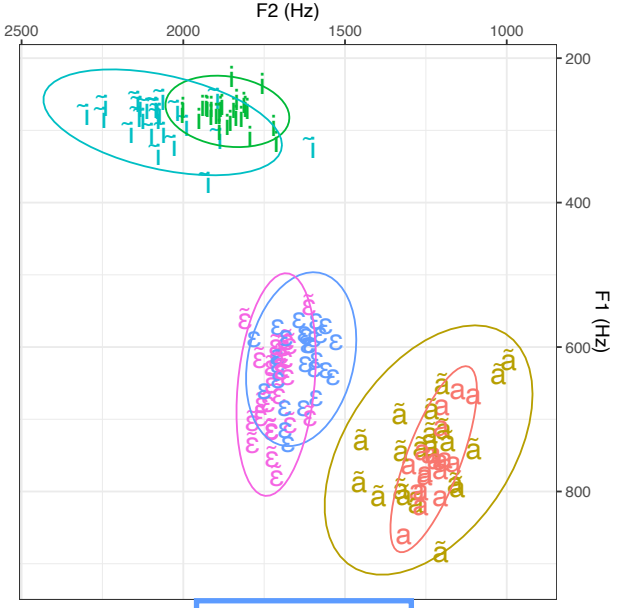
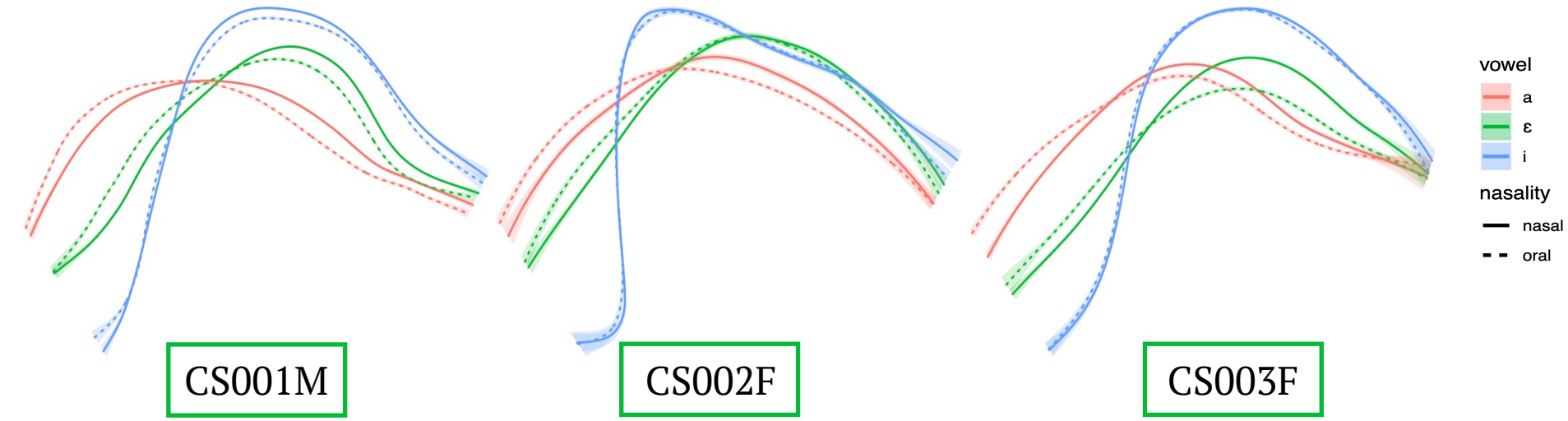


CS006M

Results (ultrasound)



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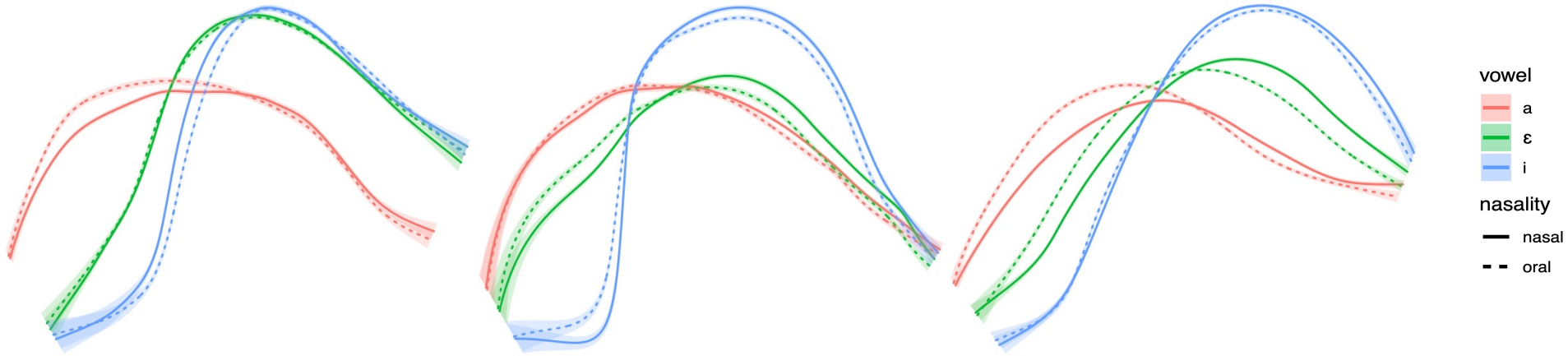

