Article

Articulatory characteristics and vowel space analysis of Mandarin Chinese non-low vowels in Korean-speaking learners

Di Duan¹ ²

¹Department of Chinese Language and Literature, Hanyang University, Seoul 04763, Korea; duandi198504@126.com
²School of International Education, Northeast Petroleum University, Daqing 163318, China

Abstract: Vowels are a fundamental component of Mandarin Chinese syllables. Accurate pronunciation of Mandarin Chinese relies on the distinct articulation of different vowels, especially the visually similar “ü” and “u”. Korean-speaking learners of Chinese Mandarin as a second language commonly exhibit non-standard pronunciation or errors in articulating “ü”, leading to confusion, particularly in non-low vowels centered around this sound. Using Praat to analyze the Formant values of non-low vowel sounds from six participants, a comparison between Korean L2 Chinese speakers and native Chinese speakers revealed vowel spaces differentiated through F2 values for /u/ and /o/, while /ɣ/ and /o/ are distinguished by F1 values. The sound similar to Korean “ㅟ” differs from /y/ in that the former is a gliding sound transitioning from low to high. The distinction between /y/ and /u/, /o/, /ɣ/ was found to be unclear, with /y/ often merging into sounds like “iu” and “io”. This aligns with historical vowel changes in Chinese “ü”, noted in previous linguistic studies, showing variations like “iu” and “io” over different periods. Korean L2 Chinese speakers tend to substitute /ɯ/ for /u/ and “ㅟ” ( /ɯ+/i/) for /y/, avoiding rounded lip movements in pronunciation, thus reducing effort and the need for additional phonemes. Furthermore, the F3 value for Korean L2 Chinese /y/ is notably lower, suggesting that the correct articulation should closely resemble the tongue position of /i/, combined with rounded lips.

Keywords: mandarin non-low vowels; Korean-speaking learners; speech analysis; formant values; vowel space

1. Introduction

Vowels are an indispensable part of Mandarin Chinese syllables. Among the six simple vowels in Mandarin, /y/ and /u/ correspond to the Pinyin written forms “ü” and “u” respectively. Although “ü” and “u” appear similar in Pinyin notation, there are significant differences in the rules for syllabic spelling in Mandarin Pinyin. It is observed that sometimes the correct pronunciation of “u” is /u/, while at other times, it is /y/. This is due to specific regulations in the “Mandarin Pinyin Scheme” for the spelling of Standard Mandarin syllables. For instance, when the vowel “ü” or syllables starting with “ü” form a syllable on their own, a ‘y’ is prefixed to these syllables, and the two dots above “ü” are omitted. When “ü” is combined with the initials j, q, x, the two dots above “ü” are also omitted. When “u” forms a syllable on its own, a glottal stop symbol ‘w’ is prefixed. Similarly, when syllables starting with “u” form a syllable on their own, “u” is transcribed as “w”. (Refer to Table 1 for details.) Therefore, despite /y/ and /u/ being phonetically distinct sounds, pronunciation confusion can still occur. (Refer to Figure 1 for details.) This represents a challenge for learners of Mandarin Chinese as a second language.
Table 1. Pinyin Spelling Rules for “ü” and “u” in Mandarin Chinese.

<table>
<thead>
<tr>
<th>Rhyme</th>
<th>Syllable</th>
<th>Spelling Rules for Syllables</th>
</tr>
</thead>
<tbody>
<tr>
<td>ü</td>
<td>yu</td>
<td>when ‘ü’ or syllables starting with ‘ü’ become independent syllables in Mandarin Chinese, ‘y’ is prefixed and the dots above ‘ü’ are removed. This process involves both an addition and a modification of the original vowel form.</td>
</tr>
<tr>
<td>üe</td>
<td>yue</td>
<td>When combined with the initials j, q and x, the two dots above “ü” are omitted. [Modification]</td>
</tr>
<tr>
<td>üan</td>
<td>yuan</td>
<td>When ‘u’ forms an independent syllable in Mandarin, a glottal stop symbol ‘w’ is prefixed to it. [Addition]</td>
</tr>
<tr>
<td>ün</td>
<td>yun</td>
<td>When syllables beginning with ‘u’ form independent syllables in Mandarin, ‘u’ is transcribed as ‘w’. [Modification]</td>
</tr>
<tr>
<td>j, q, x, ü, üe, üan, ün</td>
<td>ju, jue, juan, jun, qu, que, quan, qun, xu, xue, xuan, xun</td>
<td></td>
</tr>
</tbody>
</table>

Korean and Mandarin Chinese share a profound historical connection. One of the initial purposes of creating the Korean script, Hangul, was to represent the pronunciation of Chinese characters at the time. Thus, the Sino-Korean readings of Chinese characters can be considered a living fossil of ancient Chinese pronunciation. Kim (2002) demonstrated the potential for studying Korean vowels through the historical evolution of Mandarin vowels. Wenkai (2015) outlined the historical development of the Mandarin vowel ‘ü’, noting that during the Southern and Northern Dynasties and the Sui and Tang Dynasties, it was pronounced as “io”. By the Five Dynasties period, it had already shifted to “iu”, and it wasn’t until the Ming and Qing Dynasties that it consistently evolved into the modern pronunciation of “ü”. This suggests that the sound ‘ü’ closely resembles or is often confused with the pronunciations “io” and “iu”. (Table 2) Additionally, Wenkai (2015) also detailed the evolution of the Korean vowel “ㅜ”. It is evident that the Mandarin vowel ‘ü’ and the Korean vowel ‘ㅜ’ are perceived as similar in the pronunciation of Korean speakers. (Table 3)

Table 2. Historical Evolution of the Mandarin Vowel ‘ü’.

