

Beijing Mandarin nasalization upon rhotic suffixation is phonologized

Kaustubh Ghoshal¹, Christine Gu¹, Zhilang Liu², Felix Fonseca Quesada³,
Gideon Kortenhoven¹, Vitor Lacerda Siqueira¹ and Lisa Davidson¹

¹New York University, ²CUNY Graduate Center, ³Stony Brook University

PART 01

Rhotic suffixation in Beijing Mandarin

Background and literature review

Rhotic suffixation (*erhua*) in Beijing Mandarin

Rhotic suffix overwrites nasal coda

Diminutive /-ɿ/ replaces the coda (if present) and can affect the vowel (Dow 1972, Duanmu 1990, Lin & Wang 1992).

/CV + -ɿ/ → [CVɿ]

/CVn + -ɿ/ → [CVɿ]

/CVŋ + -ɿ/ → [CṼɿ]

Table 1: Rhotic suffixation (Zhang 2000)

Stem	Suffixed	Gloss
p ^h an	p ^h aɿ	‘plate’
p ^h aŋ	p ^h ãɿ	‘side’
əin	əiɿ	‘heart’
əiŋ	əĩɿ	‘star’

Nasalization on vowels is **not lexically contrastive** in Beijing Mandarin.

Where does the difference come from?

Possibility 1: Phonetic difference in stem form nasalization

Different amounts of nasalization in the stem vowel? (Zhang 2000)

/CV_n/ [C[̃]V_n]

/CV_η/ [C[̃]V_η]

Direct reference to phonetic details in the phonology.

Experimental support: Greater nasal airflow in CV_η than in CV_n words.

Limitations: Only two speakers, did not measure suffixed forms.

Where does the difference come from?

Possibility 2: Lexical contrast preservation

Suffixed forms preserve the nasal place contrast in the stem forms:

$$[CV_n] \leftrightarrow [CV_l]$$

$$[CV_\eta] \leftrightarrow [C\tilde{V}_l]$$

Phonological contrast is preserved according to Dispersion Theory (Flemming 1995).

Fu (2022) follows Zhang (2000) in assuming different levels of nasalization, but this is not strictly necessary for an explanation based on contrast preservation.

Experimental support: None for nasalization.

Motivation for the present study

Experimental investigation of nasalization contrast

Aim: Directly measure nasalance in both stem and suffixed forms to investigate the robustness and origin of the nasalization pattern.

Question 1: Is there a significant difference in nasalance between the two types of suffixed forms /CVn + ɹ/ and /CVŋ + ɹ/ as claimed in the literature?

Question 2: Is there a significant difference in nasalance between the stem forms /CVn/ and /CVŋ/, supporting Zhang's (2000) phonetics-based explanation of the pattern?

PART 02

A nasometry study on rhotic suffixation

Experimental details and findings

Methods

Stimuli

- 24 noun stems: 8 CV, 8 CVn, 8 CVŋ
- Each stem used with and without the suffix; total of 48 target items
- All target items had high (55) tone and the low vowel /a/ (e.g., /t͡saŋ/ (55))
- 48 fillers containing different vowels and different tones (e.g., /pʰən/ (35))
- All items were presented in frame sentences in written Chinese.
- All items phrase-medial with same following context.
- Frame sentences also included the rhotic suffix to make the register sound natural.

Methods

Stimuli

Example sentences:

- | | | | | | |
|---------|---------|----------|------------------|---------|-------------|
| 老师 | 教了 | 学生 | “裆儿” | 这个 | 字儿 |
| laoshi | jiao-le | xuesheng | [tan-r] | zhe-ge | zi-r |
| teacher | taught | student | “crotch-R” | this-CL | character-R |

‘The teacher taught the student the character “dangr”.’
- | | | | | |
|--------------------|--------|----------------|---------|-------------|
| 生词表里 | 有 | “帮” | 这个 | 字儿 |
| shengcibiao-li | you | [pan] | zhe-ge | zi-r |
| vocabulary.list-in | exists | “gang” | this-CL | character-R |

‘The vocabulary list has the word “bang” in it.’

