

**Production of English Liquid Consonants in Coda Position by Native Mandarin
Chinese Speakers**

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Table of Contents

1 Introduction and Theoretical Overview	1
1.1 Phonology in Language Learning	1
1.2 Language Transfer	2
1.3 Natural Phonological Processes	3
2 Native Mandarin Speakers' Acquisition of English	4
2.1 Differences Between Syllable Structure and Sound Inventory of Mandarin and English	4
3 Methods	6
3.1 Current Study	6
3.2 Participants and Data	6
3.3 Data and Measurements	7
3.4 Limitations	8
3.5 Predictions	9
4 Results	10
4.1 Results from Transcriptions	10
4.2 F3 Confirmation of Classification	12
4.3 Results from F3 Pattern Observed in the Measurements	13
5 Conclusion and Discussion	14
5.1 Hypotheses and Predictions	15
5.2 Discussion	16
5.3 Conclusions	16
References	18
Appendix	20

1 Introduction and Theoretical Overview

During the process of acquiring a new language, the discrepancies between the sound structures of one's native language (L1) and the target language (L2) generally amplify the difficulty of learning. With English emerging as the global lingua franca, many countries, including China where Mandarin is the official language, have made it mandatory to include English as a part of their educational curriculum. Because English and Mandarin Chinese possess distinct sound inventories, they diverge in many respects. To learn the other language and discern the subtle variations in pronunciation, native Mandarin speakers must employ specific productions. Since /ɪ/, /l/, and /ɪl/ sounds appear in syllable coda positions in English, but not in Mandarin, can Mandarin speakers produce these sounds at English syllable coda? If not, what productions do they make when pronouncing the words with /ɪ/, /l/, and /ɪl/ at syllable coda positions? This study will examine the hypotheses that: 1. Mandarin speakers will be able to pronounce /ɪ/ sound at coda positions; 2. Mandarin speakers will substitute the /l/ sound with vowels; and 3. Native Mandarin speakers will drop /ɪ/ and substitute the /l/ sound with vowels when producing /ɪl/. To support the study, I will introduce some relevant theories and ideas in the following sections.

1.1 Phonology in Language Learning

In the process of learning a new language, the most crucial aspects are grammar, vocabulary, and sound system. While grammar and vocabulary could be acquired and improved through practices and memorization, phonology needs sophisticated imitation. Thus, a native-like pronunciation is hard to achieve and accent is normal in L2 acquisition (Archibald, 1998).

With different sound inventories for different languages, it makes it harder for language learners to perceive and produce the pronunciation of a new language. In addition, differences in syllable structures across languages can also affect the acquisition of a second language, including the perception, segmentation, and production of syllables (Ali et al., 2011; Yasufuku and Doyle, 2021).

1.2 Language Transfer

Another phenomena that should be considered in second language acquisition is language transfer, also known as cross linguistic influence, which refers to the way in which a speaker's knowledge of their language can affect the acquisition of a second language, or how knowledge of a second language can impact their native language. This influence can manifest in various language domains, including phonology, morphology, syntax, and semantics, and can occur through different mechanisms, such as transfer, interference, and facilitation. Transfer can be both positive or negative, depending on whether the comprehension of L1 improves the proficiency of L2. Interference is a broader concept that include negative language transfer, it refers to all errors that may occur when the two languages spoken by a bilingual speaker interact. Facilitation, on the other hand, refers to the positive influence one language could have on the other when the two languages share certain similarities. Language transfer, interference, and facilitation are all unintended, and they will exhibit different degrees of severity or strength (Jarvis and Pavlenko, 2007). Understanding the complex nature of language transfer is crucial for language educators and learners, as it can help learners develop more effective strategies for

learning a second language, and inform the correlation between language learners' "accent" on the second language and their native language.

1.3 Natural Phonological Processes

In the process of language transfer, certain features of the native language may be transferred to the second language, while others may not. One possible explanation for this selective transfer is the influence of natural phonological process. Natural phonological processes refer to the systematic ways in which speech sounds are altered across languages in order to facilitate ease of articulation. These processes are also important in second language acquisition. These processes can be triggered by factors such as stress, tone, or neighboring sounds, and are used by speakers to simplify sound production and make speaking easier. Natural phonological processes include several phenomena, namely assimilation, dissimilation, and deletion. Assimilation refers to when a sound becomes more similar to neighboring sounds in terms of phonetic features, while dissimilation refers to making a sound less similar to its neighboring sounds in terms of such features. Deletion, also known as elision, on the other hand, results in the omission of a sound from a word entirely. (Donegan, 2002). An example of assimilation is L-vocalization, which is a phonological process that occurs at syllable coda positions, in which the consonant /l/ is realized as a vowel-like sound, typically a central or rounded vowel. Linguist John Wells firstly proposed the theory of l-vocalization in his book, *"Accents of English"*. Wells suggested that l-vocalization is often found in non-standard dialects of English and typically occurs in syllable codas, where /l/ is replaced with a vowel like sound that is produced with the tongue in a similar position to that of /l/. The specific vowel-like sounds

that are produced to replace /l/ can vary in different dialects (Wells, 1982). Understanding natural processes can help with understanding the structure and operation of language.

2 Native Mandarin Speakers' Acquisition of English

As a Mandarin speaker, I am particularly attentive to the sounds in English that are not in the Mandarin sound system, and have always been intrigued by the way that myself and other native Mandarin speakers produce these unfamiliar sounds in English. I noticed that many native Mandarin speakers tend to be confused over words with sounds /ɹ/ and /l/ at the end of syllables when speaking English. Such difficulties pose a challenge for native Mandarin speakers in the process of learning English.

