An Acoustic Study of L2 VGn Rime Production

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1. INTRODUCTION

Mandarin speakers are often heard to produce English *down* (/dawn/) as Mandarin *dàng* (/dɑŋ/). 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/gòng/gòu* (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 /ɴ/). 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.

Mean value	*gown*	*cow*	*gàng*	*kào*
F3-F2_fh	1422	1492	1415	1691
F1-F0_fh	631	727	623	665
F3-F2_sh	1767	1803	1753	1893
F1-F0_sh	587	509	606	526

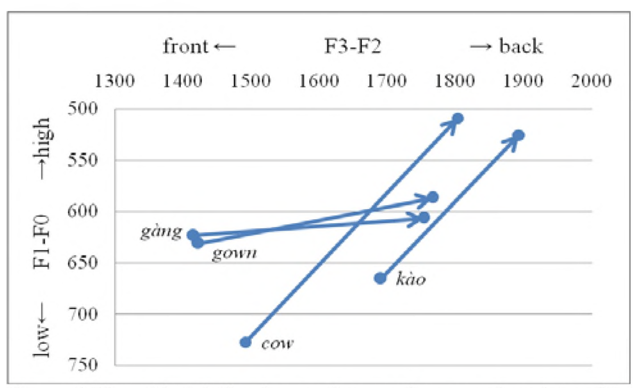

Figure 1 Vowel height/backness changes for *gown/cow/gàng/kào*

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).

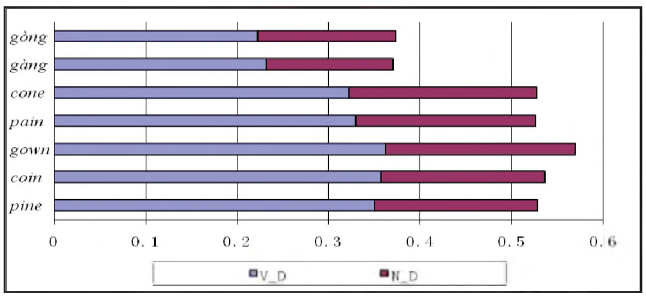

Figure 2 V_D and N_D for *pine/coin/gown/cone/pain/gàng/gòng*

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/pain/cone* ($V\_D + N\_D > 0.5s$). The short and almost identical duration for *gàng/gòng* is expected due to the fact that Mandarin 4^{th} 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).

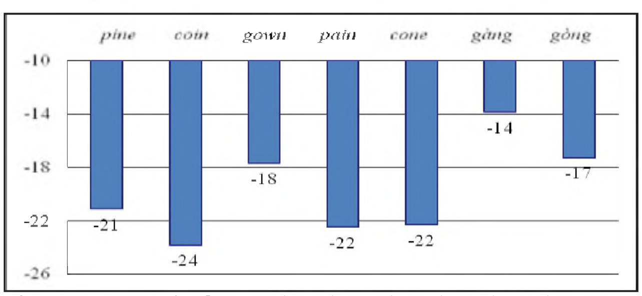

Figure 3 Mean ΔdB for *pine/coin/gown/pain/cone/gàng/gòng*

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, $p < .001$, $=.003$, $<.001$, $<.001$, $=.016$, respectively), but not for *gòng* ($p = .763$), indicating that /n/ in *gown* can be identified with the velar /ŋ/ in *gòng*. Also, mean ΔdB for *gàng* was significantly lower than for *pine/coin/gown/pain/cone/gòng* (the results from the pairewise comparisons, $p < .001$, $<.001$, $=.016$, $<.001$, $<.001$, $=.039$, 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 /ɴ/ rather than velar /ŋ/.

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, /n/ in *gown* is at the further back than at the presumed alveolar region, and /ŋ/ 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.

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