Methods

Participants

- 12 native speakers of Beijing Mandarin (10 females, 2 males)
- Lived continuously in Beijing until completion of high school, currently reside in New York
- Participants were paid for their time

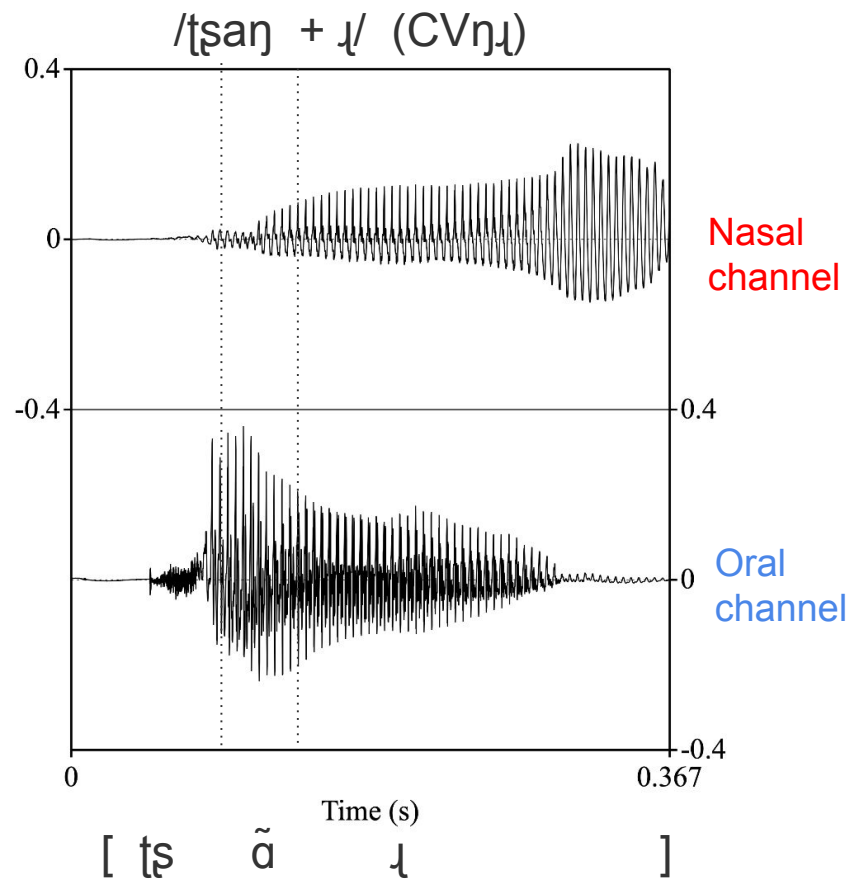
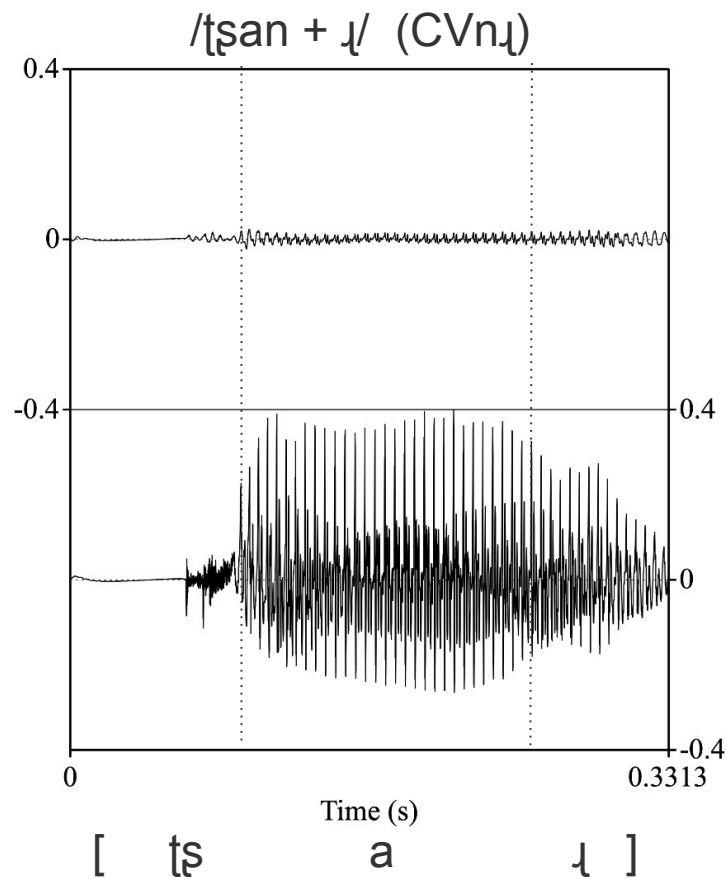
Methods

Experimental setup

- Glottal Enterprises nasometer (NAS-1 SEP Clinic), separately captures nasal and oral channels
- Recorded in a soundproof booth at the NYU Linguistics Department
- Participants held the nasometer themselves and read out the stimuli sentences in a self-paced manner
- Acoustic data analyzed using Praat and R



Sample target items



Data and analysis

The pre-nasal vowel and the nasal stop were segmented for stem forms.
The entire rime (VR) was segmented for suffixed forms.