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Pre-Q</th>
<th>W. Han</th>
<th>E. Han</th>
<th>S/N Dyn.</th>
<th>Sui/Tang</th>
<th>Five Dyn.</th>
<th>Song</th>
<th>Yuan</th>
<th>Ming/Qing</th>
<th>Mod.</th>
</tr>
</thead>
<tbody>
<tr>
<td>魚(Fish)</td>
<td>ia</td>
<td>iɔ</td>
<td>iɔ</td>
<td>io</td>
<td>iu</td>
<td>iu</td>
<td>iu</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
</tr>
<tr>
<td>雨(Rain)</td>
<td>iua</td>
<td>iuɔ</td>
<td>iuɔ</td>
<td>io</td>
<td>iu</td>
<td>iu</td>
<td>iu</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
</tr>
<tr>
<td>局(Office)</td>
<td>iɔ</td>
<td>iuɔ</td>
<td>iuɔ</td>
<td>io</td>
<td>iu</td>
<td>iu</td>
<td>iu</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
</tr>
</tbody>
</table>

Table 3. Evolution of the Korean Vowel ‘ㅜ’.

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Evolution Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>한국어 ‘ㅜ’</td>
<td>[u], [ui], [wi]</td>
</tr>
</tbody>
</table>

The phonetic relationship between the Mandarin vowel ‘ü’ and the historical phonetic evolution of the Korean vowel ‘ㅜ’ is complex, underscoring the difficulty in pronouncing ‘ü’. It also highlights the similarity between ‘ü’ and the sounds “io”,
“iu” in Mandarin, as well as “/rfc” in Korean. Furthermore, the syllabic spelling of Modern Standard Mandarin can lead to pronunciation challenges for learners of Mandarin as a second language, particularly during the initial stages of learning.

For Korean learners of Mandarin as a second language, there is a noticeable difficulty in pronouncing non-low vowels centered around /y/. A search in Google Scholar reveals a lack of specific research on non-low vowels in Mandarin. Sun (2009) work primarily analyzed the acoustic features of vowels in the International Phonetic Alphabet (IPA) system for Mandarin, Japanese, and English, without delving into the pronunciation challenges faced by Mandarin L2 learners. This study utilized Praat software for analyzing Mandarin vowels. The phonetic errors in the Mandarin “ü” sound made by Korean L2 learners have been acknowledged in literature, with a focus on perceptual explanations rather than detailed phonetic experiments. Xu (2016) study described and analyzed the acquisition and errors in “u” and “ü” sounds among six Mandarin L2 learners from different countries using F1, F2, F3 measurements in Praat. However, the study’s limitations include its reliance on the author’s perception for determining pronunciation accuracy, and the inclusion of only one Korean participant, which did not yield a comprehensive F1, F2, F3 dataset or vowel space illustrations for Korean L2 learners. In terms of the correlation between Korean “/rfc” and Mandarin “ü”, scholars have shown more interest in historical analysis or perceptual comparisons within Korean, comparing “/r/” with similar sounds. Although standard F1 and F2 values for Korean vowel pronunciation are available in Korean phonetics literature, they do not include “/r/”. The vowel “/r/” is akin to a complex diphthong and its pronunciation is categorized as a gliding sound, distinct from other simple vowels.

Therefore, this study will employ Praat software for experimental research. Praat’ can measure the Formant values of sounds, clearly illustrating the differences in the pronunciation of non-low vowels between Korean learners of Mandarin as a second language and native Mandarin speakers. Experiments and statistical plotting based on Praat software, which combines experimental phonetics with simple data analysis, will be used to analyze and process the acoustic data of both Korean Mandarin L2 learners and native Mandarin speakers. This analysis aims to investigate the pronunciation of non-low vowels by Korean Mandarin L2 learners and identify differences from native speaker pronunciations.


2. Experiment

2.1. Participants

The participants consisted of six college students. The experimental group comprised three Korean L2 Chinese beginners, while the control group included three L1 Chinese. The three Korean-speaking learners are all from Seoul and use Standard Korean. The three native Chinese speakers are all from northern China and use Mandarin Chinese.

2.2. Stimuli

Non-low vowels mainly refer to vowels whose tongue positions are in the upper half of the vowel chart. In Mandarin Chinese, the non-low vowels primarily include /y/, /i/, /u/, /o/, /ɣ/, and /e/. The vowels /i/ and /a/ are used as reference sounds. There are five or six contrastive vowel phonemes in Mandarin: one low vowel phoneme (/a/), one mid vowel phoneme (/ɤ/), and three high vowel phonemes (/i/, /y/, /u/) (Duanmu, 2007; Huang and Liao, 1983; Lin, 2007). This study designed 13 target words for the study. (As shown in the Table 4 below). This paper examines the comparison of the aforementioned sounds within the non-low vowels region, primarily involving the following pairs: /i/, /y/, /u/; /u/ and /o/; /u/ and /ɣ/; /ɣ/ and /o/.