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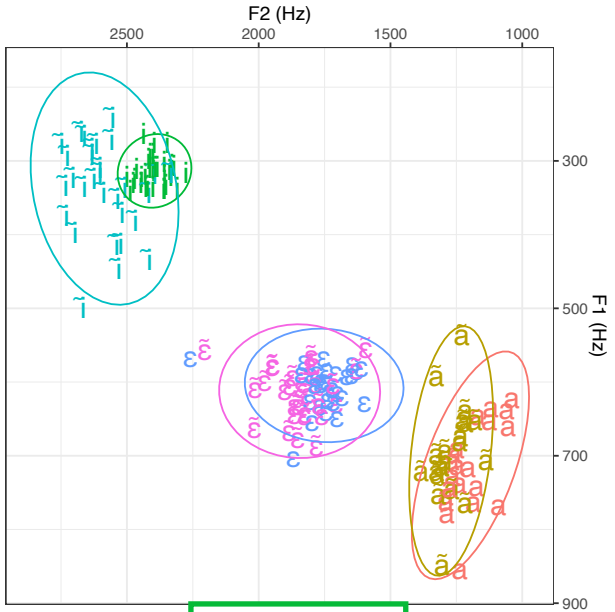

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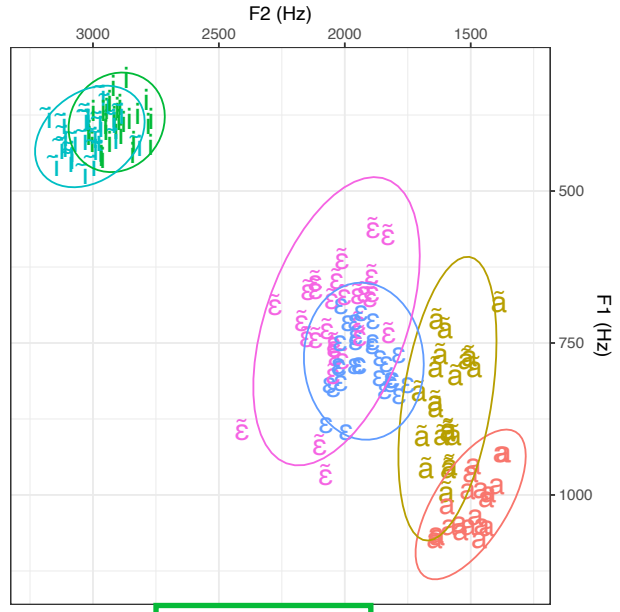

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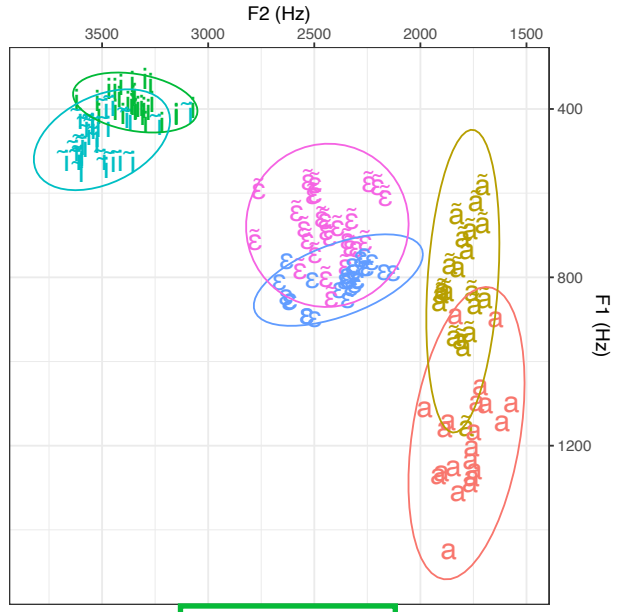

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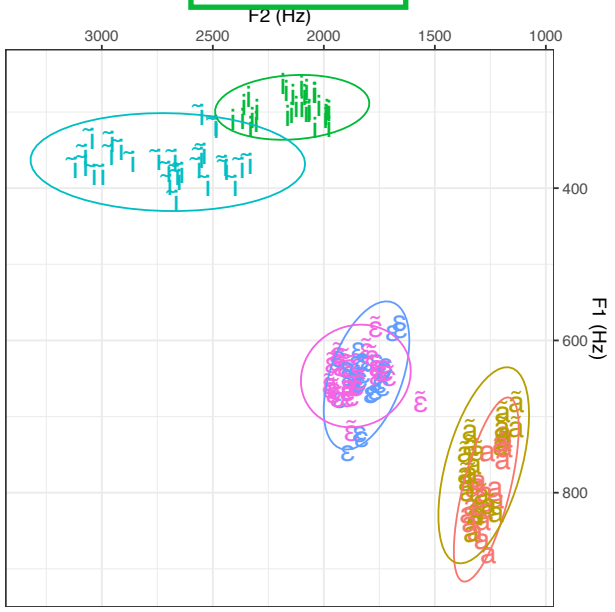