2.1 Differences Between Syllable Structure and Sound Inventory of Mandarin and English

In English, a syllable consists of optional onsets, nucleus, and optional codas (e.g., “ask” /æsk/ is an English word without onset, “go” /go/ is an English word without coda). Mandarin, on the other hand, has a different syllable structure. Unlike English, which can have complex codas consisting of up to five consonants after the nucleus (e.g., “angsts” /æŋksts/), the part after the nucleus in Mandarin is referred to as the “ending,” which can be either vocalic or consonantal. If we consider the Mandarin ending as equivalent to the English coda and focus only on the consonantal cases, the only possible consonants are nasal “n” (/n/) and “ng” (/ŋ/) (Cardoso, 2015; Hansen, 2001; Triskova, 2011).

Phonological processes are particular to languages, Erhua is a phonological process in Mandarin that involves adding a rhotic sound at the end of a word, commonly used in colloquial

speech in Northern Chinese dialects. Mandarin, influenced by Northern dialects, includes many words with Erhua. This feature is also frequently found in Chinese textbooks, such as the widely used edition for first grade students. For instance, the word 快点 (pinyin: "kuài diǎn") is written as 快点儿 in a text, with the character "儿" (pinyin: er, /ɪ/) added at the end. However, the pronunciation for this word may vary by region. This addition may be pronounced as a smooth, continuous "kuài diǎnr" by Northern Chinese dialect speakers, while those who do not have Erhua in their native dialects may pronounce it as separated "kuài diǎn er" or "kuài diǎn e". This process may make it more convenient for some Mandarin speakers to produce /ɪ/ sounds at English syllabic coda positions. Previous research has examined the relationship between post-vocalic Erhua and the English /ɪ/ sound, it has also investigated the English pronunciation of Mandarin and Cantonese speakers. The research has found that Mandarin Chinese speakers tend to produce clearer English /ɪ/ sound and differentiation between /ɪ/ and /l/ than Cantonese speakers (Derrick, 2005). However, most codas in Mandarin are realized as nasals which means that coda sounds other than nasals or certain /ɪ/ sounds are absent in Mandarin.

A previous study about the acquisition of coda consonants by Mandarin speakers was focused on early child L2 learners, and mainly examined /t/, /s/, and /n/. Such acquisition is influenced by both children's language development and linguistics feature of the coda consonants, such as cluster complexity (Rattanasone, Xu, and Demuth, 2013). The studies on /r/ at coda positions have concluded that Mandarin speakers tend to delete word-medial /r/ following /o/, or replace it with another sound, such as /l/ (Shih, 2008). Previous study on production of English syllable final /l/ and /ɪ/ by Mandarin Chinese speakers has found the high error rate for Mandarin speakers when producing syllable-final /l/, their productions include

vocalization, deletion, and retroflexion. Compared to the high error rate for /l/, Mandarin speakers show a higher accuracy in /ɹ/ production (He, 2004; Smith, 2010).

3 Methods

This section will describe the materials and procedures used in the study, and provide information of experiment conduction and data analysis.

3.1 Current Study Objectives

The present study extends previous research by investigating the production of liquid consonants /ɹ/ and /l/, as well as the consonant cluster /ɹl/, by native Mandarin speakers at English syllabic coda positions. By exploring this aspect of second language acquisition, this study aims to contribute to our understanding of cross-linguistic differences in the production of English sounds. This builds upon previous studies that have investigated the production of English liquids by L2 learners of different linguistic backgrounds. For instance, Espinal et al. (2020) examined the acoustic characteristics of /ɹ/ and /l/ sound in English produced by Korean L2 adults, while Smith (2010) investigated the acoustic properties of these sounds in English produced by Mandarin Chinese speakers.

3.2 Participants and Data

The data for this study was collected from public online platforms featuring videos of four native Mandarin speakers reading passages in English. The four speakers, two males and two females, range from elementary school to college age, and have had no prior exposure to an

English-speaking environment according to their profiles. Their English language learning has been restricted to their academic curriculum at school and possibly English classes outside of school. However, the regions from which the four speakers come are unknown.

3.3 Data and Analysis

The materials read by one male speaker and one female speaker are in forms of daily conversation and a diary written in the voice of an elementary school aged girl, from elementary school textbooks. The materials read by the other male speaker and female speaker are texts from college level English textbooks for general education English classes in Chinese universities. In this study, 112 words with syllabic codas containing either /ɹ/ or /l/ were extracted, with nine of these words recurring multiple times. To ensure consistency, the suggested American English pronunciation from the dictionary are used as the standard model for these words. Spectrograms were used to track the trends of F3 trends in the syllables with /ɹ/, /l/ or /ɹl/ codas, which can help with close phonetic transcription. The F3 trends should decline at the end with coda /ɹ/, while they should rise at the end in syllables with coda /l/. The F3 trends of the syllables that contained coda /ɹ/, /l/, or /ɹl/ were marked with “s” (indicating a straight-line trend), “d” (indicating a downward trend at the end), and “u” (indicating an upward trend at the end). By analyzing the trends, I could determine whether the speakers produced /ɹ/ or /l/, or deleted them. To aid in the analysis, I recorded the mean value of F3 for each syllable containing coda /ɹ/, /l/, or /ɹl/. Additionally, the intensity of syllables containing /ɹ/ or /l/ at coda positions is also measured, as vowels are generally more intense than consonants. The intensity value of syllables with /ɹ/, /l/, or /ɹl/ at coda positions can be used to determine whether speakers drop these consonants in their

pronunciation. Specifically, if the intensity of a syllable with a liquid or liquid cluster at the coda position is on the same level to that of syllables with no coda, it suggests that the speaker has dropped the consonant at the syllable final. The F3 and intensity values can provide further insight into the phonological processing.

