PERCEPTUAL CONFUSABILTIY OF WORD-FINAL NASALS IN SOUTHERN MIN AND MANDARIN: IMPLICATIONS FOR CODA NASAL MERGERS IN CHINESE

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ABSTRACT

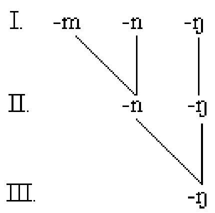
The relative perceptual confusability of the coda nasals /m/, /n/, and /ŋ/ was investigated in Southern Min and Mandarin for insight into the nasal mergers that have happened in the history of the Chinese languages. Coda /m/ was the most confusable of the nasals, mirroring the historical pattern in which the bilabial was the first coda nasal to be lost. In both Southern Min and Mandarin, the alveolar and velar nasals were mutually confused. Identification of coda nasals was affected by the preceding vowel; there was lower accuracy following the high front vowel /i/ than other vowels. Tone did not have any consistent effects on nasal identification, although Southern Min speakers tended to have less accurate identification of nasals with low tones.

Keywords: perceptual confusability, coda nasal, nasal merger, Chinese languages

1. INTRODUCTION

Three types of syllable-final nasals, bilabial /m/, alveolar /n/ and velar /ŋ/, have undergone a merger process from Middle Chinese to Modern Chinese [1, 8]. Some Chinese languages (Cantonese, Hakka, Southern Min) preserve all three coda nasals /m, n, ŋ/, others (Mandarin, Xiang, Gan) preserve only /n, ŋ/, while others (Jin, Wu, Eastern Min) preserve only /ŋ/. Chen [1] proposed a unidirectional (anterior-to-posterior) process of syllable-coda nasal merger in Chinese dialects. (See Figure 1.)

Figure 1: The unidirectional pattern of coda nasal merger in Chinese languages. (Redrawn from [1] p.102)



However, Zee [8] argued that -m>-n and -ŋ>-n were the major merger trajectories while -n>-ŋ was a minor tendency.

The merger process of syllable-final nasals has arisen from historical sound changes in Chinese languages. From a listener-oriented point of view, sound change occurs in the transmission of speech from speaker to listener [3, 4]. The pattern of merger and loss, /m/ > /n/ > /ŋ/ (or /m/ > /ŋ/ > /n/), may be due to a hierarchy of perceptual confusability among the coda nasals. This study examines the perception of coda nasals in two Chinese languages: Southern Min, which preserves all the three coda nasals, and Mandarin, which preserves only coda /n/ and /ŋ/.

Vowel quality has been found to affect the perceptual confusability of coda nasals in English and Mandarin [2, 6, 7]. Based on this previous work, the high front vowel /i/ was predicted to result in more, and the low vowel /a/ to result in fewer, misidentifications of coda nasals. Additionally, as segments over which tone is realized, coda nasals have been found to affect the production of lexical tone in Zhenhai Chinese [5]: The height and shape of F0 varied in relation to the duration of coda nasal /ŋ/. At the same time, coda nasal /ŋ/ was audibly longer in syllables with low and mid concave tones than in those with high falling and low convex tones. In this study, tone was included as an exploratory variable in coda-nasal perception.

2. METHODS

2.1. Experiment 1: Southern Min

2.1.1. Subjects

Nineteen native speakers of Quanzhou Southern Min were recruited: four talkers and fifteen listeners. All listeners, as college students, were familiar with the Latin alphabetic notations for /m/, /n/, and /ŋ/ as ‘m’, ‘n’ and ‘ng’.

2.1.2. Stimuli

Block 1 of the stimuli was designed to investigate the effect of vowel on the perception of coda nasals. Eight real words that consisted of three nasal coda types and three vowel types, all with mid-level tone were used: /sim33/, /sin33/, /siŋ33/, /səm33/, /səŋ33/, /sam33/, /san33/ and /saŋ33/ (/-ən/ was not included, as it is not found in Southern Min). Each word was recorded five times by the four talkers, which created 160 tokens in Block 1. Block 2 was designed to explore the effects of lexical tones on the perception of coda nasals. The syllable frame /taN/ was combined with three nasal types /m, n, ŋ/ and five tone types: 33 (mid-level), 24 (rising), 22 (low-level), 41 (falling), 55 (high-level), creating 15 real words. Each syllable-tone sequence was recorded three times by the four talkers, which generated 180 tokens in Block 2.

2.1.3. Procedure

Both recording of the stimuli and the perceptual confusion experiment were conducted with a random order word list in a quiet room. Before the perception experiment, the syllable-tone sequences (e.g., sam33 or taŋ41) were presented aurally and the listeners were asked to provide a subjective familiarity rating using a 1-5 point scale. In the perceptual confusion experiment, the stimuli were embedded in pink noise with a +4dB SNR and played one at a time. Listeners were required to select 'm', 'n' or 'ng'. After the forced choice identification task, lexical familiarity ratings (1-5 pt. scale) were collected by visually presenting all the Chinese characters associated with each syllable-tone sequence.

