VOWEL EFFECTS ON THE PERCEPTION OF NASAL PLACE OF ARTICULATION IN WUXI WU AND FUQING MIN

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ABSTRACT

Both Wuxi Wu and Fuqing Min have only one coda nasal, respectively /n/ and /ŋ/. However, Wuxi allows allophones depending on the pre-nasal vowel while Fuqing has been described as somewhat fronting toward /ɲ/. This study investigates how Mandarin speakers, whose native language has two phonemes of coda nasal /-n/ and /-ŋ/, perceptually identify place of articulation of coda nasals in three age groups' production of Wuxi Wu and Fuqing Min. The results of forced-choice identification tasks show that nasals after /o/ and nasal vowel /ɔ̃/ in Wuxi were identified as /ŋ/ while nasals after /i/ and /ə/ and nasal vowel /ã/ were identified as /n/. In contrast, nasals in Fuqing were identified as /ŋ/ only after /u/ and /o/ but mainly as /n/ after /i/, /y/, /e/, /ø/ and /a/. Surprisingly, older group's production was identified with more /ŋ/s than mid-age and younger groups' in both languages.

Keywords: coda nasal, vowel, coarticulation, perception, Chinese languages

1. INTRODUCTION

There were three coda nasals in old Chinese—bilabial /m/, alveolar /n/ and velar /ŋ/. However, coda nasals in Chinese have been experiencing a merger process. Although some modern Chinese languages, such as Cantonese, Haka and Southern Min, still preserve all the three coda nasals, some have lost the /m/ coda, such as Mandarin, Gan and Xiang, and others only preserves either /n/ or /ŋ/ [2, 17].

Wu is a Chinese language spoken in Shanghai City, Zhejiang Province and the southern part of Jiangsu Province. Most researchers agree that there is no /n/ vs. /ŋ/ contrast in syllable coda in Wu [1, 11, 13]. In some dialects, such as Shanghai and Wenzhou, the coda nasal is more backward like /ŋ/, while in other dialects, such as Suzhou, more frontward like /n/, or even simply concomitant with a velum opening when producing the vowel and thus like a nasalized vowel, such as Changshu. However, the nasal place of articulation (POA) mainly depends on the quality of the preceding vowel [11, 12].Wuxi Wu has all the three above-mentioned nasal qualities and they have been documented with monophthongs as /ã/, /ɔ̃/, /in/, /ən/, /oŋ/ and considered with more /n/ finals in its syllable structures [14, 18].

Fuqing Min is a dialect of Eastern Min. Standard Eastern Min is spoken in Fuzhou, the capital of Fujian Province. The phonology of Fuqing dialect is close to that of Fuzhou dialect, except for slight differences in diphthongs, tone values and tone sandhi rules [10]. Min is primarily known for Southern Min, the language spoken in the southeast of China, mainly around the cities of Quanzhou, Xiamen and Zhangzhou. However, Eastern Min and Southern Min has no mutual intelligibility. Southern Min has the complete three coda nasals /m/, /n/ and /ŋ/ while Eastern Min has only one coda nasal /ŋ/. The coda nasal in Fuqing has been claimed to be fronting toward /ɲ/ [7].

The uncertainty and instability of nasal POA in Wuxi and Fuqing are presumably attributed to the quality of pre-nasal vowels due to the vowel-nasal coarticulation. Vowels have been found to affect the POA of adjacent consonants [6]. These coarticulated acoustic cues facilitate the perception of phonetic contrasts that are correlated to the neighboring sounds [15]. The coarticulatory cues on neighboring vowels specifically influence the perception of POA for nasals [9]. Previous studies have revealed that vowel quality has a strong impact on the nasal place identification [5, 16] and the identification of /n/ and /ŋ/ codas could be language-specific [4]. Therefore, this study is interested in whether vowel quality impacts the nasal POA in Wuxi and Fuqing and whether this impact can be mirrored by the perception of Mandarin speakers, whose native language has both /n/ and /ŋ/ codas.

Diaglossia happens in both Wuxi and Fuqing. All residents in Wuxi and Fuqing are societal bilinguals. Wuxi speakers learn Wu first and Mandarin follows. Fuqing speakers also learn Mandarin as a second language (L2) but Eastern Min is their first language (L1). However, with the national popularization of Putonghua (standard Mandarin) in school education and mass media, younger bilinguals speak more Mandarin in daily life than the old generation. The close contact with Mandarin may result in sound change of the only coda nasal in Wuxi and Fuqing. Therefore, this study is also interested in whether there is a sound change of coda nasal over age group in Wuxi and Fuqing, which could also be mirrored by the perception of native Mandarin speakers.

2. EXPERIMENT 1: WUXI WU

This experiment examines the perception of coda nasal in Wuxi Wu by Mandarin speakers.

