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Article

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

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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.

	Rhyme	Syllable	Spelling Rules for Syllables
ü	ü üe üan ün	yu yue yuan yun	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.
	j, q, x, ü, üe, üan, ün	ju, jue, juan, jun, qu, que, quan, qun, xu, xue, xuan, xun	When combined with the initials j, q and x, the two dots above “ü” are omitted. [Modification]
u	u	wu	When ‘u’ forms an independent syllable in Mandarin, a glottal stop symbol ‘w’ is prefixed to it. [Addition]
	uo uai uei uan uen uang ueng	wo wai wei wan wen wang weng	When syllables beginning with ‘u’ form independent syllables in Mandarin, ‘u’ is transcribed as ‘w’. [Modification]

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 “ㅟ”. It is evident that the Mandarin vowel ‘ü’ and the Korean vowel ‘ㅟ’ are perceived as similar in the pronunciation of Korean speakers. (**Table 3**)

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

	Pre-Q	W. Han	E. Han	S/N Dyn.	Sui/Tang	Five Dyn.	Song	Yuan	Ming/Qing	Mod.
鱼(Fish)	ia	iɔ	iɔ	iɔ	io	iu	iu	iu	ü	ü
雨(Rain)	iua	iuɔ	iuɔ	io	iu	iu	iu	iu	ü	ü
局(Office)	iɔ	iuɔ	iuɔ	io	iu	iu	iu	iu	ü	ü

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

Vowel	Evolution Process
한국어 ‘ㅟ’	[uj]>[ü]>[wi]

The phonetic relationship between the Mandarin vowel ‘ü’ and the historical phonetic evolution of the Korean vowel ‘ㅟ’ 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 "ㅟ" 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.

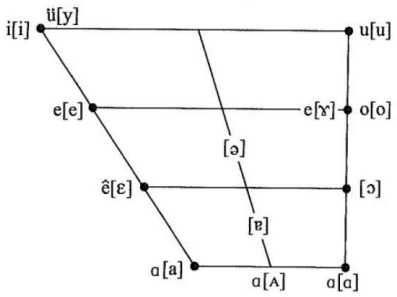


Figure 1. Mandarin vowel articulation chart.

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 "ㅟ" and Mandarin "ü", scholars have shown more interest in historical analysis or perceptual comparisons within Korean, comparing "ㅟ" with similar sounds. Although standard F1 and F2 values for Korean vowel pronunciation are available in Korean phonetics literature, they do not include "ㅟ". The vowel "ㅟ" 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[1] 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[2] 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 /tɕ/, /tɕʰ/, /ɕ/) in Mandarin. 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 Baike[3].

Table 4. List of target words.

Pronunciation	/ʂuʂu /	/itʰoʊ /	/tɕʰy fu/	/ʂoʊ ʂu/	/ɕy fu/	/tɕytsi/	/wo fu/
Chinese Words	叔叔	一头	屈服	收书	虚浮	橘子	窝夫
Meanings	'Uncle'	'suddenly and swiftly'	'yield'	'Collect book'	'illusory'	'orange'	'Waffle'
Pronunciation	/lu fukʊŋ/	/weɪ tʰʊŋ/	/ʂɣtʰoʊ/	/y fu/	/ ja tʰoʊ/	/joʊ fu/	
Chinese Words	卢浮宫	胃痛	舌头	渔夫	丫头	优抚	
Meanings	'Louvre'	'Stomachache'	'Tongue'	'Fisherman'	'(informal)Young girl '	'preferential treatment or care'	

The filler words involved in the study are as follows: /y /(渔夫), / y /(虚浮), / y

/(橘子), / y /(屈服), /u/(叔叔), /u/(卢浮宫), /o/(收书), /o/(窝夫), /o/(优抚), /ɣ /(舌头), /e/(胃痛), /i /(一头), /a/(丫头). 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).