The selection of target vowels is primarily based on their considerable level of difficulty for L2 learners, particularly after the retroflex, and palatal fricatives and affricates (/ʂ/ and /ɕ/). This difficulty has been noted in previous studies by Lu (1984), Zhu and Wang (1997), Wang (2001), and Wang and Deng (2009).

In addition, the sequence of target words containing /y/ is randomized in the list of target words. The purpose is to prevent participants from guessing the intent of the test, avoid the influence of negative transfer from the second language, and ensure that each sound represents the participant’s natural level of pronunciation. Furthermore, the tonality of the target words should avoid words with tonal variation to ensure that the subsequent measurements of formant values are not affected, thereby maintaining the precision and objectivity of the experiment. The target words selected in this paper are all derived from the “Chinese Dictionary” or the Chinese entries included in Baidu Baike³.

<table>
<thead>
<tr>
<th>Table 4. List of target words.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pronunciation</strong></td>
</tr>
<tr>
<td><strong>Chinese Words</strong></td>
</tr>
<tr>
<td><strong>Meanings</strong></td>
</tr>
<tr>
<td><strong>Pronunciation</strong></td>
</tr>
<tr>
<td><strong>Chinese Words</strong></td>
</tr>
<tr>
<td><strong>Meanings</strong></td>
</tr>
</tbody>
</table>

The filler words involved in the study are as follows: /y /l(漁夫), l y /l(虛浮), 1 y
For better illustrate and demonstrate the scenarios involving /y/, single vowel syllables like /y/ (渔夫) and initial-final combined syllables such as /y/ (虚浮), /y/ (橘子), /y/ (屈服) were designed.

The main focus of the experiment revolves around these filler words. The formant values of the filler words are measured for both Korean L2 Chinese learners and L1 Chinese. Tongue position diagrams are constructed based on F1 and F2, allowing for a quantitative analysis of instances of pronunciation confusion and the underlying causes.

2.3. Procedure

2.3.1. Participant recordings

Participants were instructed to read all the target words three times.

2.3.2. Measurement of formant values

The F1, F2, and F3 values of each vowel were measured. Tables 5–7 displays the formant values of three Korean L2 Chinese learners, while Tables 8–10 presents the formant values of three L1 Chinese.

Table 5. <L2 vowel: Mandarin Chinese vowels produced by a Korean-speaking learner > (1).

<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
<td>F3(Hz)</td>
</tr>
<tr>
<td>/u/ (叔叔)</td>
<td>298</td>
<td>1654</td>
<td>2578</td>
</tr>
<tr>
<td>/i/ (一头)</td>
<td>269</td>
<td>2145</td>
<td>3212</td>
</tr>
<tr>
<td>/y/ (屈服)</td>
<td>434</td>
<td>812</td>
<td>2398</td>
</tr>
<tr>
<td>/o/ (收书)</td>
<td>380</td>
<td>797</td>
<td>2373</td>
</tr>
<tr>
<td>/y/ (虚浮)</td>
<td>437</td>
<td>1032</td>
<td>2609</td>
</tr>
<tr>
<td>/y/ (橘子)</td>
<td>402</td>
<td>998</td>
<td>2559</td>
</tr>
<tr>
<td>/u/ (卢浮宫)</td>
<td>483</td>
<td>1121</td>
<td>2502</td>
</tr>
<tr>
<td>/e/ (胃痛)</td>
<td>410</td>
<td>2249</td>
<td>3024</td>
</tr>
<tr>
<td>/o/ (窝夫)</td>
<td>393</td>
<td>704</td>
<td>2593</td>
</tr>
<tr>
<td>/y/ (舌头)</td>
<td>499</td>
<td>1106</td>
<td>2433</td>
</tr>
<tr>
<td>/y/ (渔夫)</td>
<td>338</td>
<td>1933</td>
<td>2278</td>
</tr>
<tr>
<td>/a/ (丫头)</td>
<td>557</td>
<td>1250</td>
<td>2433</td>
</tr>
<tr>
<td>/o/ (优抚)</td>
<td>393</td>
<td>994</td>
<td>2461</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
<td>F3(Hz)</td>
</tr>
<tr>
<td>/u/ (叔叔)</td>
<td>370</td>
<td>1291</td>
<td>3176</td>
</tr>
<tr>
<td>/i/ (一头)</td>
<td>348</td>
<td>2238</td>
<td>3055</td>
</tr>
<tr>
<td>/y/ (屈服)</td>
<td>367</td>
<td>2029</td>
<td>2234</td>
</tr>
</tbody>
</table>
### Table 6. (Continued).