The words were categorized based on whether they had /ɪ/, /l/, or /ɪl/ at the syllabic coda position. The environments in which these sounds occurred are also recorded, such as whether they were in a consonant cluster or followed by a particular onset in the next syllable. The aim is to explore whether native Mandarin speakers employ different approaches to produce these sounds based on the surrounding environment. Finally, the production of these sounds are analyzed by comparing all of the measurements collected. By doing so, the aim is to identify the relationship between different production methods of /ɪ/ or /l/ sounds by native Mandarin speakers and the environments in which these sounds were produced.

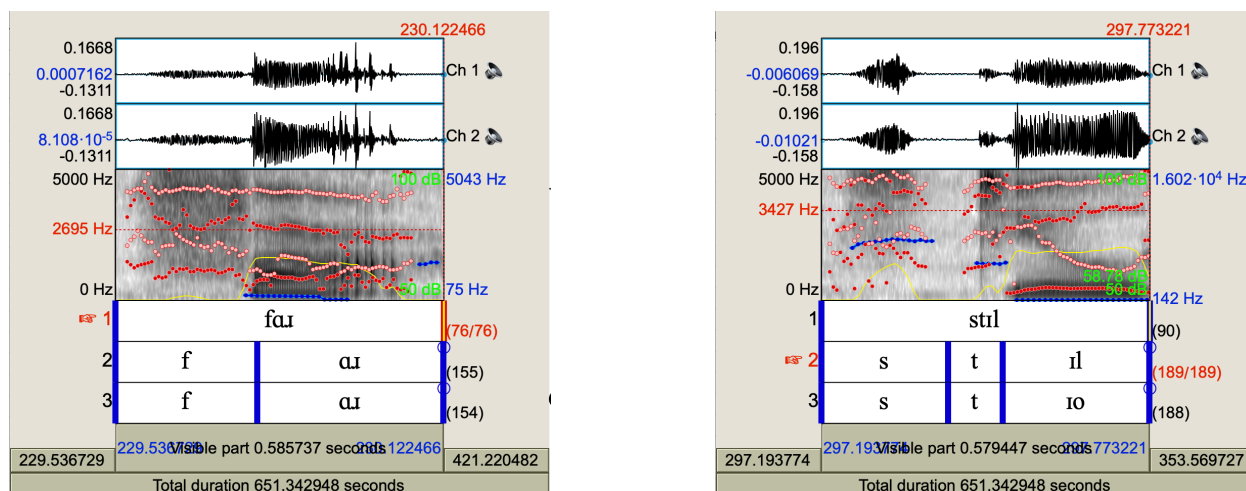


Figure 3.2. Spectrograms of the words “far” and “still” show declining and inclining F3 at the end, respectively.

3.4 Limitations

This study has the following caveats. Firstly, the speakers probably come from various regions of China, where their first language or most used language may not be Mandarin, but rather the dialect of their respective areas. This may affect their perception and production of English due to the influence of their dialects. Secondly, although most English textbooks used in Chinese schools contain American expressions, some British expressions are also incorporated into them. For example, some textbooks use “biscuits” instead of “cookies/crackers” and “trousers” instead of “pants”. While students learn pronunciation from their teachers, recordings in the form of tapes or CDs that come with the textbooks often include both American and British pronunciations. Thirdly, many English learners in China learn the language by watching TV shows and imitating the pronunciation of the characters. This may expose them to a mixture of British and American accents, potentially leading to non-rhotic pronunciation. Therefore, these factors may impact the way in which the participants perceive and produce English, and should be taken into account when analyzing the data.

3.5 Predictions

The study aims to investigate the production of the /ɪ/, /l/, and /ɪl/ sounds by native Mandarin speakers in syllabic coda positions in English. One prediction is that these speakers will be able to produce the /ɪ/ sound due to the presence of “er” in Mandarin, as well as the prevalence of Erhua in many dialects. However, regional differences may lead to less rhotic pronunciation, particularly among speakers from southern China who do not perform Erhua in their dialects.

Another prediction is that native Mandarin speakers will substitute the /l/ sound with alternative sounds such as /o/ in syllabic coda positions in English, as a form of l-vocalization, given that Mandarin does not have /l/ as a coda in its sound inventory, and /l/ is produced with a similar tongue position to that of /o/,

Finally, when producing the consonant cluster /ɪl/, it is predicted that native Mandarin speakers will simplify the cluster by deleting one of the consonants, most likely /ɪ/, and substituting /l/ with /o/. The reason for this prediction is that /l/ is produced with an open vocal tract, similar to vowels, and can be connected smoothly with the vowels preceding the coda and does not require transition from vowel to consonant. Out of all the vowels in Mandarin, /o/ is the most similar in sound to /l/.

4 Results

This section includes analysis based on results from the experiments, namely the results from transcriptions, F3 confirmation of classification, and results from F3 pattern observed in the measurements.