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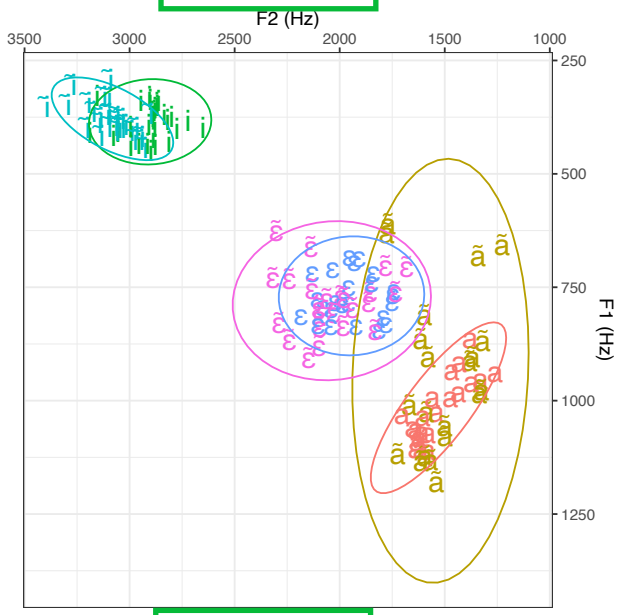

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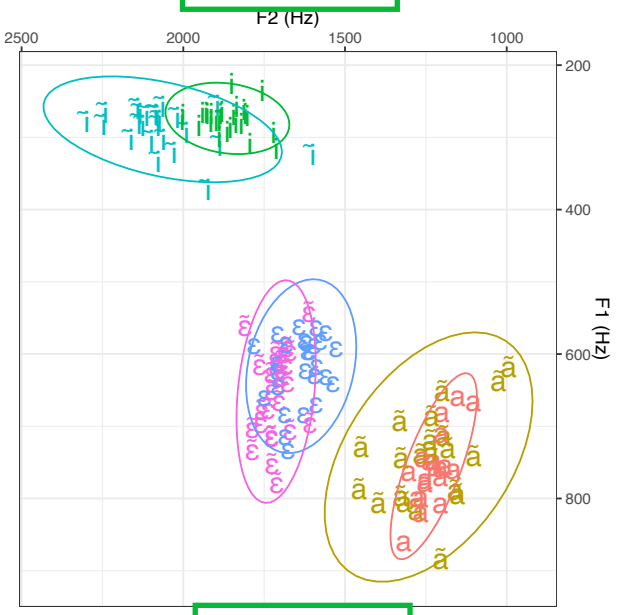
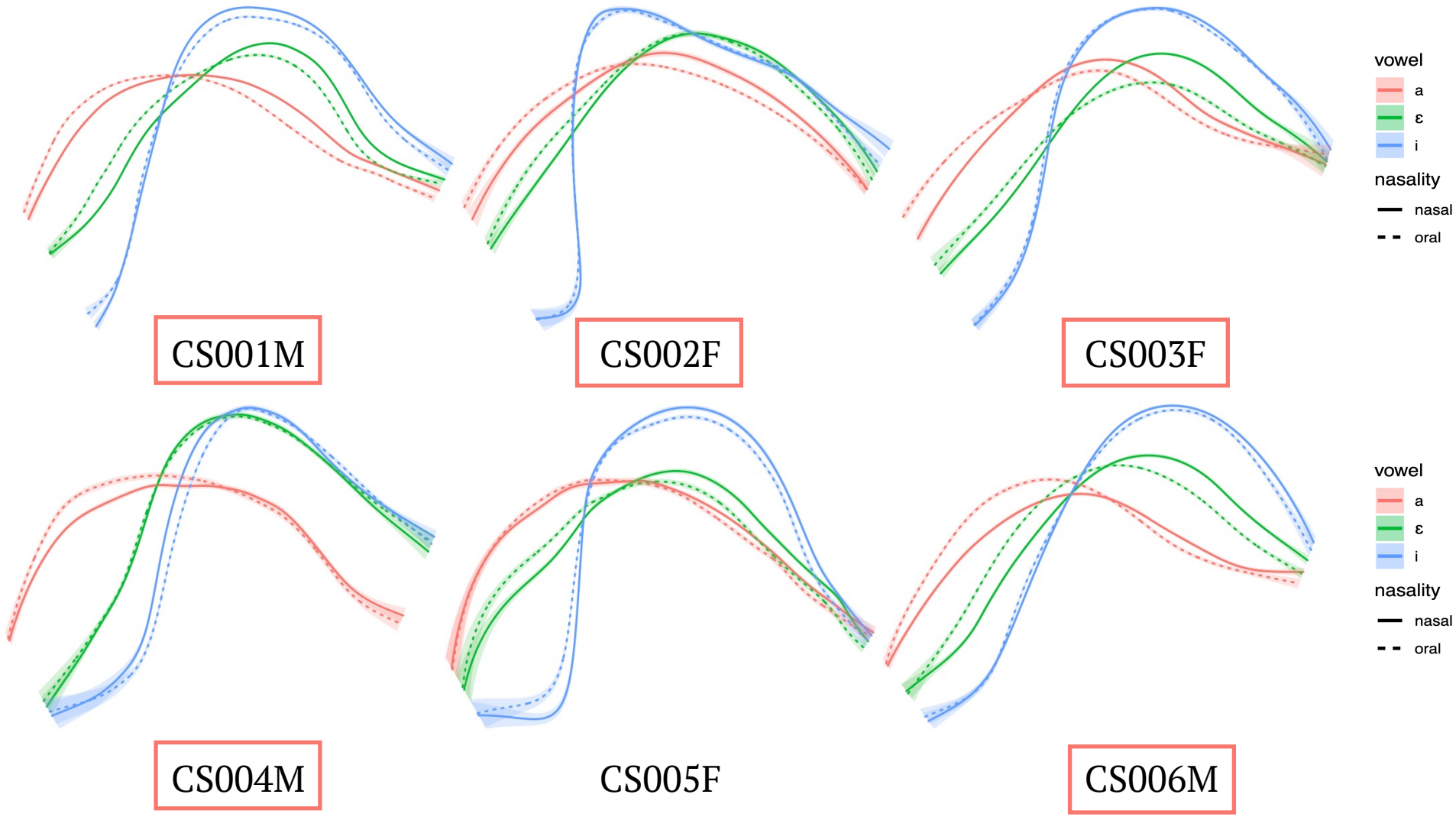
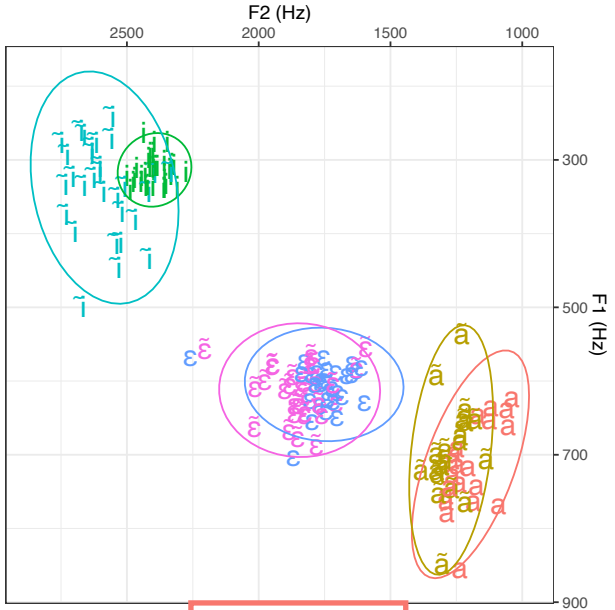