<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
<td>F3(Hz)</td>
</tr>
<tr>
<td>/a/ (收书)</td>
<td>328</td>
<td>789</td>
<td>2506</td>
</tr>
<tr>
<td>/u/ (虚浮)</td>
<td>397</td>
<td>1283</td>
<td>2303</td>
</tr>
<tr>
<td>/y/ (橘子)</td>
<td>343</td>
<td>1543</td>
<td>2363</td>
</tr>
<tr>
<td>/a/ (卢浮宫)</td>
<td>400</td>
<td>983</td>
<td>3433</td>
</tr>
<tr>
<td>/ao/ (胃痛)</td>
<td>434</td>
<td>2086</td>
<td>2379</td>
</tr>
<tr>
<td>/o/ (窝夫)</td>
<td>441</td>
<td>643</td>
<td>2604</td>
</tr>
<tr>
<td>/i/ (舌头)</td>
<td>496</td>
<td>998</td>
<td>2715</td>
</tr>
<tr>
<td>/u/ (渔夫)</td>
<td>301</td>
<td>1683</td>
<td>2216</td>
</tr>
<tr>
<td>/e/ (丫头)</td>
<td>318</td>
<td>2109</td>
<td>2579</td>
</tr>
<tr>
<td>/ao/ (优抚)</td>
<td>459</td>
<td>726</td>
<td>2649</td>
</tr>
</tbody>
</table>

### Table 7. <L2 vowel: Mandarin Chinese vowels produced by a Korean-speaking learner > (3).

<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
<td>F3(Hz)</td>
</tr>
<tr>
<td>/a/ (叔叔)</td>
<td>355</td>
<td>1423</td>
<td>2347</td>
</tr>
<tr>
<td>/i/ (一头)</td>
<td>297</td>
<td>2318</td>
<td>2866</td>
</tr>
<tr>
<td>/y/ (屈服)</td>
<td>338</td>
<td>2212</td>
<td>3026</td>
</tr>
<tr>
<td>/a/ (收书)</td>
<td>413</td>
<td>1019</td>
<td>2491</td>
</tr>
<tr>
<td>/e/ (虚浮)</td>
<td>338</td>
<td>2234</td>
<td>2994</td>
</tr>
<tr>
<td>/y/ (橘子)</td>
<td>484</td>
<td>1304</td>
<td>2655</td>
</tr>
<tr>
<td>/a/ (卢浮宫)</td>
<td>386</td>
<td>899</td>
<td>2737</td>
</tr>
<tr>
<td>/o/ (胃痛)</td>
<td>434</td>
<td>2085</td>
<td>2591</td>
</tr>
<tr>
<td>/a/ (窝夫)</td>
<td>543</td>
<td>779</td>
<td>2875</td>
</tr>
<tr>
<td>/i/ (舌头)</td>
<td>529</td>
<td>989</td>
<td>2955</td>
</tr>
<tr>
<td>/y/ (渔夫)</td>
<td>340</td>
<td>1504</td>
<td>2462</td>
</tr>
<tr>
<td>/a/ (丫头)</td>
<td>365</td>
<td>2278</td>
<td>2716</td>
</tr>
<tr>
<td>/o/ (优抚)</td>
<td>671</td>
<td>1250</td>
<td>2491</td>
</tr>
</tbody>
</table>

### Table 8. <L1 vowel: Mandarin Chinese vowels produced by a native speaker > (1).

<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
<td>F3(Hz)</td>
</tr>
<tr>
<td>/a/ (叔叔)</td>
<td>328</td>
<td>831</td>
<td>2715</td>
</tr>
<tr>
<td>/i/ (一头)</td>
<td>290</td>
<td>2456</td>
<td>3277</td>
</tr>
<tr>
<td>/y/ (屈服)</td>
<td>336</td>
<td>2153</td>
<td>2566</td>
</tr>
<tr>
<td>/a/ (收书)</td>
<td>454</td>
<td>1250</td>
<td>2213</td>
</tr>
</tbody>
</table>
### Table 8. (Continued.)

<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th></th>
<th>2nd</th>
<th></th>
<th>3rd</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
<td>F3(Hz)</td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
<td>F3(Hz)</td>
</tr>
<tr>
<td>/y/ (虚浮)</td>
<td>329</td>
<td>1991</td>
<td>2617</td>
<td>347</td>
<td>2070</td>
<td>2448</td>
</tr>
<tr>
<td>/y/ (橘子)</td>
<td>299</td>
<td>2019</td>
<td>2706</td>
<td>280</td>
<td>2022</td>
<td>2666</td>
</tr>
<tr>
<td>/u/ (卢浮宫)</td>
<td>388</td>
<td>757</td>
<td>2833</td>
<td>402</td>
<td>702</td>
<td>2842</td>
</tr>
<tr>
<td>/e/ (胃痛)</td>
<td>455</td>
<td>2077</td>
<td>2762</td>
<td>454</td>
<td>2037</td>
<td>2729</td>
</tr>
<tr>
<td>/o/ (高夫)</td>
<td>487</td>
<td>691</td>
<td>3107</td>
<td>446</td>
<td>767</td>
<td>2991</td>
</tr>
<tr>
<td>/y (舌头)</td>
<td>496</td>
<td>1208</td>
<td>2888</td>
<td>453</td>
<td>1250</td>
<td>2674</td>
</tr>
<tr>
<td>/y/ (渔夫)</td>
<td>286</td>
<td>2074</td>
<td>2847</td>
<td>288</td>
<td>2111</td>
<td>2630</td>
</tr>
<tr>
<td>/a/ (丫头)</td>
<td>789</td>
<td>1250</td>
<td>2548</td>
<td>747</td>
<td>1208</td>
<td>2380</td>
</tr>
<tr>
<td>/o/ (优抚)</td>
<td>445</td>
<td>912</td>
<td>2684</td>
<td>444</td>
<td>860</td>
<td>2807</td>
</tr>
</tbody>
</table>