2.1. Methods

2.1.1. Participants

Eighteen native Wuxi Wu speakers were recruited from the urban area for three age groups: younger, mid-age and older (age around 25, 50 and 70). Each group has three males and three females. All speakers were born and raised in Wuxi and speak Mandarin as L2. Mid-age and older speakers have lived in Wuxi for over 30 years and use Wuxi dialect in daily communication. Younger speakers speak Wuxi dialect at home but Mandarin mainly in social communication.

Twenty native Mandarin speakers (mean age 24.1 years) who were born and raised in northern China were recruited as listeners. None of them speak other Mandarin varieties or other Chinese languages. All participants are familiar with the Romanization convention for /n/ and /ŋ/, which are noted as 'n' and 'ng' respectively in Pinyin script.

2.1.2. Stimuli

The stimuli were high-frequency words and selected from [13]. All the fifteen monosyllabic words are high-level tone (marked "44" in the five-scale system of tone values) and respectively consist of three consonants /ts/, /tsʰ/ and /s/, three vowels /i/, /ə/ and /o/ with the nasal coda or nasal vowel /ã/ and /õ/. The stimulus syllables were tentatively transcribed as follows: /tsʰiN/, /tsiN/, /siN/, /tsʰaN/, /tsaN/, /saN/, /tsʰəN/, /tsəN/, /səN/, /tsʰɒN/, /tsɒN/, /sɒN/, /tsʰoN/, /tsoN/, /soN/. The target words were embedded in a carrier sentence /x, tsəʔ kəʔ zɨ dəʔ x/ 'x, this character is read as x' in the production experiment. The first "x" in the carrier sentence was extracted as the target item for the perception experiment.

2.1.3. Procedure

Each speaker recorded 75 target tokens (5 vowels × 3 consonants × 5 repetitions) in the carrier sentence in a random order with natural voice and normal speech rate. The stimuli were recorded in a quiet room in mono channel by a Marantz PMD661 recorder and a Shure SM10A-CN head-worn microphone and digitized onto an SD card to save on a personal computer.

The perception experiment was conducted in a sound-attenuated booth. The third repetition of the production experiment was selected as the stimuli of the perception experiment. The intensity of the stimulus words was RMS (root mean square) normalized to 70 dB. Stimuli were presented in a random order using the Praat ExperimentMFC program with Sony MDR-7506 professional studio headphones. Listeners were asked to participate in a forced-choice identification task to judge the nasal type (either 'n' or 'ng') by clicking the corresponding button on the computer screen.

2.2. Results

A logistic regression was conducted to determine the relationship between listeners' responses (two levels: /n/, /ŋ/) and the two independent variables—vowel (five levels: /a/, /ə/, /i/, /o/, /ɒ/) and age (three levels: younger, mid-age, older), using R (version 3.5.0). The /n/ response was set as the reference level since it is documented more than /ŋ/ and nasal vowels in Wuxi. The vowel /a/ was set as the reference level because the nasal vowel /ã/ was heard as the most /n/ codas among the five vowels. The older group was set as the reference level because older speakers were considered as the most conservative speaker group.

The statistical results are reported in Table 1. Mandarin listeners' identifications of Wuxi nasal production of the younger group are significantly different from that of the older group; however, there was no statistical difference between the mid-age and older groups. Except for /ə/, the nasal identifications with /i/ and /o/ and the nasal vowel /õ/ show highly significant differences from that of the nasal vowel /ã/. Another set of logistic regression, taking the mid-age group as the reference level, reveals that the younger group demonstrates a marginal difference from the mid-age group ($p = 0.069$).

Table 1: Logistic regression results of nasal identification by vowel and age in Wuxi Wu.

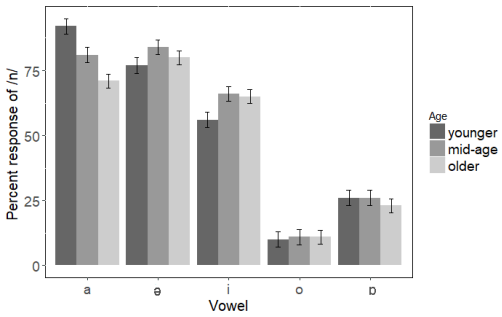
	Est.	*SE*	*z*	*p*
(Intercept)	1.303	0.093	13.964	0.000
ə	-0.033	0.109	-0.304	0.761
i	-0.929	0.101	-9.240	0.000
o	-3.538	0.125	-28.332	0.000
ɒ	-2.530	0.105	-24.030	0.000
mid-age	0.127	0.081	1.559	0.119
younger	0.277	0.083	3.344	0.001

The percentage of /n/ responses in the identification task by vowel type and age group was then plotted in Figure 1.

3. EXPERIMENT 2: FUQING MIN

This experiment examines the perception of coda nasal in Fuqing Min by Mandarin speakers.