	1st			**2nd**			**3rd**		
	F1(Hz)	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**
/u/ (叔叔)	298	1654	2578	240	1712	2404	269	1712	2462
/i / (一头)	269	2145	3212	269	2116	3097	297	2087	3068
/y/(屈服).	434	812	2398	471	675	2379	441	606	2745
/o/ (收书)	380	797	2373	396	791	2400	414	811	2401
/y/(虚浮).	437	1032	2609	469	934	2525	425	999	2804
/y/(橘子).	402	998	2559	406	979	2398	401	978	2469
/u/(卢浮宫).	483	1121	2502	453	1015	2326	383	977	2484
/e/(胃痛).	410	2249	3024	406	2264	2947	389	2062	2359
/o/(窝夫).	393	704	2593	370	720	2498	392	713	2615
/ɣ / (舌头)	499	1106	2433	529	1163	2404	471	1106	2347
/y/(渔夫).	338	1933	2278	335	1872	2205	395	1169	2283
/a/(丫头).	557	1250	2433	586	1279	2462	499	1308	2520
/o/(优抚).	393	994	2461	401	987	2434	413	891	2625

Table 6. <L2 vowel: Mandarin Chinese vowels produced by a Korean-speaking learner > (2).

	1st			**2nd**			**3rd**		
	F1(Hz)	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**
/u/ (叔叔)	370	1291	3176	370	1124	2548	412	1208	2464
/i / (一头)	348	2238	3055	351	2239	3081	340	2276	3032
/y/(屈服).	367	2029	2234	306	2032	2156	331	2124	2311

Table 6. (*Continued*).

	1st			2nd			3rd		
	F1(Hz)	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**
/o/ (收书)	328	789	2506	370	747	2715	328	789	2799
/y/(虚浮).	397	1283	2303	410	1324	2218	421	1269	2321
/y/(橘子).	343	1543	2363	364	1556	2462	332	1499	2213
/u/(卢浮宫).	400	983	3433	396	968	2612	383	983	2674
/e/(胃痛).	434	2086	2379	445	1801	2287	446	1850	2282
/o/(窝夫).	441	643	2604	423	887	2634	423	689	2586
/ɣ / (舌头)	496	998	2715	579	1082	2590	537	1082	2674
/y/(渔夫).	301	1683	2216	291	1651	2220	300	1794	2370
	318	2109	2579	313	2114	2587	314	2147	2701
/a/(丫头).	496	1208	2590	579	1459	2590	663	1417	2715
/o/(优抚).	459	726	2649	449	714	2635	420	708	2617

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

	1st			2nd			3rd		
	F1(Hz)	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**
/u/ (叔叔)	355	1423	2347	367	1423	2520	340	1321	2347
/i / (一头)	297	2318	2866	271	2410	2741	319	2231	2942
/y/(屈服).	338	2212	3026	324	2150	3141	312	2317	2997
/o/ (收书)	413	1019	2491	440	991	2231	399	1019	2491
/y/(虚浮).	338	2234	2994	310	2151	2899	329	2135	2951
/y/(橘子).	484	1304	2655	487	1007	3039	421	1321	2771
/u/(卢浮宫).	386	899	2737	353	1355	2351	367	1423	2251
/e/(胃痛).	434	2085	2591	454	2089	2627	443	2087	2617
/o/(窝夫).	543	779	2875	620	755	2915	554	835	2892
/ɣ / (舌头)	529	989	2955	560	1018	3014	527	987	2995
/y/(渔夫).	340	1504	2462	367	1569	2503	379	1934	2499
	365	2278	2716	342	2076	2740	359	2271	2697
/a/(丫头).	673	1250	2491	689	1321	2521	673	1160	2391
/o/(优抚).	499	861	2996	447	752	2877	479	796	2724

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

	1st			2nd			3rd		
	F1(Hz)	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**
/u /(叔叔)	328	831	2715	328	831	2799	328	873	2799
/i /(一头)	290	2456	3277	296	2505	3351	344	2214	2561
/y/(屈服).	336	2153	2566	334	2063	2553	348	2028	2465
/o/ (收书)	454	1250	2213	454	1250	2213	412	1333	2213

Table 8. (*Continued*).