### Table 9. <L1 vowel: Mandarin Chinese vowels produced by a native speaker > (2).

<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th></th>
<th>2nd</th>
<th></th>
<th>3rd</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
<td>F3(Hz)</td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
<td>F3(Hz)</td>
</tr>
<tr>
<td>/u/ (叔叔)</td>
<td>355</td>
<td>932</td>
<td>2491</td>
<td>357</td>
<td>927</td>
<td>2369</td>
</tr>
<tr>
<td>/i/ (一头)</td>
<td>355</td>
<td>2145</td>
<td>2953</td>
<td>355</td>
<td>1954</td>
<td>2841</td>
</tr>
<tr>
<td>/y/ (屈服)</td>
<td>290</td>
<td>2117</td>
<td>3251</td>
<td>291</td>
<td>2105</td>
<td>3158</td>
</tr>
<tr>
<td>/o/ (收书)</td>
<td>355</td>
<td>846</td>
<td>2549</td>
<td>355</td>
<td>846</td>
<td>2641</td>
</tr>
<tr>
<td>/y/ (虚浮)</td>
<td>265</td>
<td>2090</td>
<td>2934</td>
<td>279</td>
<td>2167</td>
<td>3107</td>
</tr>
<tr>
<td>/y/ (橘子)</td>
<td>259</td>
<td>2181</td>
<td>2817</td>
<td>280</td>
<td>2322</td>
<td>3240</td>
</tr>
<tr>
<td>/a/ (卢浮宫)</td>
<td>313</td>
<td>904</td>
<td>2931</td>
<td>316</td>
<td>880</td>
<td>2761</td>
</tr>
<tr>
<td>/e/ (胃痛)</td>
<td>427</td>
<td>1933</td>
<td>2261</td>
<td>396</td>
<td>2057</td>
<td>2499</td>
</tr>
<tr>
<td>/o/ (高夫)</td>
<td>394</td>
<td>855</td>
<td>2379</td>
<td>413</td>
<td>839</td>
<td>2344</td>
</tr>
<tr>
<td>/y (舌头)</td>
<td>471</td>
<td>1106</td>
<td>3299</td>
<td>452</td>
<td>1130</td>
<td>3110</td>
</tr>
<tr>
<td>/y/ (渔夫)</td>
<td>269</td>
<td>2095</td>
<td>3057</td>
<td>256</td>
<td>1979</td>
<td>3160</td>
</tr>
<tr>
<td>/a/ (丫头)</td>
<td>615</td>
<td>1221</td>
<td>2635</td>
<td>589</td>
<td>1320</td>
<td>2351</td>
</tr>
<tr>
<td>/o/ (优抚)</td>
<td>360</td>
<td>853</td>
<td>3367</td>
<td>403</td>
<td>805</td>
<td>2397</td>
</tr>
</tbody>
</table>

### Table 10. <L1 vowel: Mandarin Chinese vowels produced by a native speaker > (3).

<table>
<thead>
<tr>
<th></th>
<th>1st</th>
<th></th>
<th>2nd</th>
<th></th>
<th>3rd</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
<td>F3(Hz)</td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
<td>F3(Hz)</td>
</tr>
<tr>
<td>/u/ (叔叔)</td>
<td>234</td>
<td>904</td>
<td>2318</td>
<td>327</td>
<td>990</td>
<td>2433</td>
</tr>
<tr>
<td>/i/ (一头)</td>
<td>269</td>
<td>1798</td>
<td>2953</td>
<td>269</td>
<td>1914</td>
<td>2895</td>
</tr>
<tr>
<td>/y/ (屈服)</td>
<td>324</td>
<td>1649</td>
<td>2864</td>
<td>316</td>
<td>1639</td>
<td>2949</td>
</tr>
<tr>
<td>/o/ (收书)</td>
<td>442</td>
<td>1077</td>
<td>2202</td>
<td>442</td>
<td>1019</td>
<td>2520</td>
</tr>
<tr>
<td>/y/ (虚浮)</td>
<td>316</td>
<td>1639</td>
<td>2887</td>
<td>315</td>
<td>1660</td>
<td>2890</td>
</tr>
<tr>
<td>/y/ (橘子)</td>
<td>323</td>
<td>1716</td>
<td>2911</td>
<td>323</td>
<td>1715</td>
<td>2783</td>
</tr>
<tr>
<td>/a/ (卢浮宫)</td>
<td>329</td>
<td>835</td>
<td>2846</td>
<td>357</td>
<td>893</td>
<td>2879</td>
</tr>
</tbody>
</table>
Table 10. (Continued).

<table>
<thead>
<tr>
<th></th>
<th>1st F1(Hz)</th>
<th>2nd F1(Hz)</th>
<th>3rd F1(Hz)</th>
<th>2nd F2(Hz)</th>
<th>3rd F2(Hz)</th>
<th>2nd F3(Hz)</th>
<th>3rd F3(Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>/e/ (胃痛)</td>
<td>464</td>
<td>1597</td>
<td>2082</td>
<td>471</td>
<td>1487</td>
<td>2540</td>
<td>472</td>
</tr>
<tr>
<td>/œ/ (窝夫)</td>
<td>474</td>
<td>827</td>
<td>2912</td>
<td>475</td>
<td>839</td>
<td>2747</td>
<td>505</td>
</tr>
<tr>
<td>/ɨ/ (舌头)</td>
<td>471</td>
<td>1221</td>
<td>2404</td>
<td>529</td>
<td>1106</td>
<td>2462</td>
<td>557</td>
</tr>
<tr>
<td>/y/ (渔夫)</td>
<td>277</td>
<td>1774</td>
<td>2794</td>
<td>304</td>
<td>1683</td>
<td>2386</td>
<td>309</td>
</tr>
<tr>
<td>/œ/ (丫头)</td>
<td>759</td>
<td>1221</td>
<td>2376</td>
<td>759</td>
<td>1250</td>
<td>2318</td>
<td>788</td>
</tr>
<tr>
<td>/œ/ (优抚)</td>
<td>462</td>
<td>828</td>
<td>2740</td>
<td>495</td>
<td>781</td>
<td>2827</td>
<td>488</td>
</tr>
</tbody>
</table>