CS006M

Results (ultrasound)





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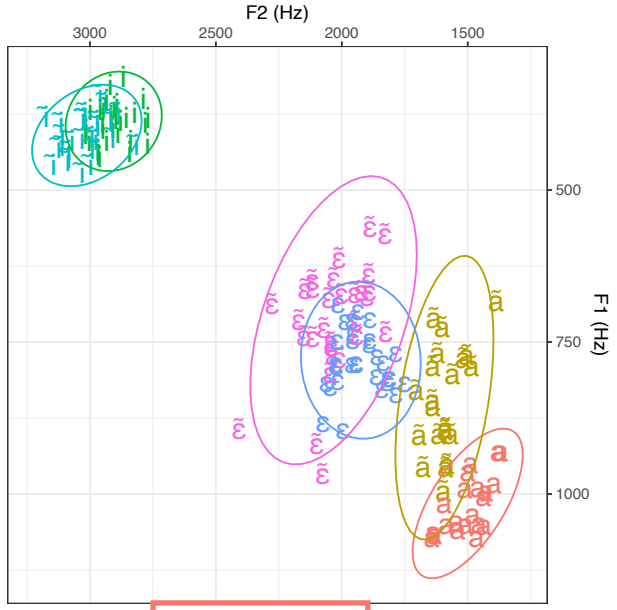

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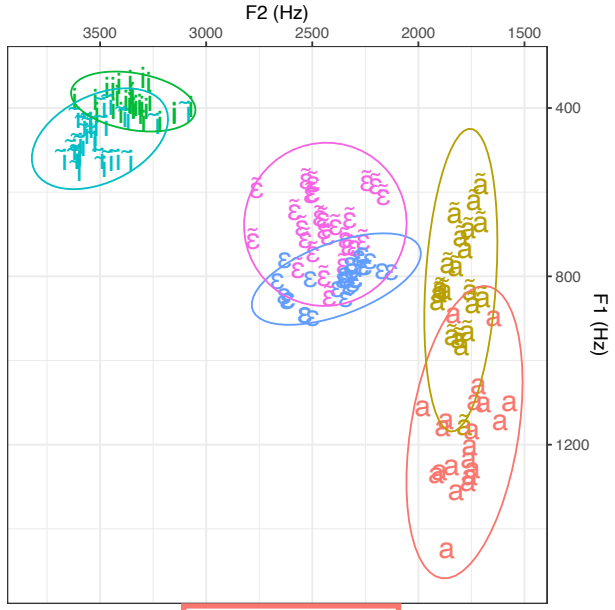

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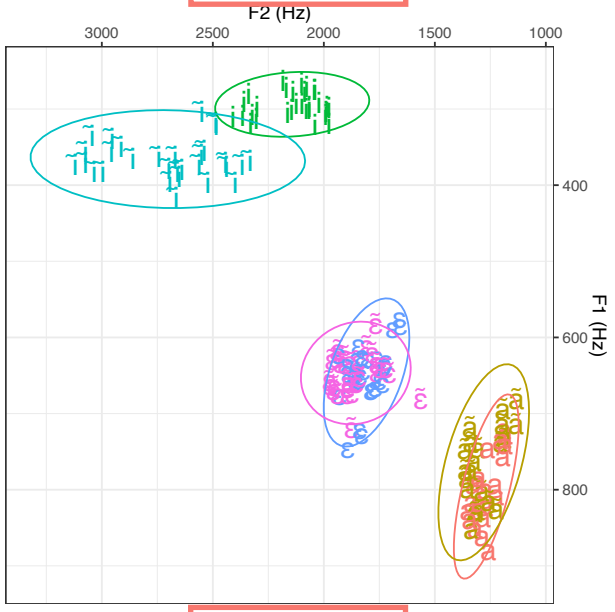