	1st			2nd			3rd		
	F1(Hz)	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**
/y/(虚浮).	329	1991	2617	347	2070	2448	338	1982	2434
/y/(橘子).	299	2019	2706	280	2022	2666	294	2003	2659
/u/(卢浮宫).	388	757	2833	402	702	2842	409	767	2789
/e/(胃痛).	455	2077	2762	454	2037	2729	484	2035	2771
/o/(窝夫).	487	691	3107	446	767	2991	456	880	3109
/ɣ /(舌头)	496	1208	2888	453	1250	2674	495	1250	2757
/y/(渔夫).	286	2074	2847	288	2111	2630	303	2059	2737
/a/(丫头).	789	1250	2548	747	1208	2380	705	1208	2338
/o/(优抚).	445	912	2684	444	860	2807	508	906	2708

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

	1st			2nd			3rd		
	F1(Hz)	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**
/u /(叔叔)	355	932	2491	357	927	2369	370	932	2510
/i /(一头)	355	2145	2953	355	1954	2841	355	2145	2841
/y/(屈服).	290	2117	3251	291	2105	3158	290	1967	2222
/o/ (收书)	355	846	2549	355	846	2641	370	851	2549
/y/(虚浮).	265	2090	2934	279	2167	3107	281	2118	3139
/y/(橘子).	259	2181	2817	280	2322	3240	268	2165	3096
/u/(卢浮宫).	313	904	2931	316	880	2761	311	869	2590
/e/(胃痛).	427	1933	2261	396	2057	2499	353	2026	2618
/o/(窝夫).	394	855	2379	413	839	2344	556	794	2378
/ɣ /(舌头)	471	1106	3299	452	1130	3110	460	1200	2980
/y/(渔夫).	269	2095	3057	256	1979	3160	265	2058	3021
/a/(丫头).	615	1221	2635	589	1320	2351	615	1221	2651
/o/(优抚).	360	853	3367	403	805	2397	387	880	2343

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

	1st			2nd			3rd		
	F1(Hz)	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**
/u /(叔叔)	234	904	2318	327	990	2433	267	933	2549
/i /(一头)	269	1798	2953	269	1914	2895	297	1971	2953
/y/(屈服).	324	1649	2864	316	1639	2949	333	1609	2715
/o/ (收书)	442	1077	2202	442	1019	2520	413	875	2520
/y/(虚浮).	316	1639	2887	315	1660	2890	305	1668	2785
/y/(橘子).	323	1716	2911	323	1715	2783	313	1682	2586
/u/(卢浮宫).	329	835	2846	357	893	2879	353	868	2666

Table 10. (*Continued*).

	1st			2nd			3rd		
	F1(Hz)	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**
/e/(胃痛).	464	1597	2082	471	1487	2540	472	1564	2518
/o/(窝夫).	474	827	2912	475	839	2747	505	827	2676
/ɣ/(舌头)	471	1221	2404	529	1106	2462	557	1163	2520
/y/(渔夫).	277	1774	2794	304	1683	2386	309	1747	2789
/a/(丫头).	759	1221	2376	759	1250	2318	788	1250	2318
/o/(优抚).	462	828	2740	495	781	2827	488	831	2810

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.

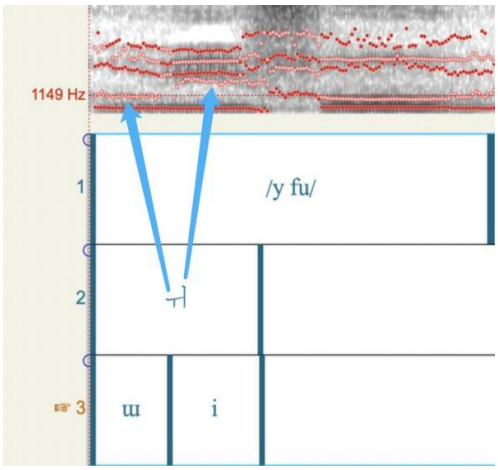


Figure 2. F2 Performance in /y/ Pronunciation by Korean L2 Chinese Learners.