During the measurements, it was found that Korean L2 learners exhibited a notable bifurcation in the F2 value when pronouncing /y/, which is significantly different from that of native speakers. This variation is depicted in Figures 2 and 3. Therefore, in Table 11, the pronunciation data for Korean L2 learners were recorded in two distinct segments: a lower front segment and a higher back segment, and the formant values were measured separately for each.

**Figure 2.** F2 Performance in /y/ Pronunciation by Korean L2 Chinese Learners.

**Figure 3.** F2 Performance in /y/ Pronunciation by Native Chinese Speakers.
3. Results

Based on the measurement results, the average formant values of Korean L2 Chinese learners and L1 Chinese are as follows. Table 12 shows the average formant values for each specific filler word. Table 11 displays the consolidated average formant values for the same phonemes. Additionally, in Table 11, the situation mentioned in Figures 2 and 3 is separately calculated for the average formant values.

Table 11. Average formant values of Korean L2 Chinese and L1 Chinese speakers.

<table>
<thead>
<tr>
<th></th>
<th>Korean L2 Chinese</th>
<th>L1 Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
</tr>
<tr>
<td>/u/ (叔叔)</td>
<td>400</td>
<td>1191</td>
</tr>
<tr>
<td>/o/ (收书, 窝夫, 优抚)</td>
<td>429</td>
<td>811</td>
</tr>
<tr>
<td>/y/ (屈服)</td>
<td>358</td>
<td>1672</td>
</tr>
<tr>
<td>/y/ (虚浮)</td>
<td>394</td>
<td>1546</td>
</tr>
<tr>
<td>/y/ (橘子)</td>
<td>404</td>
<td>1276</td>
</tr>
<tr>
<td>/l/</td>
<td>337</td>
<td>1873</td>
</tr>
<tr>
<td>/y/ (渔夫)</td>
<td>340</td>
<td>1504</td>
</tr>
<tr>
<td>/l/</td>
<td>318</td>
<td>2109</td>
</tr>
<tr>
<td>/o/ (胃痛)</td>
<td>413</td>
<td>2060</td>
</tr>
<tr>
<td>/i/ (舌头)</td>
<td>477</td>
<td>1272</td>
</tr>
<tr>
<td>/a/ (丫头)</td>
<td>613</td>
<td>1295</td>
</tr>
<tr>
<td>/u/ (一头)</td>
<td>306</td>
<td>2234</td>
</tr>
</tbody>
</table>

Table 12. Average formant values of Korean L2 Chinese and L1 Chinese speakers.

<table>
<thead>
<tr>
<th></th>
<th>Korean L2 Chinese</th>
<th>L1 Chinese</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1(Hz)</td>
<td>F2(Hz)</td>
</tr>
<tr>
<td>/u/ (叔叔)</td>
<td>336</td>
<td>1431</td>
</tr>
<tr>
<td>/i/ (一头)</td>
<td>306</td>
<td>2234</td>
</tr>
<tr>
<td>/y/ (屈服)</td>
<td>358</td>
<td>1672</td>
</tr>
<tr>
<td>/o/ (收书)</td>
<td>385</td>
<td>861</td>
</tr>
<tr>
<td>/y/ (虚浮)</td>
<td>394</td>
<td>1546</td>
</tr>
<tr>
<td>/y/ (橘子)</td>
<td>404</td>
<td>1276</td>
</tr>
<tr>
<td>/l/ (卢浮宫)</td>
<td>400</td>
<td>1191</td>
</tr>
<tr>
<td>/e/ (胃痛)</td>
<td>429</td>
<td>2063</td>
</tr>
<tr>
<td>/o/ (渔夫)</td>
<td>462</td>
<td>747</td>
</tr>
<tr>
<td>/l/ (舌头)</td>
<td>525</td>
<td>1070</td>
</tr>
<tr>
<td>/y/ (渔夫)</td>
<td>337</td>
<td>1873</td>
</tr>
<tr>
<td>/a/ (丫头)</td>
<td>613</td>
<td>1295</td>
</tr>
<tr>
<td>/o/ (优抚)</td>
<td>439</td>
<td>826</td>
</tr>
</tbody>
</table>
From Figure 4, it can be observed that Korean L2 Chinese speakers pronounce /i/ and /e/ quite accurately. For beginners among Korean learners, the F1 value for /a/ is slightly low, a common issue among Mandarin L2 learners, characterized by insufficient mouth opening and a slightly high tongue position for /a/.