4.1 Results from Transcriptions

Out of the 112 words studied, 68.75% contained /ɪ/ at the syllabic coda position. Of these 77 words, 25.97% were pronounced with the /ɪ/ dropped entirely, while another 25.97% were modified such that both the /ɪ/ at the coda position and the preceding vowel were altered. The remaining 45.45% words were produced with the /ɪ/ pronounced in the regular way (as the suggested American pronunciation in dictionaries). In two cases, speakers dropped a non-/ɪ/

phoneme in the consonant cluster at the coda position. Notably, in all instances where syllabic codas with /ɹ/ are pronounced in the regular way, up to 85.71% of the preceding vowels are /ə/.

29.46% out of the 112 words studied had /l/ at the syllabic coda position. 33.33% of them were pronounced with the /l/ dropped, while 36.36% were produced with the /l/ pronounced as the suggested pronunciation in dictionary. 30.3% out of the 33 words were modified, affecting both the /l/ at the coda position and the preceding vowels. This partially supports the prediction that Mandarin speakers may substitute /l/ at syllabic coda positions with alternative sounds. However, in the most cases, speakers tended to drop the /l/ sound or produce it in its usual form. Of the 30.3% cases where the syllable with /l/ coda were modified, 60% were modified to sounds containing /o/. Among these, two cases were /l/ modified to /o/, two were /ɹl/ modified to /ɹo/, one was /ɔl/ modified to /o/, and one was /əɹl/ modified to /o/. It is important to note that the /o/ sound to which /l/ is modified is not rounded, as /o/ in Mandarin is produced without lip rounding (as in Pinyin “ou”). For the four cases where the original sound consisted of a vowel and /l/, it is difficult to determine whether the modification was for the /l/ or if the speakers dropped the /l/ and then modified the preceding vowel.

The presented pie charts depict the proportion of occurrences for each process of /ɹ/ and /l/ in syllabic coda positions. The blue chart displays the distribution of processes in syllable codas containing /ɹ/, whereas the orange chart presents the corresponding information for syllable codas containing /l/. 45% of the /ɹ/ sounds at syllable coda positions are produced regularly, which means they are pronounced as the suggested pronunciations in dictionaries. The percentage for the same category for syllable codas containing /l/ is only 34%, suggests that speakers show a higher accuracy in producing /ɹ/ sound at syllable coda positions. In the chart

for syllable codas containing /ɪ/, the production of dropping /ɪ/ takes the highest percentage, which diverges from the prediction that native Mandarin speakers would modify /ɪ/ in syllable codas to an alternative vowel.

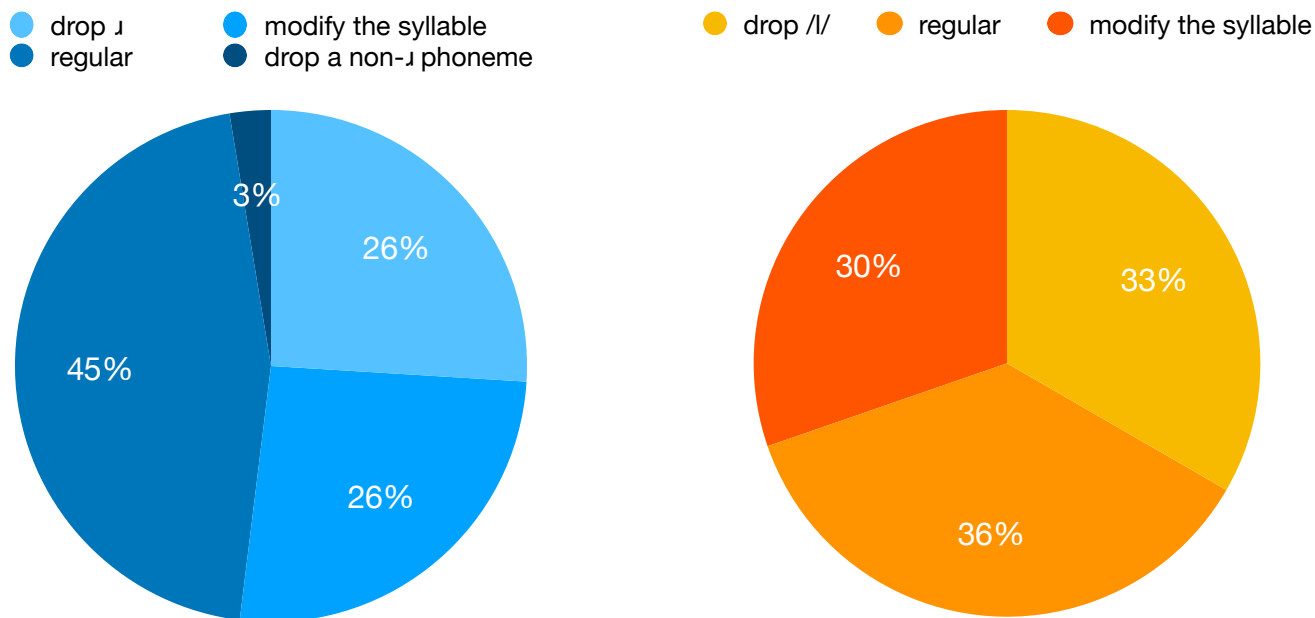


Figure 4.1. The percentage of each coda production that includes /ɪ/ and /I/.