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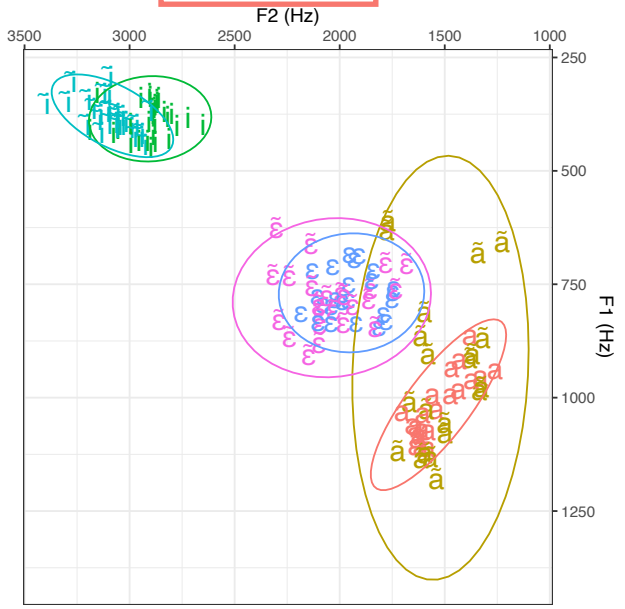
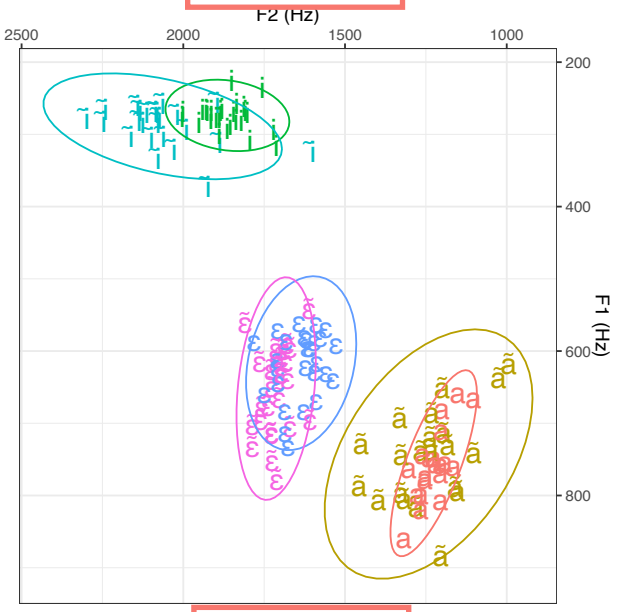


CS005F



CS006M

Results (ultrasound)

- For /ĩ/, a higher tongue position was observed in three speakers
  - help maintain the F1 at the low value
- For /ɛ̃/ and /ã/, most speakers showed an advanced tongue position
  - not realized as higher F2
- For /ɛ̃/, a higher tongue position was observed in four speakers
  - not realized as higher F1 except one speaker
- For /ã/, a higher tongue position was observed in two speakers
  - consistent with lower F1
  - enhance the acoustic effect of nasality (F1 lowering)
- Some speakers used identical lingual gestures:
  - optional and speaker-, vowel-specific adjustments

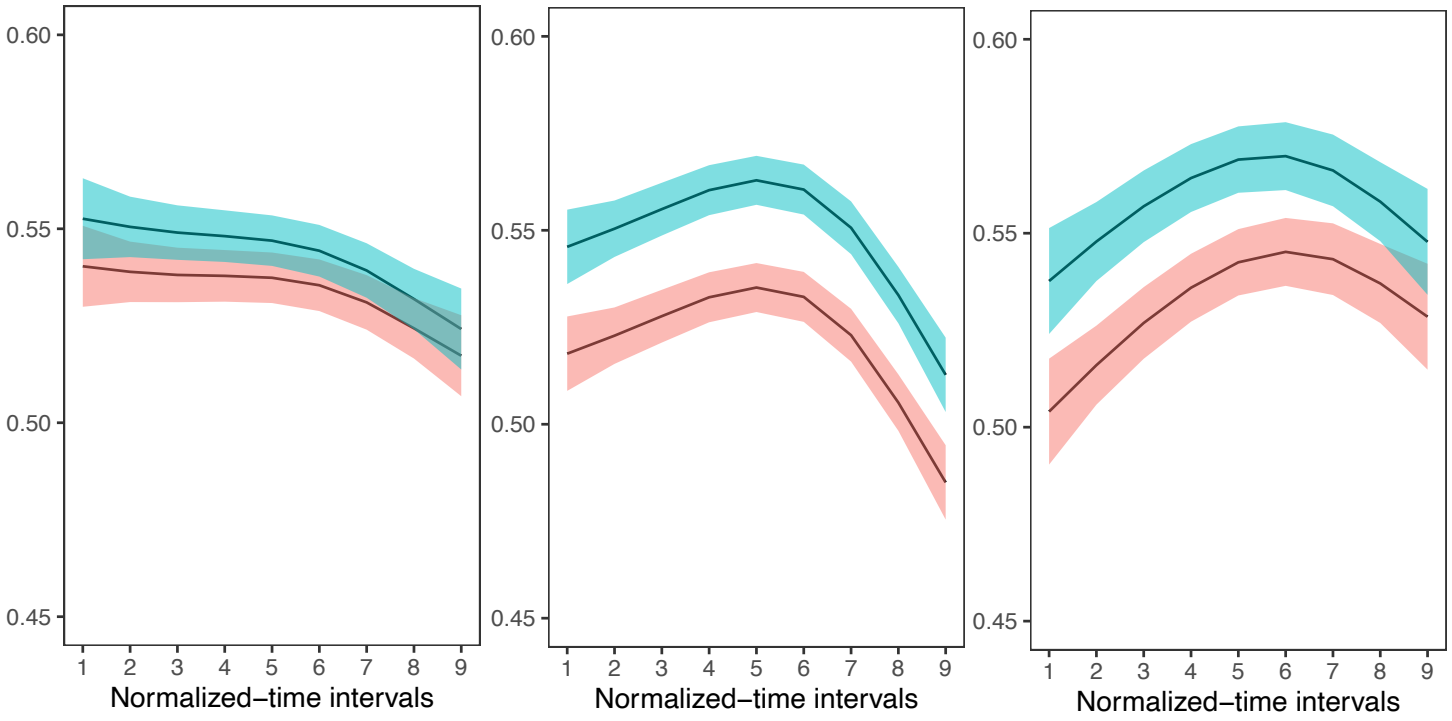
Methodology (EGG)