Nasal and oral intensity (=RMS amplitude) were measured at 50 timepoints per interval, and nasalance was calculated as $A_{nasal} / (A_{oral} + A_{nasal})$ (Carignan 2018)

Nasalance measures analyzed using a linear mixed effect regression (LMER)
Bayesian generalized additive mixed effect models (GAMMs)

- Smooth difference function: nasalance by timepoint
- Main effects: syllable type, onset consonant
- Random effects: word, speaker

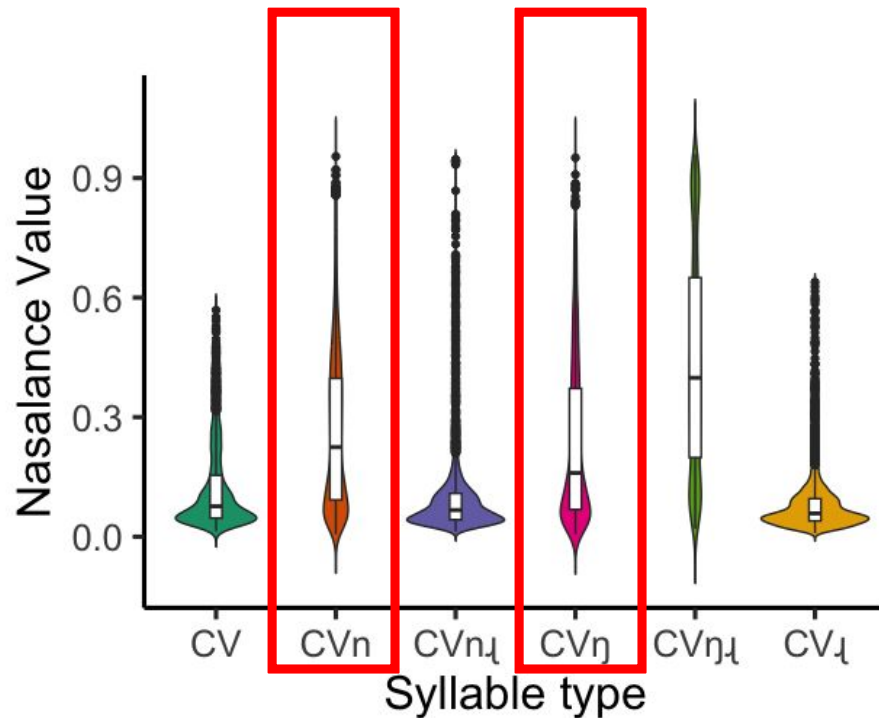
Results

Mean nasalance values over the interval:

- ❖ Stem forms **CV_n** and **CV_ŋ** do not have significantly different nasalance.
- ❖ Suffixed forms **CV_nɿ** and **CV_ŋɿ** have significantly different nasalance.

Contrast	Estimate	SE	p-value
CV _n –CV _ŋ	0.0254	0.0165	0.3865
CV _n ɿ–CV _ŋ ɿ	0.3428	0.0165	<.0001