4.2 F3 Confirmation of Classification

Of the 77 syllables containing a coda with /ɪ/ that are expected to have a downward F3 trend only 29% showed this trend, while 48% had a straight-line F3 trend and 23% showed an upward F3 trend. This suggests that less than one-third of the syllables with /ɪ/ coda fit the predicted F3 trend. Combining this observation with the earlier finding that 45% of the syllables with /ɪ/ coda were produced as suggested pronunciation by Mandarin speakers, we can conclude that native Mandarin speakers can generally produce syllabic coda /ɪ/, but their production of /ɪ/ is less rhotic than standard American English models.

For the 33 syllables containing a coda with /l/ that were expected to have an upward F3 trend, 33% showed such a trend, while 49% had an F3 trend as a straight line, and 18% had a downward F3 trend. Only one-third of the syllables with /l/ codas conformed to the predicted F3 trend, which is slightly higher than that of syllables with /ɹ/ codas, and almost half of the syllables with /l/ codas had an F3 trend as a straight line. While the slope for F3 is a common trend for vowels, it is difficult to conclude that the percentage of upward F3 trend is associated with the accuracy of the speakers' pronunciation of /l/ in English coda positions. However, this observation may confirm that native Mandarin speakers typically vocalize the /l/ sound in the production.

4.3 Results from F3 Pattern Observed in the Measurements

To support these observations, I measured the average F3 values of each coda containing /ɹ/, /l/, and /ɹl/ with their preceding vowels. However, it should be noted that the /ɹl/ codas have a very small sample size of only two cases and are thus not very representative. On average, the F3 for /l/ codas is higher than that for /ɹ/ codas, with values of 2843.19 Hz and 2773.05 Hz, respectively, as presented in Figure 4.3.1. I conducted two-tailed t-tests on /l/ and /ɹ/ codas separately for four speakers, comparing /l/ or /ɹ/ present versus absent from the pronunciations. The results for /ɹ/ and /l/ codas by four speakers have shown that the difference is significant ($p < 0.05$), as illustrated in Figure 4.3.2. This finding demonstrates that there are differences in F3 values when /ɹ/ and /l/ are absent among the speakers, confirming the expectations for acoustic features and the accuracy of the classification of the presence or absence of /l/ or /ɹ/.

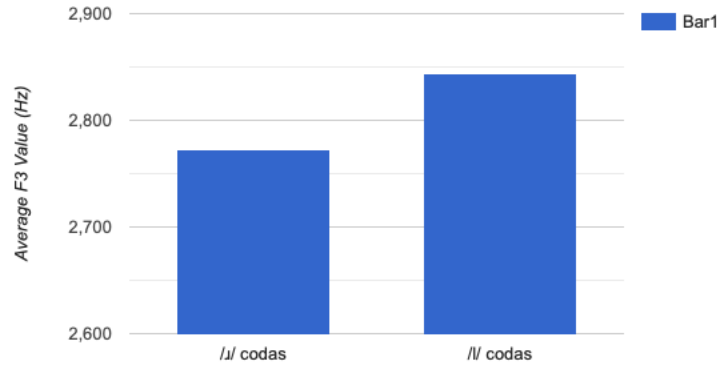


Figure 4.3.1. Average F3 value for syllables with /ɹ/ codas and /l/ codas.

	P-value (speaker 1)	P-value (speaker 2)	P-value (speaker 3)	P-value (speaker 4)
/ɹ/	0.014	0.039	0.034	0.045
/l/	0.024	0.001	0.025	0.035

Table 4.3.2. P-values for two-tailed t-tests comparing the F3 values of /l/ and /ɹ/ codas for four speakers, with /l/ or /ɹ/ present versus absent from the pronunciations.

5 Conclusion and Discussion

This section will present the results found in the experiments and subsequent analysis of the hypotheses. I will also provide a discussion of the results, the contribution of this study, and future implications.

5.1 Hypotheses and Predictions

This study tested the following hypotheses and found the following results:

1. *Speakers will be able to produce the /ɹ/ sound due to the presence of “er” in Mandarin, as well as the prevalence of Erhua in many dialects.* This hypothesis was verified by a greater proportion of “regular” pronunciation, as indicated in dictionaries, in syllable codas containing /ɹ/ as compared to those containing /l/. This shows that speakers pronounce /ɹ/ sounds more accurately than /l/ sounds.

2. *Native Mandarin speakers will substitute the /l/ sound with alternative sounds such as /o/ in syllabic coda positions in English, as a form of l-vocalization.* This hypothesis was not confirmed because the proportion of “modify the syllable” in syllable codas containing /l/ is smaller than the proportion of “drop /l/.” This indicates that dropping /l/ is a more common approach for native Mandarin speakers when produce syllable-final /l/, compared to modifying the /l/ sound, or the entire syllable.

3. *Native Mandarin speakers will simplify the cluster by deleting one of the consonants, most likely /ɹ/, and substituting /l/ with /o/ when producing the consonant cluster /ɹl/. The* hypothesis could not be confirmed due to insufficient sample size. Among the two cases of /ɹl/ observed in the experiment, the speakers exhibit a tendency to drop the /l/ sound, thereby producing only the /ɹ/ sound. This finding is contrary to the prediction that native Mandarin speakers would delete /ɹ/ when producing the consonant cluster /ɹl/.

5.2 Discussion

The study explored the factors that initiate language transfer and how it impacts the perception and production of a second language. The findings of different productions of words with /ɪ/, /l/, and /ɪl/ codas can potentially be used by English teachers and Mandarin Chinese students learning English to enhance the English pronunciation of native Mandarin speakers. Additionally, this study has the potential to create awareness among individuals who interact with Mandarin-speaking English learners, reducing the likelihood of miscommunication due to misinterpretation or mishearing.