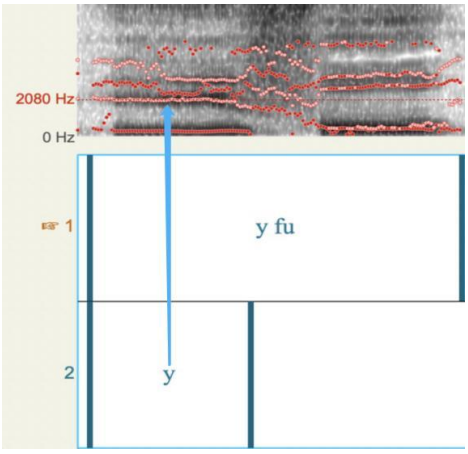


Figure 3. F2 Performance in /y/ Pronunciation by Native Chinese Speakers.

3. Results

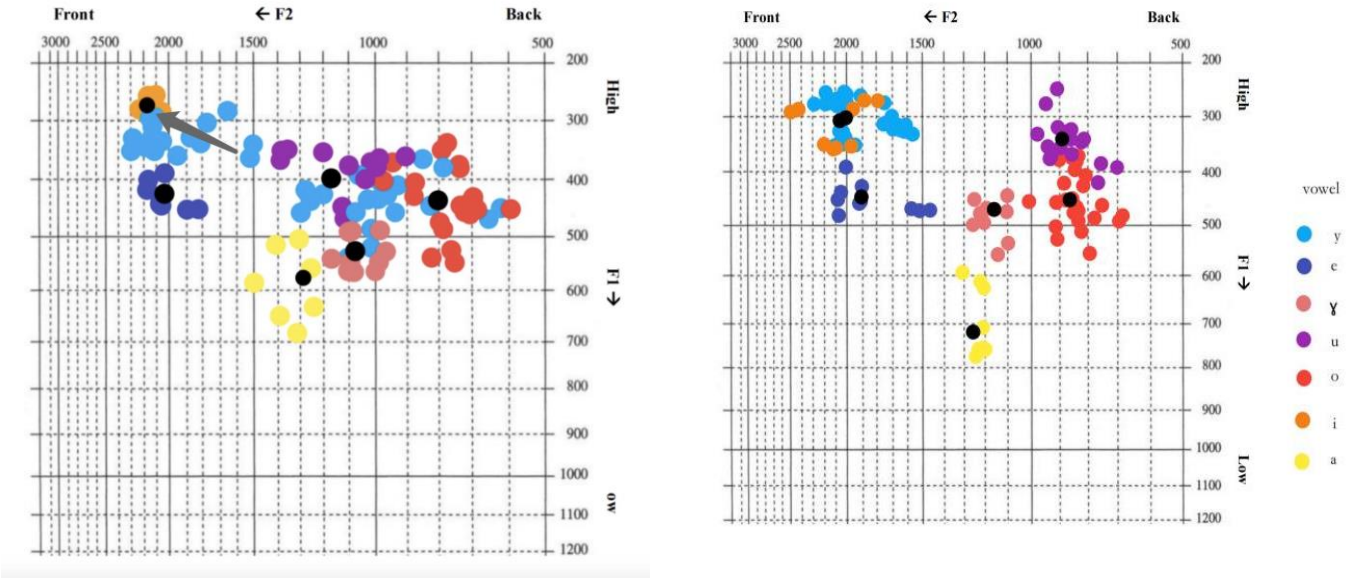
Based on the measurement results, the average formant values of Korean L2 Chinese learners and L1 Chinese are as follows. **Table 12** shows the average formant values for each specific filler word. **Table 11** displays the consolidated average formant values for the same phonemes. Additionally, in **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.