Output of LMER on mean data



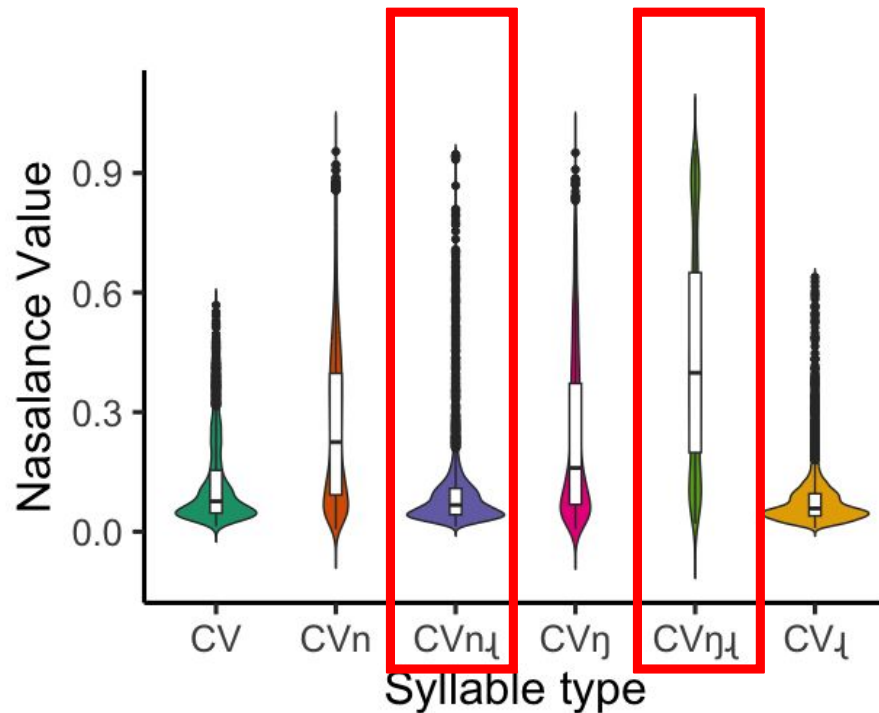
Results

Mean nasalance values over the interval:

- ❖ Stem forms CV_n and CV_η do not have significantly different nasalance.
- ❖ Suffixed forms $CV_n\downarrow$ and $CV_\eta\downarrow$ have significantly different nasalance.

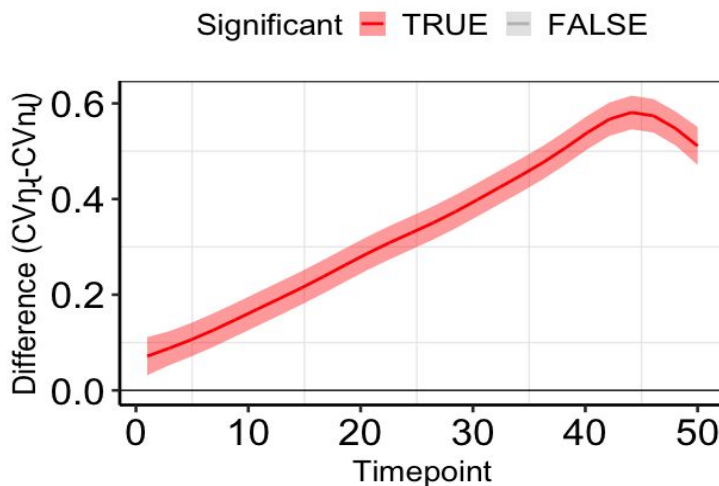
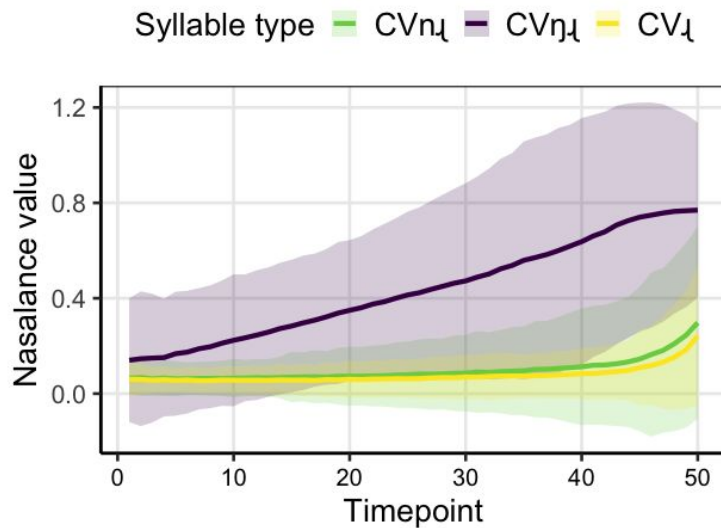
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Results