In Mandarin, the pronunciation of /u/ and /o/ are quite similar, as both are rounded vowels and difficult to distinguish. Korean L2 Chinese speakers differentiate these sounds using F2 values, whereas native Chinese speakers distinguish /u/ and /o/ primarily by the difference in F1 values, which indicates the height of the tongue. Therefore, it is found that the F2 value for /o/ by Korean L2 Chinese speakers is smaller, indicating that the correct tongue position should be slightly more forward, while for /u/, both F1 and F2 values are higher, meaning the tongue should be raised and positioned further back.

In Mandarin, the pronunciation positions of /ɣ/ and /o/ are quite close, but the difference can be seen in their F1 values. Another distinction is that the pronunciation of /o/ requires rounded lips, while /ɣ/ does not. From Figure 4, the F1 value for /ɣ/ by Korean L2 Chinese speakers is higher, suggesting the correct tongue position should be higher, nearly consistent with that for /o/.

The pronunciation position of /y/ is close to /i/, with the difference being that /y/ is a rounded vowel. From Figure 4, it can be seen that Korean L2 Chinese speakers have a broad presence in the non-low vowel area for /y/, indicating unclear pronunciation and existing issues. There are mainly four problems. First, /y/ overlaps significantly with /u/ for Korean L2 Chinese speakers. When initially learning Mandarin Pinyin, they struggle to distinguish whether “u” in a syllable should be pronounced as “/u/” or “/ɣ/”, influenced by negative L2 transfer, leading to the initial inclination to pronounce it as “/u/”. Therefore, special memorization of syllable spelling rules is needed to avoid errors. Second, there is considerable overlap between /y/ and /o/, related to mistaking “ü” for “u”. For instance, Korean L2
Chinese speakers might pronounce “yu” (渔夫) as “iu”, where “iu” and “iou” in Mandarin Pinyin actually refer to the same syllable, but “iou” is typically abbreviated to “iu”. The sound naturally transforms to the “io” part of “iou”. Third, /y/ slightly overlaps with /ɣ/, mainly due to confusion between “ü” and “u”. This is also due to unfamiliarity with the use of the glottal stop “y” in Mandarin syllable spelling rules, mistaking the “y” in “yu” as “i”. When “ü” forms a syllable on its own, it requires the addition of the glottal stop “y”, which is silent. Lastly, in Figure 4, we find that /y/ pronounced by Korean L2 Chinese speakers also appears between /i/ and /u/. The tendency of Korean L2 Chinese speakers to read /y/ as “ㅟ” has been widely noted in past research. In the Experiment section of this paper, Table 11 shows that for Korean L2 learners’ pronunciation of /y/, F2 splits into two distinct segments. The lower front segment has an average F1 value of 340 and an average F2 value of 1504, comparable to Shin (2016) measurements for /ɯ/. The higher back segment corresponds to the pronunciation of /i/. In terms of the F2 value range, the F2 values for /u/ produced by Korean L2 Chinese speakers are mostly within the range of F2 values for /y/ produced by native Chinese speakers. The similar sound to “ㅟ” produced by Korean L2 Chinese speakers replaces the fixed pronunciation position of /y/ (almost identical to /ɨ/) and the rounded lip movement with a gliding sound from low to high. Comparing Shin Ji-young’s (2016) measurements for /u/ with the measurements for /u/ by Korean L2 Chinese speakers in this study, it appears that Korean L2 Chinese speakers are replacing the pronunciation of /u/ with /ɯ/, hence the experimental results observed where Korean L2 Chinese speakers use F2 to differentiate /u/ and /o/, but in reality, they are producing the sound of /ɯ/, not the Mandarin /u/. (As shown in the Figure 5 below) Korean L2 Chinese speakers are avoiding the rounded lip movement. The Mandarin phoneme inventory does not include /ɯ/.

![Figure 5](image)

Figure 5. Shin (2016). Formant Chart (10 male standard language speakers).

4. Discussion

Overall, Korean L2 Chinese speakers indeed face challenges with the pronunciation of non-low vowels, often leading to confusion. They use F2 values to differentiate between /u/ and /o/, while /y/ and /o/ are distinguished by F1 values. The F1 value for /a/ is slightly lower. The pronunciation similar to “ㅟ” differs from /y/ in that the former is a gliding sound moving from low to high. The distinction between /y/ and /u/, /o/, /ɣ/ is not very clear, mainly due to unfamiliarity with
Mandarin Chinese syllable spelling rules, including the use of the glottal stop “ü” and the modification rules for “ii” in syllables. This results in confusion of /y/ with “iu” and “io”. This finding aligns with the historical vowel changes in “ü” identified by Wenkai (2015), where the pronunciation of “ü” historically, surprisingly, still appears in the modern pronunciation of ‘ü’ by Koreans, reflecting the Sino-Korean readings as a living fossil of Chinese. The established pronunciations of “ü” in different periods were merely conventional agreements of those times. Therefore, non-low vowels are particularly challenging for Korean L2 Chinese speakers, prone to ambiguity. This issue seems to relate to Korean L2 Chinese speakers avoiding rounded lip movements, substituting /ɯ/ for /u/, and “˧” (/[u+ʌ]/) for /y/, which simplifies pronunciation while reducing the number of phonemes used, reflecting the principle of linguistic economy.

