An Acoustic Study of L2 VGN Rime Production
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1. INTRODUCTION
Mandarin speakers are often heard to produce English down (/dən/) as Mandarin dàng (/dag/). Previous studies (e.g., Hansen 2001) revealed that the preceding vowel context has a significant effect on the production of an L2 consonant and may interact with L1 transfer processes. Also, Chen (2000) found that in Mandarin VN (a monophthong vowel followed by a nasal coda /n/ or /ŋ/) rimes, nasal place tends to co-vary with vowel backness. In order to explore vowel context and possible L1 (First Language) influence on L2 (Second Language) nasal coda production, this study adopts an acoustic approach to examine English VGn (a diphthong vowel followed by /n/) rimes produced by Mandarin speakers.

2. METHOD
2.1 Participants & Test Materials
Twenty (10 male and 10 female) native Mandarin Chinese students at the University of Victoria participated in this study. Test words include 5 English words with VGn rimes, pine/coin/gown/pain/cone, 5 corresponding words with VG rimes, pie/coy/cow/pay/go, and 4 Mandarin words with Vŋ (a monophthong vowel followed by /ŋ/)/VG rimes, gàng/kào/gông/gōu (presented as Chinese characters in the actual test but here in PinYin orthography). The 4 Mandarin words were chosen to contrast with the 4 similar sounding English words, gown/cow/cone/go, respectively.

2.2 Procedure
The word-reading task was performed in a sound-attenuated room in the Phonetics laboratory of the University of Victoria. Participants were instructed to read the test words presented on-screen through the Microsoft PowerPoint program. Each test word successively appeared 4 times (hence 4 tokens for each word) in a PowerPoint slide. The successive appearance of the 4 tokens was to improve the chance for a word to be produced consistently. There was a 2-second interval following each appearance of a token and the participants were instructed to read each word by the rhythm of its appearance. A total of 1120 tokens (14 words x 4 repetitions x 20 speakers) were collected and analyzed using Praat 4.4.22.

2.3 Acoustic parameters
For each token, mean F1-F0 and F3-F2 (differences between the first and fundamental formant frequencies and between the third and second formant frequencies) over the first half (_fh) and second half (_sh) of vowel duration were respectively used to estimate vowel height and backness changes over the duration. Also, the vowel and nasal duration (V_D & N_D) of each token were measured to infer the degree of vowel-nasal coupling. Last, the band energy difference (ΔdB) between 0–525 Hz and 770–1265Hz bands over nasal duration were calculated to predict nasal place (alveolar /n/, velar /ŋ/, or uvular /l/). Based on previous findings (e.g., Kurowski & Blumstein, 1987), this study assumes that the less the ΔdB, the more backed the nasal place.

3. RESULTS
3.1 Vowel measurements
Figure 1 illustrates vowel height/backness changes over the duration in English gown/cow and the contrasting Mandarin gàng/kào. The x-axis represents mean F3-F2 in Hz and the y-axis represents mean F1-F0 in Hz. The greater the F3-F2, the more backed the vowel, and the smaller the F1-F0, the higher the vowel.

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Figure 1 Vowel height/backness changes for gown/cow/gàng/kào
In Figure 1, /a/ in gàng moving to the further back happens to resemble /aw/ in gown because the height of /w/ in /aw/ is greatly lowered. A 2-tailed paired samples t-test revealed that there was a non-significant vowel height change over the duration for /aw/ in gown (t = 1.388, p = .181). In contrast, a significant vowel backness change over the duration was found in gàng (t = -6.127, p < .001). Since significant vowel height/backness changes over the duration are expected for a diphthong but not for a monophthong vowel, both the non-significant vowel height change in gown and the significant vowel backness change in gàng suggest a strong nasal influence on the preceding vowel.

3.2 Durational measurements

Figure 2 illustrates mean vowel and nasal duration (V_D & N_D) for each of the 7 words, pine/coin/gown/cone/pain/gàng/gòng, across tokens and speakers. The x-axis represents duration in second (s).

![Figure 2 V_D and N_D for pine/coin/gown/cone/pain/gàng/gòng](image)

In Figure 2, the 2 Mandarin words gàng/gòng have similar duration (V_D + N_D < 0.4s) and are shorter than the 5 English words, pine/coin/gown/cone/pain (V_D + N_D > 0.5s). The short and almost identical duration for gàng/gòng is expected due to the fact that Mandarin 4th tone words are normally produced with a very short duration and that Mandarin as a syllable-timed language favors syllables with similar length. Note that short duration (especially N_D) implies a strong degree of vowel-nasal coupling.

3.3 Nasal measurements

Figure 3 illustrates mean ΔdB for pine/coin/gown/cone/pain/gàng/gòng, across tokens and speakers. The y-axis represents the band energy difference in Decibels (dB).

![Figure 3 Mean ΔdB for pine/coin/gown/cone/gàng/gòng](image)

In Figure 3, gàng has the least mean ΔdB (-14dB) among all the 7 words, and gown has the least mean ΔdB (-18dB) among the 5 English words, comparable to that in gòng (-17dB). A repeated measures one-way ANOVA test revealed that mean ΔdB for gown is significantly different from that for pine/coin/pain/cone/gàng (the results from the pairwise comparisons, p < .001, .003, .001, .016, respectively), but not for gòng (p = .763), indicating that /w/ in gown can be identified with the velar /h/ in gòng. Also, mean ΔdB for gàng was significantly lower than for pine/coin/pain/cone/gàng (the results from the pairwise comparisons, p < .001, .001, .016, .001, .039, respectively), indicating that the nasal place in gàng is further back than in the rest of the words and thus can be considered as uvular /h/ rather than velar /h/.

4. DISCUSSION

The Mandarin speakers’ production of English VGN and Mandarin Vŋ rimes is subject to a strong vowel-nasal coarticulation effect. For instance, the high glide /w/ in gown is greatly lowered and the central vowel /a/ in gàng becomes further backed. Conversely, /w/ in gown is at the further back than at the presumed alveolar region, and /h/ in gàng is at the further back than at the presumed velar region. The nasal place in gown/gàng co-varies with the vowel backness change over the duration.

Furthermore, the strong vowel-nasal coarticulation effect in Mandarin speakers’ production of English VGN rimes may be related to rhythmic factors rather than L1 transfer; that is, given the controlled 2-second interval between every 2 tokens presented on-screen in the reading test, the English VGN rimes had to be read within the time frame, resulting in a vowel-nasal backness assimilation effect similar to that in the Mandarin Vŋ rimes.

REFERENCES


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