The experiment recorded the occurrence of the consonant cluster /ɪ/, /l/, or /ɪl/ at syllable coda position and the onset of the subsequent syllable (as displayed in the appendix). However, due to the limited sample size, the correlation between the production of /ɪ/, /l/, and /ɪl/ sounds at syllable coda and the consonant cluster and the following vowel is not clearly understood. Future studies can expand the sample size and investigate the relationship between the environment of /ɪ/, /l/, and /ɪl/ sounds at syllable coda, including the length of the consonant clusters, the combination of different consonants in the cluster, and the backness and height of the following vowels, and their production.

5.3 Conclusions

The present study investigated how non-native speakers produce unfamiliar sounds in their second language (L2). Language transfer, a crucial factor that affects sound production, heavily impacts speakers' ability to produce unfamiliar sounds. Specifically, the current research examined how different qualities of the speakers' first language (L1) influence their production

of English liquids in coda position. The findings indicate that the speakers demonstrated higher accuracy in producing the /ɹ/ sound, particularly in /əɹ/, this could be due to the transfer of Erhua from Mandarin to English. Nonetheless, the transfer of Erhua only occurred in the pronunciation of /ɹ/ after the vowel /ə/, and not after other vowels. This suggests that language transfer only occurs under specific conditions, namely when the sound in the L1 can correspond completely to the sound in L2, and not in cases where the structures and components of the sounds are very similar.

The study looked into the production of English liquid consonant codas /ɹ/, /l/, and /ɹl/, by native Mandarin Chinese speakers. The results have shown that native Mandarin speakers cannot accurately produce the English liquid consonant codas all the time, when they struggle with the pronunciation, speakers conduct different approaches to produce these sounds that are absent from Mandarin sound system. The approaches include dropping and vocalization for /ɹ/ and /l/ sounds, and a combination of consonant deletion and vocalization for consonant cluster /ɹl/.

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Appendix:

The following chart shows the measurements of the words with syllabic codas containing the consonants /ɹ/, /l/, and /ɹl/ are color-coded green, orange, and pink, respectively. Words containing consonant clusters are highlighted with green if they include /ɹ/, and yellow if they include /l/. Words with a coda containing /ɹl/ are highlighted in green. In the “Production” column, modifications of syllables containing /l/ to similar sounds are marked in brown. Dropping a whole syllable contains /ɹ/ is marked in dark green, while dropping phonemes that are not /ɹ/, /l/, or /ɹl/ is marked in red. Dropping a single phoneme /l/ is marked in orange, while dropping a single phoneme /ɹ/ is marked in light green. Regular production of /ɹ/ and /l/ as standard pronunciation is marked in neon green and yellow, respectively.

word	IPA	speaker's pronunciation	/ɹ/ /l/	consonant cluster	onset of next syllable	f3	f3(1)	f3(2)	intensity1	intensity2	production
several	/ˈsevrəl/	/sevrə/	l			3148.363 s			59.11		əl to o
miles	/ˈmaɪlɪz/	/mɛɪlɪz/	l	ɪz		3064.292 s			66.86		ai to eɪ
retire	/ˈɹiə taɪ/	/ɹɪtɪ/	j			2856.274 u			62.5		ai to eɪ
enlarging	/ˈɹɪn ˈlɑːdʒɪŋ/	/ɹɪn ˈlɑːndʒɪŋ/	j		dʒ	2661.594 u			73.15		ai to ɔn
adventurers	/ədˈventʃəɹiəz/	/ədˈventʃəɹi/	j	ɹz		2666.357 d			65.45		drop əɪz
all	/ɔl/	/ɔ/	l			3341.386 s			66.84		drop l
all	/ɔl/	/ɔ/	l			2928.517 s			74.01		drop l
all	/ɔl/	/ɔ/	l			2833.245 s			69.88		drop l
almost	/ˈɔl moust/	/ɔmoustə/	l		m	2951.284 s			65.21		drop l
basketball	/ˈbæskɛt bɔl/	/ˈbæskɛtbɔ/	l			2555.358 s			71.2		drop l
fault	/fɔlt/	/fɔt/	l	ɪt		2757.715 s			72.19		drop l
sailed	/seɪld/	/seɪd/	l	ɪd		3043.516 d			68.85		drop l
twelve	/twelv/	/twɛv/	l	lv		2474.085 s			75.39		drop l
volleyball	/ˈvɔltbɔl/	/ˈvɔltbɔ/	l			2533.719 u			71.8		drop l
whole	/hoʊl/	/hoʊ/	l			3118.074 s			67.49		drop l
wild	/waɪld/	/waɪd/	l	ɪd		3028.208 u			67.79		drop l
girls	/gɜːls/	/gɜːs/	ɹl	ɹls		2646.449 u			75.58		drop l
world	/wɜːld/	/wɜːd/	ɹl	ɹld		2586.063 u			62.62		drop l
after	/ˈæftə/	/ɹftə/	j		t	3484.424 s			69.74		drop j
after	/ˈæftə/	/ɹftə/	j			2688.499 s			66.62		drop j
are	/ə/	/ə/	j			2460.456 s			74.41		drop j
before	/bɪˈfɔ/	/bɪfɔ/	j			3303.713 s			67.36		drop j
determined	/dɪtəˈmɪnd/	/dɪtənmɪnd/	j		m	2648.336 s			65.38		drop j
early	/ˈɜːli/	/ɜːli/	j		l	1925.506 s			72.64		drop j
for	/fɔ/	/fɔ/	j			2771.556 s			68.9		drop j
fourteen	/fɔːtɪn/	/fɔtɪn/	j		t	3352.528 s			69.65		drop j
horn	/hɔːn/	/hɔn/	j	ɹn		2709.704 s			65.19		drop j
more	/mɔ/	/mɔ/	j			2776.281 s			68.14		drop j
moreover	/mɔː ˈoʊvə/	/mɔːoʊvə/	j			2916.684; 2518.155 s			66.82	63.34	drop j
morning	/ˈmɔːnɪŋ/	/ˈmɔnɪŋ/	j		n	2456.684 s			74.61		drop j
party	/ˈpɑːti/	/pɑti/	j		t	2958.357 s			77.41		drop j
popular	/ˈpɒpjələ/	/pɒpjələ/	j			2845.694 s			78.53		drop j
scores	/ˈskɔːs/	/skɔs/	j	ɹs		2931.88 s			75.71		drop j
surprised	/səˈpraɪzd/	/səpɹaɪzd/	j		pɹ	3109.41 s			59.99		drop j
sword	/ˈsɔːd/	/sɔd/	j	ɹd		2993.737 u			66.56		drop j
turned	/ˈtɜːnd/	/tɜnd/	j	ɹnd		2980.886 s			71.91		drop j
were	/wɜː/	/wə/	j			3014.605 s			64.9		drop j
your	/jɔ/	/jɔ/	j			2518.129 d			66.84		drop j
hard	/hɑːd/	/hɑ/	j	ɹd		2828.827 u			75.74		drop ɹd

