

# An acoustic study of Mandarin rhotic suffix

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## Abstract

In this study, I examine the effects of Mandarin rhotic suffix on the quality of the preceding vowels. Results from a comprehensive acoustic study including monophthongs, diphthongs, and nasal codas show that the rhotic suffix centralizes the preceding vowels, and lowers their F3, across the board. In addition, /i/-final diphthongs and /u/-final diphthongs show different effects of the suffix. Also, adding suffix deletes the alveolar nasal coda /n/, but not the velar coda /ŋ/.

Key words: Mandarin, rhotic suffix, acoustics, vowel quality

## Introduction

Mandarin rhotic suffix /ə/ (儿 "child") is historically a diminutive marker. In contemporary Mandarin, it lost its grammatical function and became a stylistic marker, which is often considered as a feature of Beijing dialect (Duanmu 2007, Chao 1968) or the speech of Mandarin speakers from northern China (Lu 1995). Previous studies on this suffix primarily focus on its phonological behavior (e.g., Duanmu 2007, Tian 2007). According to Duanmu (2007), Mandarin allows up to two segments in rime, and the rhotic suffix adds to the coda position. When the stem already has two rime segments (e.g., nasal coda or diphthong), the last segment of the stem differ from [retroflex] is replaced by the rhotic (e.g., /an/+r/→/a<sup>r</sup>/; /ai/+r/→/a<sup>r</sup>/). Although the previous studies explain the phonological behavior of this suffix, they pay little attention to the phonetic aspects of the rhotic suffix. This study aims to provide a more comprehensive analysis on the acoustic consequences of the rhotic suffix on the quality of the preceding vowels, including the stem syllables with a nasal coda or a diphthong, to which the phonological analyses draw specific attention. To my knowledge, Huang (2010) is the only study that examines the acoustic consequences of rhotic suffix on the preceding vowels, but it is limited only to monophthongs.

## Methods

### Participants and stimuli

Participants were 13 Mandarin native speakers (4M/9F, age range: 25-30), 11 of whom were from Shenyang (northern China) and 2 from Hebei (near Beijing). Shenyang speakers were recorded in a quiet room in Shenyang, with Edirol by Roland (R-09HR) recorder. Hebei speakers were recorded in Paris, in a sound-attenuated booth, using a notebook

PC, an external microphone (Audio Technica AE4100), and a preamplifier (Roland Quad-Capture). All participants speak English as the second language. Three of the participants, including the two who were tested in Paris, have learned French in the university. Another two have learned Japanese in the university.

Stimuli were 78 Mandarin words, a half of which had the rhotic suffix while the other half did not. The stimuli included 13 possible rimes of Mandarin /a, i, u, y, ɤ, ai, əi, au, əu, an, aŋ, əŋ, uŋ/ preceded by an onset consonant /t/, with the exception of /y/: /l/ was used before /y/ because Mandarin phonotactics does not allow /ty/. Three tones of Mandarin (T1, T2, and T4) were included in the current study. Tone 3, the low-dipping tone, was excluded because it is usually realized with a creaky voice (e.g., Belotel-Grenié and Grenié 1994), which makes it not suitable for formant analyses.

Participants were asked to produce each stimulus in a carrier phrase "wo<sub>214</sub> ba<sub>214</sub> \_\_ xie<sub>214</sub> hao<sub>214</sub>" (/wɔ<sub>214</sub> pa<sub>214</sub> \_\_ ɕjɛ<sub>214</sub> xau<sub>214</sub>/ "I write \_\_ well."). The stimuli were repeated five times in a random order.

## Measurements

Formants (F1, F2, F3) were measured for each vowel of all stimuli. First, the vowels were segmented from the onset of F1, to the offset of F2 (rimes without the rhotic suffix and diphthongs with the suffix), or to the onset of F3 drop (monophthongs with the suffix). Then, for monophthongs, formants were taken at the temporal midpoint of each vowel (Zee and Lee 2001) by hand. For diphthongs, formants were extracted at every 5% point of the duration of the vowel in Praat (Boersma and Weenink 2017).

## Results

### Monophthongs

Figure 1 shows the F1 and F2 of the monophthongs with and without the suffix. The vowel space reduced with the rhotic suffix. Statistical results from linear mixed effect models (predictors: suffix condition, tone, gender; by-speaker random intercept) suggest that the rhotic suffix changed the preceding vowel quality in terms of F1, F2, and F3. First, F1 significantly increased with suffix for the non-low vowels /i, u, y, ɤ/ and decreased for the low vowel /a/ ( $p$ 's < 0.0001). Second, F2 became significantly higher for the back vowels /u, ɤ/ and lower for the front vowels /i, y/ ( $p$ 's < 0.0001). The effect of suffix on /a/'s F2 interacted with speaker gender: F2 increased for males but decreased for females. This may be due to the gender difference in /a/'s F2 without the suffix (see Figure 1, top and bottom left). Finally, the suffix significantly decreased F3 for all the monophthongs ( $p = 0.0005$ ).