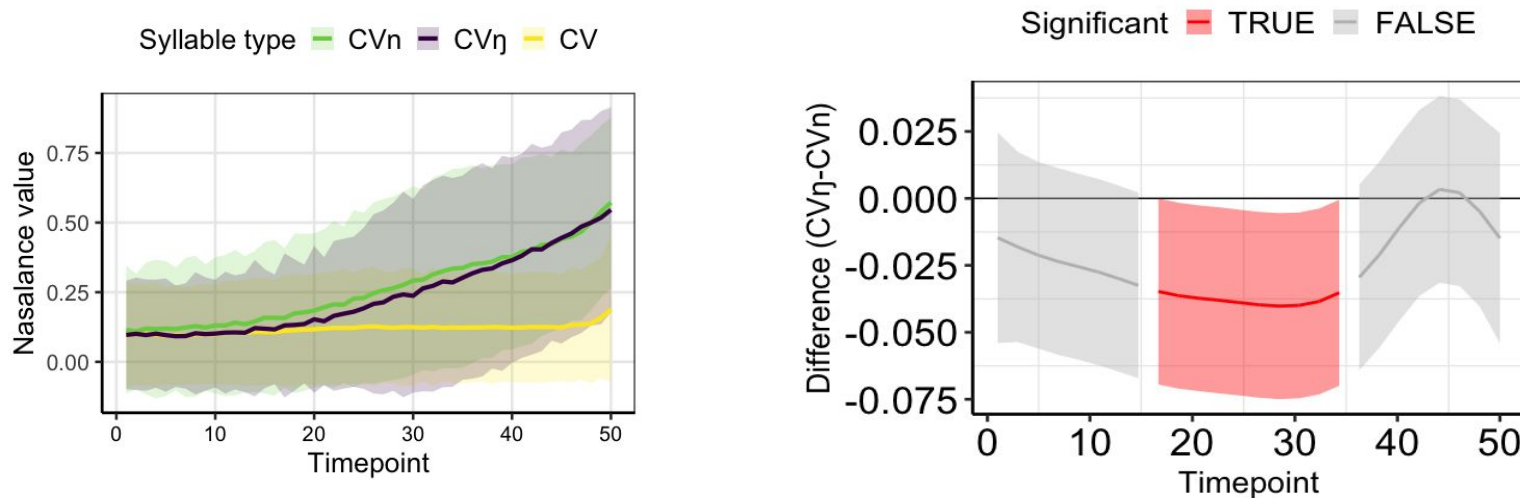
Finding 1: Significant difference in nasalance in suffixed forms. 



- ❖ $CV\eta_l$ has more nasalance (up to 0.6) than CVn_l , which confirms the pattern.
- ❖ Nasalance in $CV\eta_l$ is present **throughout the VR rime**, not just on the vowel.

Results

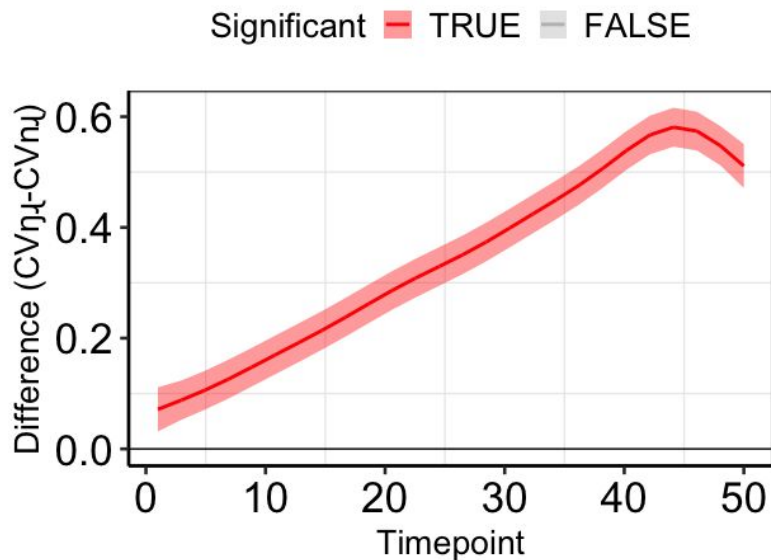
Finding 2: No corresponding difference in nasalance in stem forms. ✗