2.2. Experiment 2: Mandarin

2.2.1. Subjects

Nineteen native speakers of Beijing Mandarin were recruited: four talkers and fifteen listeners. All listeners were familiar with Chinese *Pinyin*, which uses 'n' and 'ng' for /n/ and /ŋ/.

2.2.2. Stimuli

Twenty-four syllable-tone sequences, all real words, consisted of two nasal types /n, ŋ/, three vowel types /i, ə, a/ and four tone types: 55 (High-level), 35 (Rising), 214 (Dipping) and 51 (Falling). /p/ was selected as the initial consonant. Each syllable-tone sequence was repeated three times by the four talkers, which generated 288 tokens.

2.1.3. Procedure

Similar to Experiment 1, audio familiarity ratings were conducted before the perception experiment while written familiarity ratings were collected after. 'n' and 'ng' were the possible choices for the identification task. Both recording and listening were conducted in a sound-attenuated booth. Stimuli were embedded in pink noise with -6dB SNR.

3. RESULTS

3.1. Experiment 1: Southern Min

Overall /m/ resulted in more perceptual confusions than /n/ and /ŋ/. /n/ was most accurately identified among the three coda nasals. There were more /m/-/ŋ/ confusions than /m/-n/ and /n/-/ŋ/ confusions.

For Block 1, an ANOVA with factors of nasal /m, n, ŋ/ and vowels /i, a/ showed a significant interaction of nasal and vowel [$F(2,28) = 9.15$, $p = .001$]. The second ANOVA with factors of nasal /m, ŋ/ and vowels /i, ə, a/ showed significant interaction of nasal and vowel [$F(2,28) = 6.62$, $p = .004$]. The source of the interaction was that /m/ was less correctly identified than /n/ and /ŋ/ in /i/ and /ə/ contexts, whereas /ŋ/ was least well identified in the /a/ context. Nasals following /i/ were less correctly identified than following other vowel types. (See Table 1.)

Table 1: Confusion matrix of coda nasals by vowel type in Block 1 in Southern Min (n=300).

	Heard		
Spoken	m	n	ŋ
sam33	**241**	26	33
san33	28	**247**	25
saŋ33	51	34	**215**
səm33	**167**	53	80
səŋ33	36	57	**207**
sim33	**129**	78	93
sin33	40	**207**	53
siŋ33	59	39	**202**

The overall accuracy was higher in Block 2 than Block 1 due to the use of the low vowel. A two-way ANOVA (three nasals and five tones) showed a significant interaction of nasal and tone [$F(8,112) = 7.33$, $p < .001$]. Coda /m/ was less correctly identified than /n/ and /ŋ/ in four out of five tone contexts. Overall, Tones 24 and 55 resulted in higher nasal identification accuracy and

Tones 22 and 41 resulted in lower nasal identification accuracy. (See Table 2.)

There was no significant correlation between the identification accuracy of word-final nasals and audio familiarity ratings [r(21) = -.07, *p* = .767], written familiarity ratings [r(21) = .10, *p* = .642] or homophonic word type frequency [r(21) = -.10, *p* = .641].

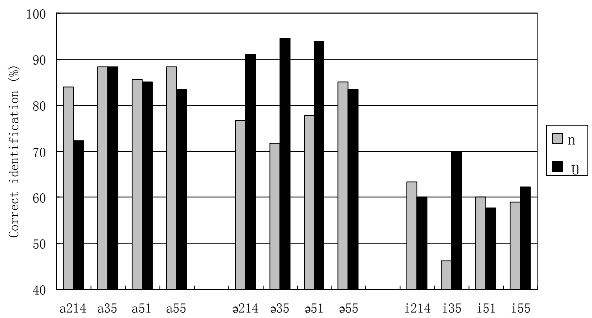
Table 2: Confusion matrix of coda nasals by tone type in Block 2 in Southern Min (n=180).

	Heard		
Spoken	m	n	ŋ
tam22	**105**	25	50
tan22	11	**160**	9
taŋ22	21	6	**153**
tam24	**158**	12	10
tan24	9	**168**	3
taŋ24	14	3	**163**
tam33	**140**	12	28
tan33	14	**141**	25
taŋ33	16	5	**159**
tam41	**134**	14	32
tan41	21	**155**	4
taŋ41	43	15	**122**
tam55	**159**	7	14
tan55	5	**160**	15
taŋ55	4	4	**172**

3.2. Experiment 2: Mandarin

A three-way ANOVA (two nasals, three vowels, four tones) returned a three way interaction [F(6, 84) = 2.65, *p* = .021]. The source of the interaction is illustrated in Figure 2. Coda /n/ tended to be more correctly identified than /ŋ/ after /a/, whereas /ŋ/ tended to be more correctly identified in /ə/ contexts. These tendencies interacted with tone.

Figure 2: The percentage of correct identification of coda nasals by vowel and tone in Mandarin.



In further exploration, a two-way ANOVA (two nasals, three vowels) showed no interaction between nasal and vowel [F(2,28) = 2.00, *p* = .154), but significant main effect of vowel [F(2,28) = 134.06, *p* < .001]. The /i/ vowel context resulted in the most misidentification of the two nasals in the three vowel contexts. (See Table 3.)