word	IPA	speaker's pronunciation	ɹ/ɹ̥/ɹ̥̥	consonant cluster	onset of next syllable	f3	f3(1)	f3(2)	intensity1	intensity2	production
first	/fɜːst/	/fɜːst/	ɹ	ɹst		2768.538	u		61.59		drop s
our	/aʊə/	/aʊ/	ɹ			2660.29	d		74.77		drop uə
impossible	/ɪmˈpɒsəbəl/	/ɪmˈpɒsəbəl/	ɹ			2821.423	s		71.3		əl to ə
useful	/ˈjuːsfəl/	/ˈjuːsfəl/	ɹ			2830.712	s		74.79		əl to ə
occur	/ɔˈkʊə/	/əˈkjuː/	ɹ			2468.613	d		75.79		əu to juː
nightmare	/ˈnaɪtˌmeɪ/	/ˈnaɪtmeɪo/	ɹ			2883.543	s		62.07		ɛɪ to aɪo
where	/weɪ/	/weɪo/	ɹ			2611.099	s		67.48		ɛɪ to ɛD
there	/ðeɪ/	/ðeɪ/	ɹ			2992.742	u		65.99		ɛɪ to ɛɪ
while	/waɪl/	/waɪo/	ɹ			2581.873	s		74.84		ɪɪ to ɪo
will	/wɪl/	/wɪo/	ɹ			2588.919	u		73.95		ɪɪ to ɪo
fear	/fɪə/	/fɛɪ/	ɹ			2976.994	u		64.25		ɪɪ to ɛɪ
years	/jɪəz/	/jɪɛz/	ɹ	ɹz		2835.25	s		74.92		ɪɪ to ɪɛ
gales	/geɪlz/	/getos/	ɹ	ɪz		3189.329	s		66.03		ɪ to o
still	/stɪl/	/stɪo/	ɹ			3328.029	u		68.26		ɪ to o
always	/ˈɔlˌweɪz/	/ˈɔlweɪz/	ɹ		w	2447.636	d		74.05		ɪ to ɹ
always	/ˈɔlˌweɪz/	/owetɪz/	ɹ		w	2303.759	d		73.95		ɔl to o
fortunately	/ˈfɔːtʃənətli/	/fɔːtʃənətli/	ɹ		tʃ	3269.42	s		72.76		ɔɪ to ɒ
warm	/wɔːm/	/wəʊm/	ɹ	ɹm		2983.907	s		65.57		ɔɪ to ə
for	/fɔː/	/fə/	ɹ			2574.97	s		64.75		ɔɪ to o
quarter	/ˈkwɔːtə/	/kwotə/	ɹ		t	3106.978; 2698.017	s		69.07	63.53	ɔɪ to o
shore	/ʃɔː/	/ʃə/	ɹ			2800.56	s		40.48		ɔɪ to o
according	/əˈkɔːdɪŋ/	/əˈkɔːdɪŋ/	ɹ		d	2313.4	u		73.68		ɔɪ to ɔɪ
or	/ɔː/	/uə/	ɹ			2695.479	s		70.12		ɔɪ to ʊD
already	/ɔːlˌɹedi/	/ɔːlˌɹedi/	ɹ		ɛ	2738.5	d		61.68		regular
deal	/diːl/	/diːl/	ɹ			2580.504	u		73.77		regular
failed	/feɪlɪd/	/fɛɪd/	ɹ	ɪd	d	2935.203	u		60.88		regular
feel	/fiːl/	/fiːl/	ɹ			3029.81	u		65.55		regular
help	/helɪp/	/helɪp/	ɹ	ɪp		2835.723	s		64.23		regular
himself	/hɪmˈself/	/hɪmˈself/	ɹ	ɪf		3008.218	s		64.55		regular
old	/oʊld/	/oʊld/	ɹ	ɪd		2858.395	u		61.6		regular
sail	/seɪl/	/seɪl/	ɹ			2806.216	d		59.82		regular
school	/skuːl/	/skuːl/	ɹ			2471.761	u		73.08		regular
school	/skuːl/	/skuːl/	ɹ			2873.146	u		70.47		regular
single	/sɪŋɡəl/	/sɪŋɡəl/	ɹ			2905.502	d		61.74		regular
welcome	/ˈwelkəm/	/ˈwelkəm/	ɹ		k	2912.765	u		66.78		regular