Diphthongization (the mispronunciation of [y] as [ui]) was observed exclusively in the target word “漁夫” (yúfū, ‘fisherman’) and not in other words during the experiment. This intriguing phenomenon was noted as part of an effort to minimize negative transfer effects; the design of target words aimed to ensure an accurate representation of the second language learners’ actual pronunciation. Korean second language learners, influenced by negative transfer from their native language, produce the sound [ui] with an F2 range that aligns with the F2 range of native speakers’ production of /y/. Consequently, the pronunciation of [ui] in Korean closely resembles the Mandarin /y/. In the pronunciation of “漁夫”, the absence of an initial consonant makes it easier to distinguish the mispronunciation [ui]. However, in other syllables with initial consonants, the influence of the consonant alters the acoustic properties. When an initial consonant combines with /y/, the F2 appears as a single line, not splitting into the more complex glide [u+i]. Learners tend to adhere to the principle of least effort, avoiding the more complex diphthongization in the presence of an initial consonant.

This study primarily focuses on the F1, F2, and F3 values in the pronunciation of non-low vowels by beginner Korean L2 Chinese speakers, identifying several pronunciation issues. In terms of F3 values, both Korean L2 Chinese speakers and native Chinese speakers have high F3 values for /i/, indicating a forward tongue position. The F3 value for /y/ should also be high, but it is slightly lower for Korean L2 Chinese speakers, suggesting that the correct tongue position for pronouncing “/y/” should be more forward and higher.

5. Conclusion

The present study examines the pronunciation output of Korean L2 Chinese speakers in Mandarin non-low vowels centered around /y/, revealing confusions in pronunciation due to negative transfer from their native language and overgeneralization in the second language. Korean L2 Chinese speakers accomplish Mandarin pronunciation by substituting similar phonemes from their native language and altering articulatory movements for similar sounds. While the phonetic samples are based on the pronunciation of modern Korean L2 Chinese speakers, a surprising finding is that the confused sounds bear a striking resemblance to the historical evolution of the Mandarin /y/ sound, predating its modern form. Language
correctness is merely a result of conventional agreement. In linguistic research, integrating the findings of diachronic studies with experimental phonetics and phonology, as well as combining experimental evidence with descriptive analysis, constitutes an exploratory endeavor in phonetic research presented in this paper. It is hoped that this attempt can serve as a preliminary step, stimulating further development in the theoretical framework of multidimensional phonetic studies.

Korean L2 Chinese speakers tend to substitute /y/ with “ㅥ,” using the glide composed of /ɯ+/i/. Specifically, they opt for the Korean /ɯl/, which does not require rounding the lips. Similarly, for the pronunciation of /u/, they utilize /ɯl/. The articulation of /ɯ/ is in a neutral position, allowing for natural production without deliberate advancement or retraction of the tongue, nor the need for lip rounding. This represents a simplification strategy adopted by Korean L2 Chinese speakers. It involves simplifying the pronunciation method, avoiding lip rounding, and reducing the number of phonemes used, resorting to the most familiar and least effortful method for speech production. In Chinese language teaching, instructors should consciously avoid using the students’ native language as an intermediary language for instruction. Although this is the most favored and least painful way for Korean L2 Chinese learners to learn a foreign language, it can lead to significant interlanguage errors in phonetic production due to negative transfer from the mother tongue.

Regarding limitations and future directions, firstly, the selection of participants could be improved in terms of number, gender, and the range of Chinese proficiency levels. Secondly, the design of target words lacks sufficient reference to difficulty levels. It would be ideal and more comprehensive to design and augment pre and post-tests using a difficulty reference standard for target words. Finally, there is a technical shortcoming in the lack of support for detection and chart creation using R language. Future research should contemplate and expand on participant numbers and proficiency levels, the design of target words, and the use of R language technology to more comprehensively present the Articulatory Characteristics and Vowel Space Analysis of Mandarin non-low vowels centered around /y/ for Korean L2 Chinese speakers.

**Funding:** This research was funded by the 2023 Ministry of Education General Research Project in Humanities and Social Sciences, titled ‘Study on Ancient Chinese Bodily Motion Verbs Based on Conceptual Fields’, grant number 23YJC740034; the 2021 Philosophy and Social Sciences Research Project of Heilongjiang Province, titled ‘A Study of the Diachronic Evolution and Synchronic Distribution of Chinese Body Displacement Verbs Based on the Conceptual Field’ grant number 21JYB159.

**Conflict of interest:** The author declares no conflict of interest.

**Notes**

1. Praat software is a speech analysis tool used for studying and analyzing speech signals. It offers a range of functions, including recording, editing, analyzing, and synthesizing speech. Praat helps users analyze the acoustic features of speech, such as fundamental frequency, formant peaks, and intensity, and provides functionalities like waveform display, spectral
analysis, and measurement of acoustic parameters. It is widely applied in fields like speech research, speech therapy, and speech education.

2. There may be also a retroflex vowel phoneme /ɻ/ in Mandarin, but it has limited distribution and lacks of a clear phonetic description (Huang and Liao, 1983; Lin, 2007). It is beyond the scope of the present study.

3. Baidu Baike is an open-content, free online encyclopedia launched by Baidu Inc. Its beta version was launched on April 20, 2006, and the official version was released on April 21, 2008. As of April 2023, Baidu Baike has included more than 27 million entries, with over 7.7 million users participating in entry editing, covering almost all known fields of knowledge.


References