- 45 (near) minimal pairs of oral and nasal vowels, diphthongs, triphthongs carrying tones /44 33 212/

- EGG parameter: CQ – lower, breathier
- Acoustic parameter (for aperiodic voice): HNR05 (sensitive to the F0 regularity (Keating et al. 2015))
  - obtained by using EggWorks (standard percentage method) and VoiceSauce

- Statistical analysis: SS ANOVA

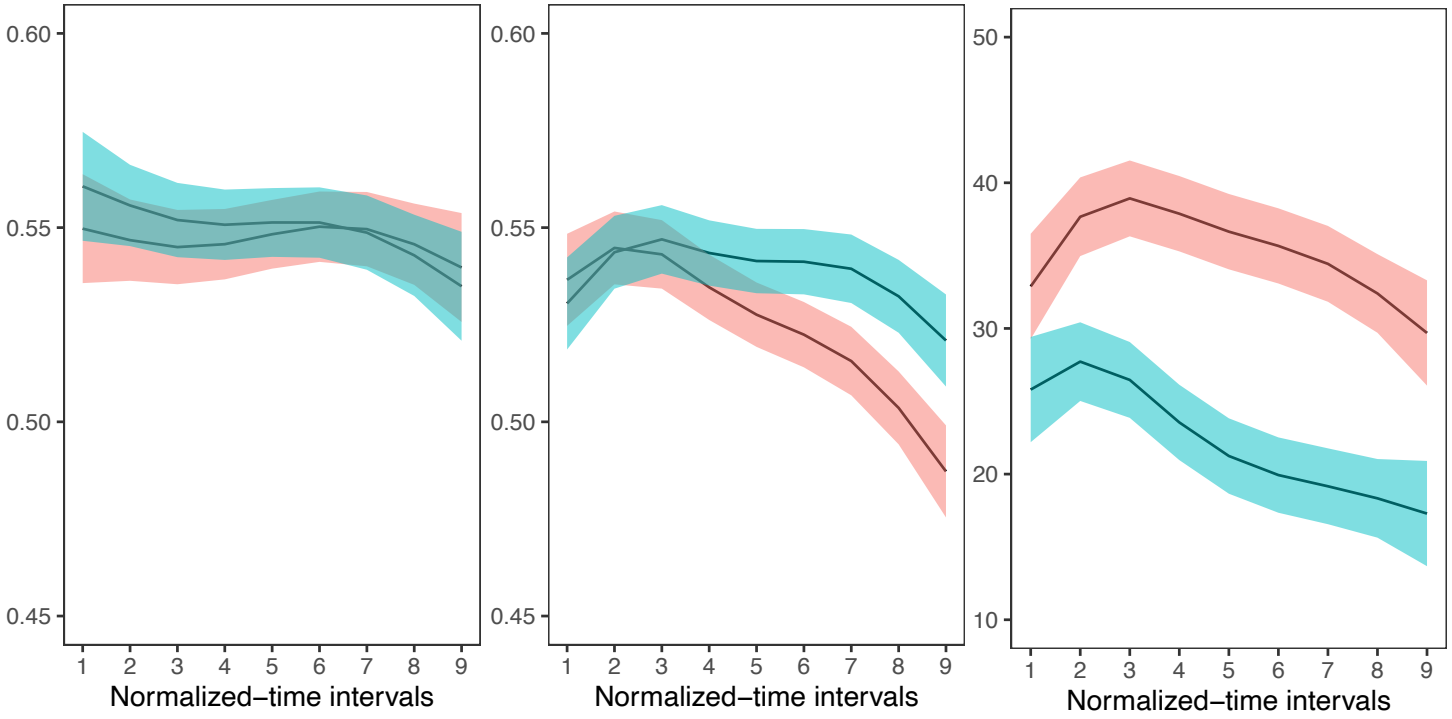
Results (EGG)



SSANOVA results of CQ of /44/ (left), /33/ (middle) and /212/ (right) carried by nasal (red) and oral (green) vowels.