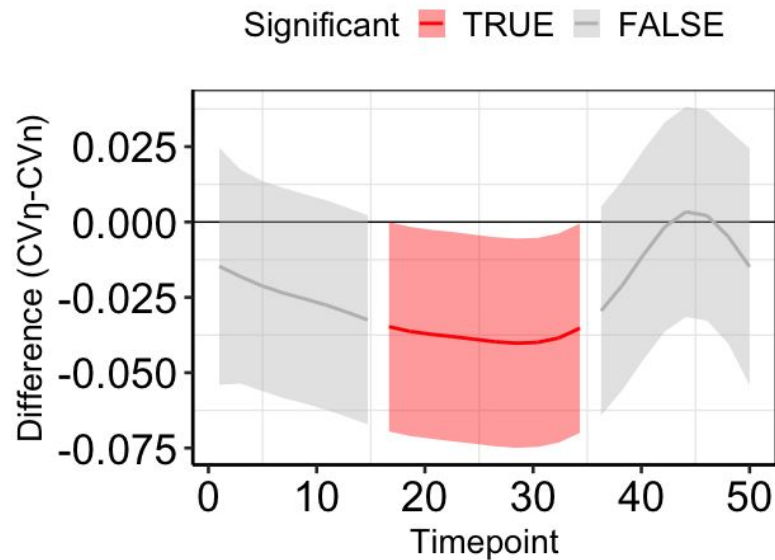
- ❖ Stem forms show a *very small difference* in nasalance in the **opposite** direction to the claim (-0.04): CVn is greater than CV_η.
- ❖ This difference might become nonsignificant with more data.

Results: side by side

❖ Nasalance difference in suffixed forms NOT from stem forms!



suffixed forms: significant difference (0.6)



stem forms: no difference (-0.04)

Summary

Question 1: Is there a significant difference in nasalance between the two types of suffixed forms /CVn + ɹ/ and /CVŋ + ɹ/ as claimed in the literature?

YES!

Question 2: Is there a significant difference in nasalance between the stem forms /CVn/ and /CVŋ/, supporting Zhang's (2000) phonetics-based explanation of the pattern?

NO!

Discussion

Opacity of pattern, no direct phonetic explanation:

- Contra previous claims (Duanmu 1990, Zhang 2000), there is no phonetic difference in the nasalance of stem vowels to cue the difference in their suffixed forms.
- There may have been a direct phonetic source for the pattern at the time of the previous studies, but this no longer exists for speakers **synchronically**.
- Lexical contrast preservation (i.e., avoidance of homophony) could be the pressure that causes this synchronically opaque pattern to persist.

Conclusion

Beijing Mandarin rhotic suffixation is an opaque phonological alternation.

- Beijing Mandarin rhotic suffixed forms show a difference in nasalization *throughout the rime*, dependent on the place of the stem nasal:

/CVn + -ɹ/	[CVɹ]
/CVŋ + -ɹ/	[C [̃] V [̃] ɹ]

- This difference *cannot* be attributed to a nasalance difference in their stem forms, which suggests the pattern is *phonologized*.
- This alternation may be due to the pressure of *contrast preservation*, even though vowel nasalization is not phonemic in Mandarin.

Thank you!

Acknowledgements

- ❖ Members of the NYU PEP Lab
- ❖ Sang-Im Lee Kim and He Yu, Experimental Phonetics & Phonology Lab, Hanyang University
- ❖ All our participants!

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Rhotic suffixation (*erhua*) in Beijing Mandarin

Rhotic suffixation: phonetics

Both retroflex and bunched variants of rhotic (King & Liu 2017, Chen & Mok 2021) depending on speaker.

Centralization and backing of pre-rhotic vowel (Liu 2019, Fu 2022, Wang & Sabev 2023).

Sociolinguistically salient variable indexing region and identity (Zhang 2008).

Beijing Speaker			Stem Rhymes			Suffixed Rhymes		
Onset	Tone	F2(Hz)	/an/	/a/	/aŋ/	/an-r/	/a-r/	/aŋ-r/
/p/	Falling	Mean	1605.82	1433.95	1545.62	1388.15	1378.29	1565.58
		s.d.	104.83	127.88	153.93	24.21	30.71	43.97
/tʂ ^h /	Low	Mean	1828.00	1882.02	1628.09	1450.05	1455.14	1538.79
		s.d.	129.12	40.82	19.66	31.47	28.47	25.45
/f/	High	Mean	1630.46	1560.24	1442.34	1321.50	1407.44	1419.65
		s.d.	110.22	289.46	77.85	112.55	63.80	77.52

Table 3: mean F2 and for stem and suffixed rhymes in Beijing.

Fu (2022): effect of rhotic suffix on low vowel F2