Table 3: Confusion matrix of coda nasals by vowel type collapsing tones in Mandarin (n=720).

	Heard	
Spoken	n	ŋ
pan	**623**	97
paŋ	128	**592**
pən	**560**	160
pəŋ	67	**653**
pin	**411**	309
piŋ	270	**450**

Another two-way ANOVA (two nasals, four tones) showed a significant interaction of tone and nasal [F(3, 42) = 7.80, *p* < .001]. The results did not show a clear pattern for a tonal effect on coda nasal identification in Mandarin. Relatively reduced identification accuracy was found for either /n/ or /ŋ/ with tones 214 and 35 in some vowel contexts. (See Figure 2 and Table 4.)

Table 4: Confusion matrix of coda nasals by tone type collapsing vowels in Mandarin (n=540).

	Heard	
Spoken	n	ŋ
pVn214	**403**	137
pVŋ214	138	**402**
pVn35	**371**	169
pVŋ35	85	**455**
pVn51	**402**	138
pVŋ51	114	**426**
pVn55	**418**	122
pVŋ55	128	**412**

Similar to Southern Min, the Pearson correlation was not significant between the identification accuracy of word-final nasals and audio familiarity ratings [r(22) = .17, *p* = .419], written familiarity ratings [r(22) = .25, *p* = .247] or homophonic word type frequency [r(22) = .26, *p* = .215].

4. DISCUSSION

The results from Southern Min in Experiment 1 revealed that /m/ is the most confusable coda nasal. These findings support a listener-oriented model of sound change, in that the historical loss of /m/ might be attributed to its perceptual confusability. However, /m/ was misheard as either /n/ or /ŋ/ in Southern Min, which did not support a pattern in which /m/ merges with /n/, as suggested previously [1, 8]. Additionally, /n/ was slightly less misidentified than /ŋ/ in Southern Min but slightly more misidentified than /ŋ/ in Mandarin. Thus, it seems that neither nasal is more likely to be misidentified than the other cross-linguistically, offering no clear support for either a pattern in which /n/ merges with /ŋ/ [1] or a pattern in which /ŋ/ merges with /n/ [8]. The mutual confusability between /n/ and /ŋ/ seems to be language-specific and driven by effects of vowel and tone on nasal production.

In both languages, the high front vowel /i/ resulted in significantly more misidentification of coda nasals than mid and low vowels /ə/ and /a/. Lower accuracy of nasal identification after high vowel /i/ may be attributed to its acoustic differences from the non-high vowels /ə/ and /a/. The extremely low accuracy of /m/ identification after /i/ in Southern Min is consistent with Zee's [7] finding that [m] was often misheard after front vowels. In Southern Min, /n/ after /a/ was most correctly identified among the three nasals in the three vowel contexts. In contrast, /ŋ/ was better identified in /ə/ context than /n/ in Mandarin. Preliminary results of the vowel acoustics indicate /a/ in Southern Min /-an/ and /ə/ in Mandarin /-əŋ/ had a noticeably higher F2 and lower F2 respectively, than their counterparts in other nasal contexts. The results in Southern Min also showed that there are more /m/-/ŋ/ confusion than /m/-/n/ and /n/-/ŋ/ confusion, which may be caused by the similar formant structure of vowels before /m/ and /ŋ/. A full study of vowel formant structure and vowel-to-nasal formant transition is under way.

The perceptual results of Block 2 in Experiment 1 on Southern Min indicated that low-level and falling tones resulted in more misidentification of coda nasals, which may be related to a low F0 in the nasal murmur. In addition, syllables with falling tones are shorter than those with other tone types and thus the coda nasals are relatively shorter [5]. No clear pattern of tonal effects on coda nasals was found in Mandarin, which may be due to the interaction with vowels as illustrated in Figure 2. In order to interpret the identification results of coda nasals related to tones, such as rising tone resulting most correct identification of /ŋ/ but least correct identification of /n/ in Mandarin as in Table 4, further acoustic analysis will involve the relationship between F0 transition and segment duration in the syllable-tone sequences.

Subjective lexical familiarity ratings and word type frequency were not correlated with the results of the identification task in either language, which indicates that there was no substantial lexical effect on the identification of coda nasals in these experiments. This was also reflected in the /n/ responses to /səm/ and /səŋ/ in Experiment 1 because /sən/ does not exist in the Southern Min lexicon. Therefore, it is reasonable to assume that the listeners identified coda nasals based on their auditory perception of the stimuli.

5. CONCLUSION

The current study did not demonstrate a clear hierarchy of perceptual confusability of coda nasals due to the bidirectional misidentification of /n/ and /ŋ/ in the two languages. Nonetheless, /m/ was found to be most confusable among the three coda nasals, which corroborates the observation that /m/ is the first nasal to be lost due to merger in the historical sound changes of the Chinese languages. To further study the role of perception on coda nasal mergers in Chinese languages, future experiments will explore the perceptual cue weight of vowel, tone, and nasal murmur on coda nasal identification.

6. ACKNOWLEDGMENTS

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