- CS001M
- Breathier voice:
  - Tone /33/
  - Tone /212/

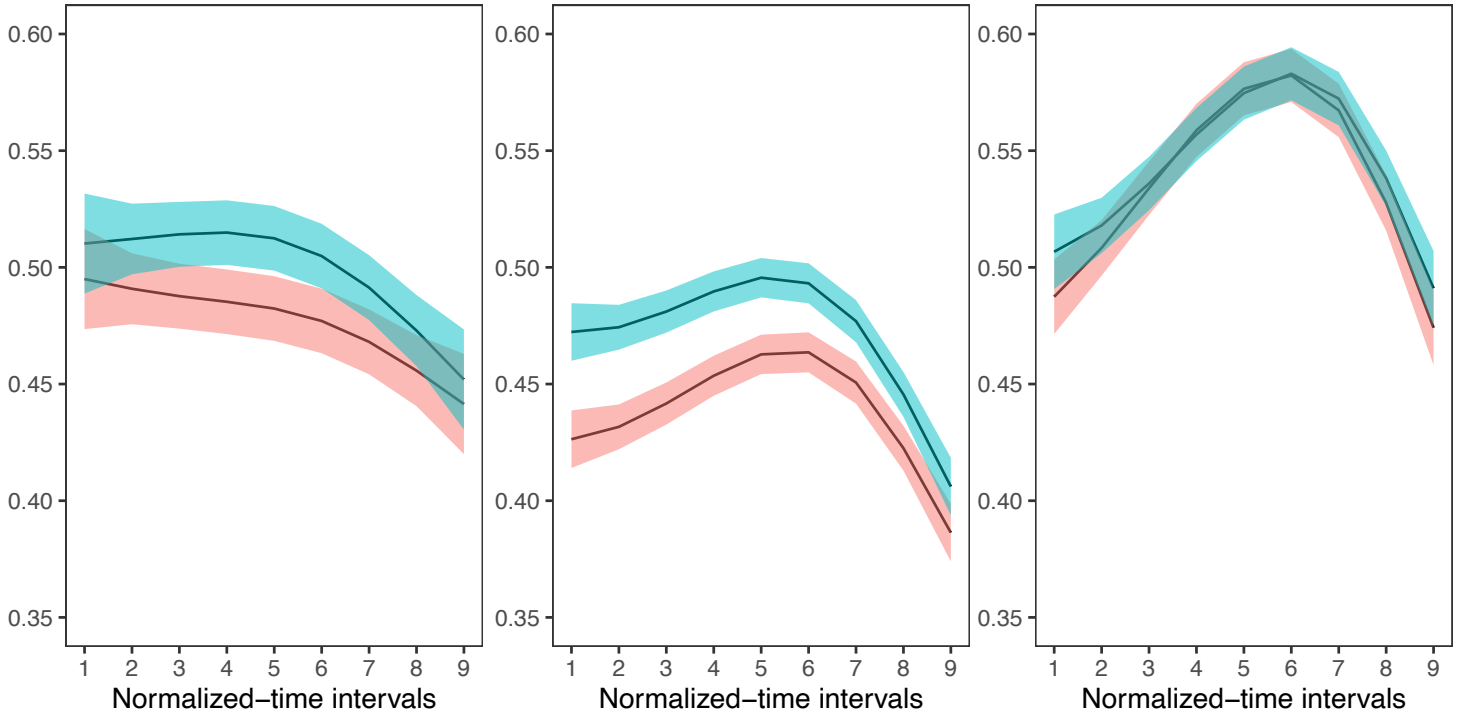
Results (EGG)



SSANOVA results of CQ of /44/ (left), /33/ (middle) and HNR05 (dB) of /212/ (right) carried by nasal (red) and oral (green) vowels.

- CS03F
- Breathier voice:
  - latter half of tone /33/
- Aperiodic voice with tone /212/
  - Nasal vowel has more regular F0

Results (EGG)