		Korean L2 Chinese			**L1 Chinese**		
		F1(Hz)	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**
/u /(叔叔, 卢浮宫).		400	1191	2819	353	831	2793
/o/ (收书, 窝夫, 优抚)		429	811	2637	441	901	2628
/y/(屈服).		358	1672	2598			
/y/(虚浮).		394	1546	2615			
/y/(橘子).		404	1276	2542	301	1948	2802
	/y/	337	1873	2470			
/y/(渔夫).	/ɯ/	340	1504	2462			
	/i/	318	2109	2579			
/e/(胃痛).		413	2060	2617	442	1868	2531
/ɣ /(舌头)		477	1272	2425	487	1182	2788
/a/(丫头).		613	1295	2515	707	1239	2435
/i/ (一头)		306	2234	3010	314	2122	2958

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

	Korean L2 Chinese			**L1 Chinese**		
	F1(Hz)	**F2(Hz)**	**F3(Hz)**	**F1(Hz)**	**F2(Hz)**	**F3(Hz)**
/u /(叔叔)	336	1431	2594	322	906	2554
/i /(一头)	306	2234	3010	314	2122	2958
/y/(屈服).	358	1672	2598	318	1926	2749
/o/ (收书)	385	861	2501	411	1039	2402
/y/(虚浮).	394	1546	2615	308	1932	2805
/y/(橘子).	404	1276	2542	293	1981	2829
/u/(卢浮宫).	400	1191	2819	353	831	2793
/e/(胃痛).	429	2063	2568	442	1868	2531
/o/(窝夫).	462	747	2745	467	813	2738
/ɣ/ (舌头)	525	1070	2896	487	1182	2788
/y/(渔夫).	337	1873	2470	284	1953	2825
/a/(丫头).	613	1295	2515	707	1239	2435
/o/(优抚).	439	826	2664	444	851	2743



Korean speech Chinese speech

Figure 4. Korean L2 Chinese and L1 Chinese speakers' vowel spaces.

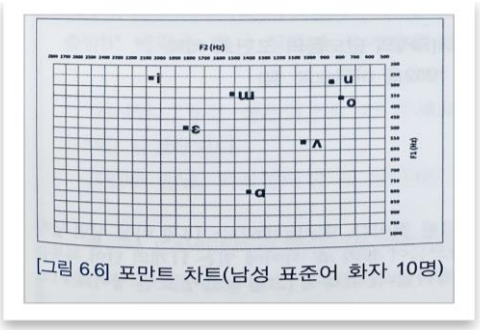
From **Figure 4**, it can be observed that Korean L2 Chinese speakers pronounce /i/ and /e/ quite accurately. For beginners among Korean learners, the F1 value for /a/ is slightly low, a common issue among Mandarin L2 learners, characterized by insufficient mouth opening and a slightly high tongue position 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 "/y/", 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/[4]. The higher back segment corresponds to the pronunciation of /i/. In terms of the F2 value range, the F2 values for /ɯ/ 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 /i/) and the rounded lip movement with a gliding sound from low to high. Comparing Shin Ji-young’s (2016) measurements for /ɯ/ 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/.



[그림 6.6] 포만트 차트(남성 표준어 화자 10명)

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 /ɣ/ 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 "y" and the modification rules for "ü" 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 "ㅟ (/ɯ/+/i/)" for /y/, which simplifies pronunciation while reducing the number of phonemes used, reflecting the principle of linguistic economy.

Diphthongization (the mispronunciation of [y] as [ɯi]) was observed exclusively in the target word "渔夫" (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 [ɯi] with an F2 range that aligns with the F2 range of native speakers' production of /y/. Consequently, the pronunciation of [ɯi] in Korean closely resembles the Mandarin /y/. In the pronunciation of "渔夫", the absence of an initial consonant makes it easier to distinguish the mispronunciation [ɯi]. 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 [ɯ+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 "ㅟ," using the glide composed of /ɯ/+/i/. Specifically, they opt for the Korean /ɯ/, which does not require rounding the lips. Similarly, for the pronunciation of /u/, they utilize /ɯ/. 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.

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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 /ɚ/ 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.

4. Shin Ji-young. KOREAN PHONETICS AND PHONOLOGY. Seoul: Park Ijeong, 2016, pp. 165. The average F1 value for male /ɯ/ is 333.5, and the average F2 value is 1517.6.

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