Figure 1: Percent responses of /n/ by vowel and age in Wuxi Wu.



3.1. Methods

3.1.1. Participants

Twelve native Fuqing speakers were recruited for three age groups: younger, mid-age and older (age around 20, 50 and 70). Each group has two males and two females. All speakers were born and raised in Fuqing and speak Mandarin as L2. Similar to Wuxi speakers, younger Fuqing speakers use more Mandarin in daily communication than mid-age and older speakers.

Another group of native Mandarin speakers with the same language background and similar education background as in Experiment 1 were recruited to serve as the listeners (mean age 23.5 years).

3.1.3. Stimuli

The stimuli were fourteen real monosyllabic words selected from [7] and consisted of seven vowels /a/, /e/, /ø/, /i/, /y/, /o/, /u/ and two tones 33 (mid-level) and 55 (high-level). The stimulus words were transcribed as /kaŋ33/, /keŋ33/, /køŋ33/, /kiŋ33/, /kyŋ33/, /koŋ33/, /kuŋ33/, /aŋ55/, /eŋ55/, /øŋ55/, /iŋ55/, /yŋ55/, /oŋ55/, /uŋ55/. These words were embedded in a carrier sentence /x, tsie si kaʔ x tse / 'x, this is the character x'. The twelve Fuqing speakers were asked to read these stimulus sentences five times. The first "x" in the carrier sentence was extracted from the first and second repetitions to make up the stimuli for the perception experiment. This procedure generated 336 tokens (2 tones × 7 vowels × 2 repetitions × 12 speakers) for the nasal identification task.

3.1.3. Procedure

The production and perception experiments were conducted in the same procedure as in Experiment 1.

3.2. Results

Another set of logistic regression was conducted in R to analyse the results of Fuqing nasal identification. Mandarin listeners' responses (two levels: /n/, /ŋ/) were set as the dependent variable. Vowel (seven levels: /a/, /e/, /i/, /o/, /ø/, /u/, /y/), age (three levels: younger, mid-age, older) and tone (two levels: 33 and 55) were set as the independent variables. The /ŋ/ response was set as the reference level. Tone 33, vowel /u/ and the older age group were set as the reference level because the /ŋ/ responses to these categories were more than those to other categories within the same variable.

The statistical results are reported in Table 2. Mandarin listeners' identifications of Fuqing nasals of both younger and mid-age groups demonstrate significant differences from that of the older group. All other vowels demonstrate highly significant differences of the post-vocalic nasal identification from the vowel /u/. However, the nasal identification of Tone 55 was not statistically different from that of Tone 33. Another set of logistic regression, taking the mid-age group as the reference level, also shows that the younger group demonstrates a significant difference from the mid-age group (p = 0.006).

Table 2: Logistic regression results of nasal identification by vowel and age in Fuqing Min.

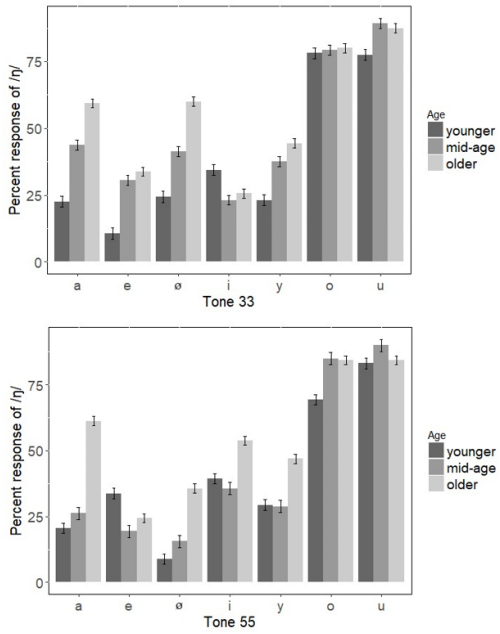
	Est.	*SE*	*z*	*p*
(Intercept)	2.275	0.106	21.426	0.000
tone 55	-0.075	0.055	-1.359	0.174
a	-2.261	0.114	-19.830	0.000
e	-2.905	0.119	-24.401	0.000
ø	-2.625	0.116	-22.566	0.000
i	-2.422	0.115	-21.082	0.000
y	-2.436	0.115	-21.189	0.000
o	-0.418	0.122	-3.425	0.001
mid-age	-0.485	0.067	-7.216	0.000
younger	-0.828	0.069	-12.033	0.000

The percentage of /ŋ/ responses in the nasal identification task by vowel type and age group was then plotted separately by tone in Figure 2.