word	IPA	speaker's pronunciation	ɹ/ɹ̥/ɹ̥̥	consonant cluster	onset of next syllable	f3	f3(1)	f3(2)	intensity1	intensity2	production
cancer	/ˈkænsə/	/kɛnsə/	ɹ			2680.68	u		60.8		regular
Chichester	/ˈtʃɪtʃɪstə/	/tʃɪtʃɪstə/	ɹ			3106.548	u		62.79		regular
clipper	/ˈklɪpə/	/ˈklɪpə/	ɹ			2870.472	u		63.47		regular
clippers	/ˈklɪpəs/	/ˈklɪpəs/	ɹ	ɹs		2816.127	u		65.96		regular
computer	/kəmˈpjutə/	/kəmˈpjutə/	ɹ			2725.469	s		72.92		regular
conquered	/ˈkɒŋkəɪd/	/ˈkɒŋkəɪd/	ɹ	ɪd		2939.192	u		65.26		regular
covered	/ˈkʌvəd/	/ˈkʌvəd/	ɹ	ɪd		2892.969	d		64.99		regular
dinner	/ˈdɪnə/	/ˈdɪnə/	ɹ			2498.578	s		70.33		regular
doctors	/ˈdɒktəɪz/	/ˈdɒktəɪs/	ɹ	ɹz		2801.598	u		60.86		regular
earlier	/ˈɜːliə/	/ˈɜːliə/	ɹ			3021.783; 2841.914	d		64.25	64.45	regular
either	/ˈiːðə/ ˈaɪðə/	/iːðə/	ɹ			2285.832	d		71.87		regular
ever	/ˈɛvə/	/ˈɛvə/	ɹ			2834.129	d		63.56		regular
ever	/ˈɛvə/	/ɛvə/	ɹ			2371.052	s		71.25		regular
far	/fɔː/	/fə/	ɹ			2626.311	d		62.76		regular
first	/fɜːst/	/fɜːst/	ɹ	stk		2428.336	d		72.73		regular
further	/ˈfɜːðə/	/ˈfɜːðə/	ɹ		ð	3046.953; 2744.093	s	d	67.2	62.19	regular
hamburgers	/ˈhæmbɜːɡɜːz/	/hæmbɜːɡɜːz/	ɹ	ɹs	ɡ	2417.974	d	u	70.17	72.88	regular
her	/hə/	/hə/	ɹ			2352.446	d		73.72		regular
homework	/ˈhoʊmˌwɜːk/	/ˈhoʊmˌwɜːk/	ɹ	ɹk		2594.383	d		73.87		regular
horses	/ˈhɔːsɪz/	/ˈhɔːsɪz/	ɹ		s	2755.993	u		68.23		regular
hour	/aʊə/	/əʊə/	ɹ			2444.383	d		73.95		regular
meter	/ˈmɪtə/	/ˈmɪtə/	ɹ			2842.443	s		63.67		regular
nearby	/ˈnɪˈbaɪ/	/ˈnɪˈbaɪ/	ɹ		b	2865.525	u		63.21		regular
nearly	/ˈnɪli/	/ˈnɪli/	ɹ		ɪ	3121.395	d		66.29		regular
other	/ˈəðə/	/ˈəðə/	ɹ			2873.269	s		66.46		regular
over	/ˈoʊvə/	/ˈoʊvə/	ɹ			2490.017	d		61.11		regular
part	/pɑːt/	/pɑːt/	ɹ	ɹt		2875.993	s		62.94		regular
shower	/ˈʃaʊə/	/ˈʃaʊə/	ɹ			2279.178	d		70.51		regular
sinister	/ˈsɪnɪstə/	/ˈsɪnɪstə/	ɹ			2942.882	u		64.25		regular
sister	/ˈsɪstə/	/ˈsɪstə/	ɹ			2811.832	d		66.53		regular
southern	/ˈsəʊðən/	/səʊðən/	ɹ	ɹn		3350.26	d		65.12		regular
thirty	/ˈθɜːdi/	/ˈθɜːti/	ɹ		t	2898.316	d		73.84		regular
thirty	/θɜːdi/	/θɜːti/	ɹ			2908.924	u		68.69		regular
together	/təˈɡeðə/	/təˈɡeðə/	ɹ			2892.534	d		61.26		regular
words	/wɜːds/	/wɜːds/	ɹ	ɹds		2669.216	d		72.88		regular
wear	/weɪ/	/weɪo/	ɹ			2807.982	s		72.35		ɪ to o
years	/jɪəz/	/jɪɛz/	ɹ	ɹz		3154.579	s		64.46		ɪ to ɛ
require	/ɪəˈkwaɪə/	/ɪˈkjo/	ɹ			2427.721	s		74.85		waɪə to ɔɪ