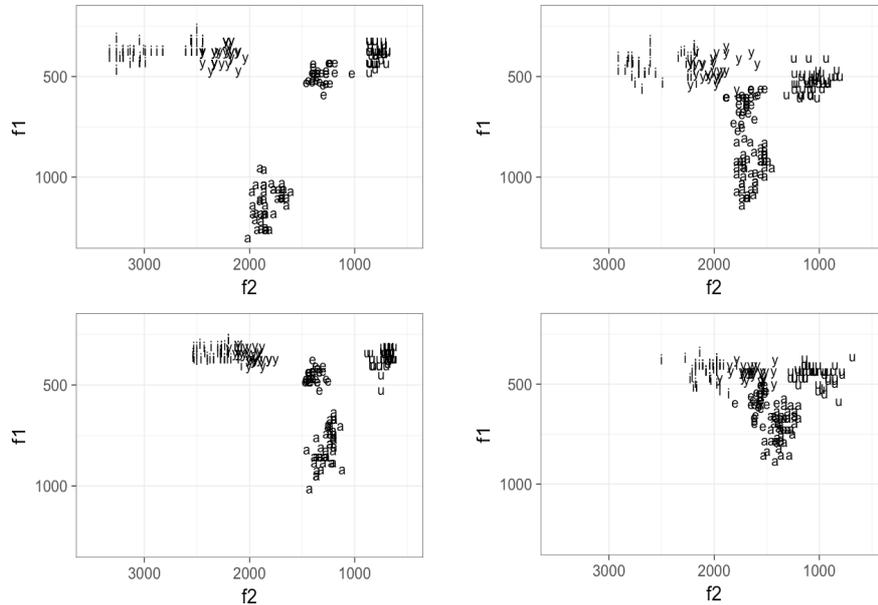


Figure 1. F1 and F2 of females (top) and males (bottom) with (right) and without (left) suffix.

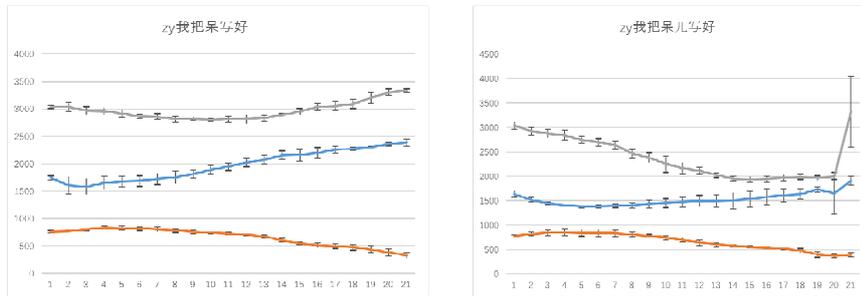


Figure 2. Formant trajectories for /ai/ without (left) and with the suffix (right).

**Diphthongs and nasal codas**

All four diphthongs /ai, əi, au, əu/ show a decrease in F3 from early on. When the suffix was added to the diphthongs ending on /i/ (/ai, əi/), F2 decreased whereas F1 did not seem to change (Figure 2). The suffix did not change F1 and F2 of the diphthongs ending on /u/ (/au, əu/, Figure 3).

On the other hand, the alveolar nasal coda /n/ deleted when the suffix was added, and the preceding vowel /a/ changed just like the monophthong /a/ (i.e., F1 decrease, F3 decrease). The velar nasal coda /ŋ/ was retained, but the rhotic suffix changed the preceding vowels, mainly by lowering their F3.

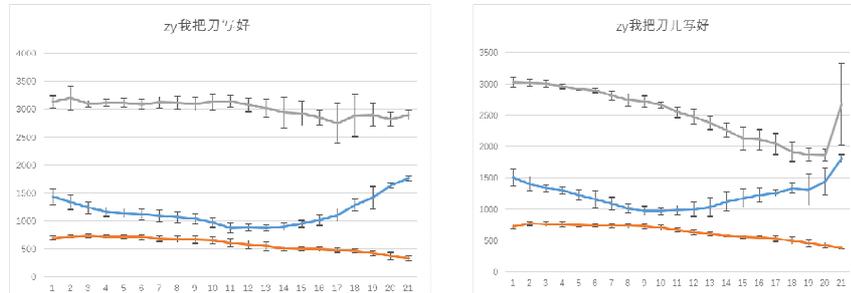


Figure 3. Formant trajectories for /au/ without (left) and with the suffix (right).

## Conclusions

In summary, the rhotic suffix centralizes the preceding vowels in terms of F1 and F2 while lowers their F3. This study finds that the rhotic influenced all the monophthongs, unlike Huang (2010). The current results on diphthongs and nasal codas provide acoustic evidence for the previous phonological studies (e.g., Duanmu 2007). Future study will aim to investigate the underlying reasons for different behaviors of /i/-final and /u/-final diphthongs and alveolar and velar nasal codas.

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