4. DISCUSSION

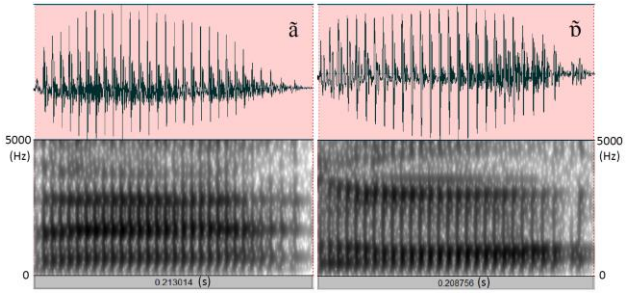
Experiment 1 indicates that nasals after /i/ and /ə/ and the nasal vowel /ã/ in Wuxi were mostly heard by Mandarin speakers as /n/ whereas the nasals after /o/ and the nasal vowel /õ/ were mainly identified as /ŋ/. This finding is not surprising since coda nasal in Wu has been argued to have allophones determined by the pre-nasal vowel [11, 12]. The POA of the alveolar nasal /n/ is closest to the tongue position of the central vowel /ə/ in these three vowels and closer to that of the front vowel /i/ than that of the back vowel /o/. The vowel /o/ is far back so as close to the POA of the velar nasal /ŋ/.

Figure 2: Percent responses of /ŋ/ in Tone 33 by vowel and age in Fuqing Min.



The nasal vowel /ã/ was heard as /n/ and /ɔ̃/ as /ŋ/ in the forced-choice identification task. Both /ã/ and /ɔ̃/ show nasalized vowel quality and with no ending of nasal murmur in the spectrogram as in Figure 3. However, /ã/ was heard mostly with the alveolar nasal /n/. This deviates from the finding that English speakers identified French nasalized vowels /ə̃/, /ɛ̃ɪ/ and /ɔ̃/ mostly as /ŋ/ [8]. This difference may be due to the vowel quality of /ã/ in Wuxi being more like the vowel /æ/ in /æn/ than the vowel /ɑ/ in /ɑŋ/ in Mandarin ("an" and "ang" in Pinyin). Mandarin listeners identified it based on their L1 experience.

Figure 3: Sample spectrograms of nasal vowel /ã/ and /ɔ̃/ in Wuxi.

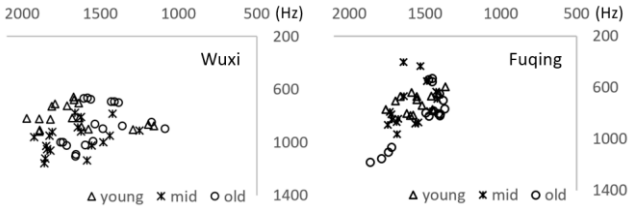


Although the mid-age group did not demonstrate a difference in their nasal production from the older group and only the younger group showed a difference from the old group in general, the younger group's production with /i/ and /ə/ were heard with more /ŋ/s than the other two groups. This may be attributed to the language contact with Mandarin. The younger group uses more Mandarin than the other two age groups. Surprisingly, their productions of /ã/ were heard with more /n/s than those of the older and mid-age groups. The left panel of Figure 4 reveals that the younger group's productions of /ã/ is further front than those of other groups.

Experiment 2 indicates that only the nasals following back vowels /u/ and /o/ were mostly identified as /ŋ/. Nasals after front vowels /a/, /e/, /ø/, /i/, /y/ were mainly heard as /n/. These findings, similar to Wuxi, support again the argument that vowel quality impacts on the perception and production of coarticulated neighboring nasals [3, 9].

Although the coda nasal in Fuqing has been argued as fronting toward /ɲ/ [7], older speakers' productions of front vowels were identified with more /ŋ/s than those of younger and mid-age speakers, suggesting older speakers are more conservative in the process of language contact and even sound change. The right panel of Figure 4 takes /a/ for example to show that the older group's productions were either further back or much lower than the productions of the younger and mid-age groups. This could contribute to Mandarin speakers identifying the nasals after the older speakers' productions of /a/ more as /ŋ/. On the other hand, younger speakers' productions of back vowels were identified with more /n/s than those of mid-age and old groups, suggesting the influence of L2 Mandarin on the young generation's production of L1 Fuqing Min.

Figure 4: Scatter plots of the mid-point F1 and F2 values of /a/ in Wuxi and Fuqing by age group.



5. CONCLUSIONS

The two experiments have found that Mandarin speakers identified the POA of nasals in both Wuxi and Fuqing based on the quality of pre-nasal vowels. Front and central vowels resulted in more /n/ identifications whereas back vowels resulted in more /ŋ/ identifications. Younger speakers produced more Mandarin-like vowels and vowel-nasal coarticulation, which resulted in more Mandarin-like nasal identifications in both languages. Further studies of nasal acoustics and articulation in Wuxi and Fuqing will be conducted to compare with those in Mandarin for insight to the sound change over language contact.

6. ACKNOWLEDGEMENT

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7. REFERENCES

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