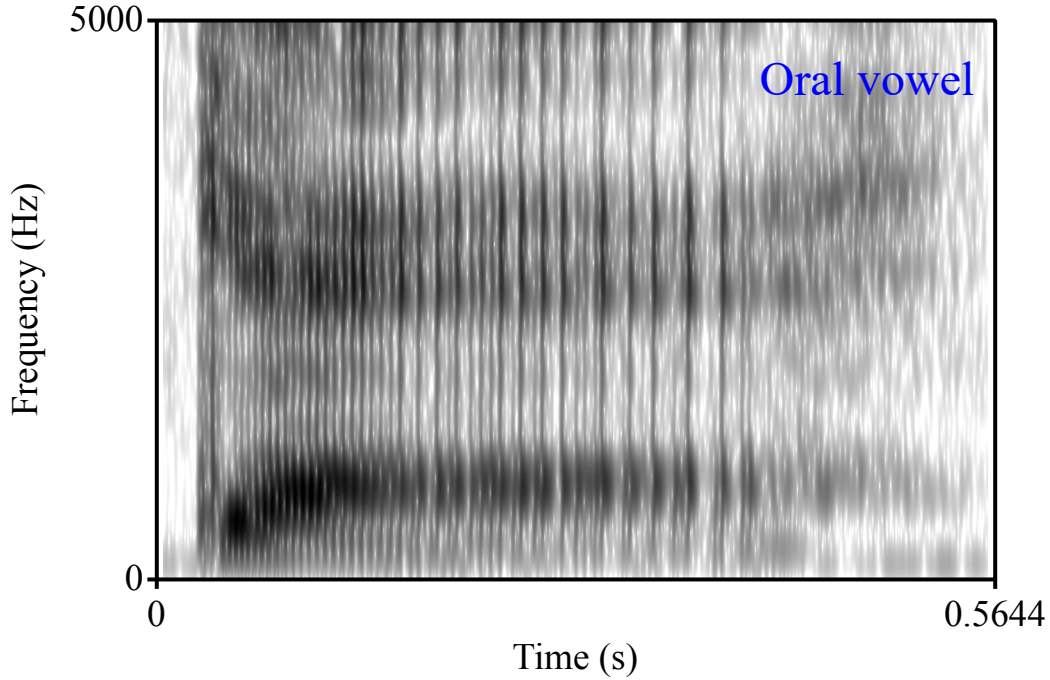


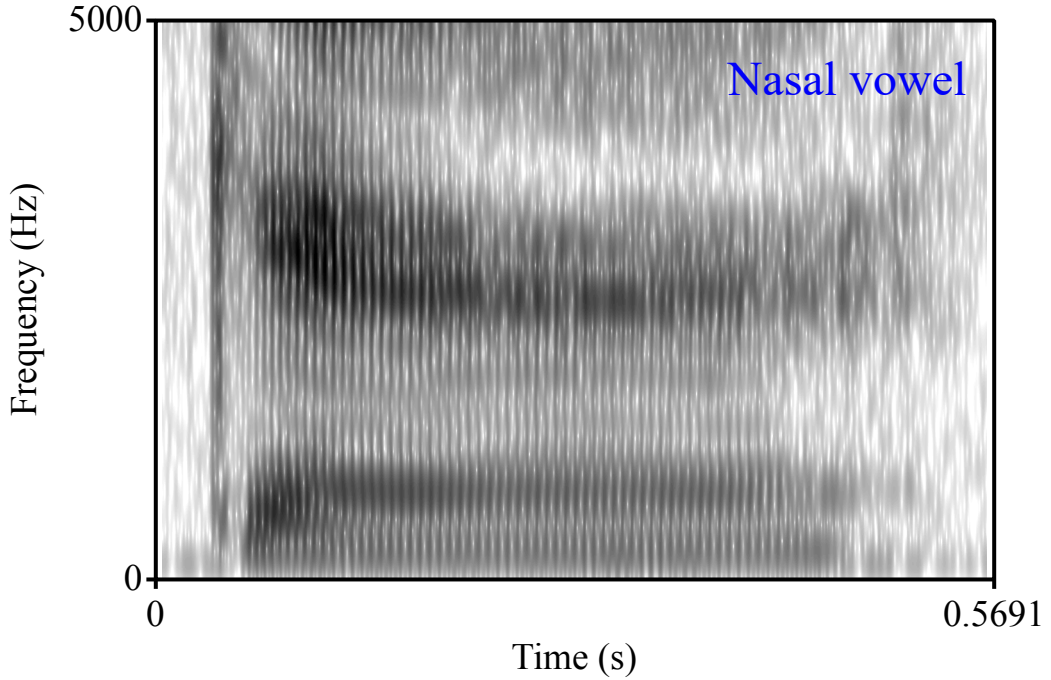
SSANOVA results of CQ of /44/ (left), /33/ (middle) and /212/ (right) carried by nasal (red) and oral (green) vowels.

- CS04M
- Breathier voice:
  - middle part of tone /44/
  - tone /33/
- No breathy voice in the creaky dipping tone

Results (EGG)

- Native speakers of Chaoshan Chinese also use breathier voice in producing nasal vowels
  - variable, not always breathier
- When the tone /212/ is associated with aperiodic voice in the oral vowels, the nasal vowels tend to have more regular F0.





Discussion

- For most speakers, [ɛ̃] and [ã] are produced with higher and more advanced tongue gestures, which were also observed in Hindi and Portuguese
  - keep velo-pharyngeal opening via palatoglossus connection
  - prevent lingual contact with the lowered velum
- For three speakers, [ĩ] is produced with a higher tongue position, which was also found in Brazilian Portuguese
- Some lingual adjustments not for acoustic enhancement, but possibly due to velum lowering or for articulatory enhancement or for acoustic compensation
- For /ĩ/, a higher tongue body won't threaten perceptual cues of nasality but can help maintain [+high] cue

Discussion

- Breathier voice is also used in producing Chaoshan nasal vowels
  - optional and variable (time and tone)

- Tone /212/ with nasality:
  - Creaky voice: no breathier voice
  - Aperiodic voice: more regular F0
  - Modal voice: breathier voice

  - Periodicity may be a requirement for the percept of nasality

Conclusion

- "Minimal difference" assumption is not supported, but lingual adjustments and breathier voice are variable and optional:
  - speaker- and vowel-specific
  - creaky voice can override breathiness typically associated with nasality

- Nasal vowels in Chaoshan Chinese: **oral vowel + [+nasal] (+ vowel- and speaker-specific enhancing or compensatory gestures)**
  - compensatory gestures can be made without threatening the perceptual cues of [+nasal]

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