English-to-Chinese negative phonetic transfer by speech recognition technology

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Abstract. Phonetic transfer refers to the phenomenon that one’s L1 sound system can influence one’s L2 phonetics. Previous studies have investigated phonetic transfer in the area of articulation, but L1’s effects on L2 pronunciation measured by speech recognition technology have been under-researched. The purpose of the research is to address this issue by focusing on a sample of 151 US university students’ Chinese learning. Speech recognition technology (HDecode tool from HTKv3.4.1) was applied to measure and evaluate participants’ English and Chinese pronunciation. Based on the quantitative data, it’s examined whether participants has applied phonetic transfer to Chinese learning and what factors might influence the results of phonetic transfer. The results show that English-to-Chinese phonetic transfer occurs both positively and negatively. The extent of positive transfer is limited to a condition when English syllables and Chinese Pinyin have the same or similar sounds. However, the extent of negative transfer is significant when English syllables and Chinese Pinyin have different structures and sounds. Furthermore, the study investigates what types of Chinese Pinyin might cause English-to-Chinese negative transfer.

1. Introduction

Different from prominence-related English, Chinese is tone-determined, featuring with four pronounced tones and a neutral tone [1]. An explanation of Chinese learning difficulties might be phonetic differences between English and Chinese, including phonology and the use of tones and stress [2]. Language transfer indicates that L1 can influence L2 acquisition [3]. When certain features in two languages are similar to each other, one can expect to demonstrate positive transfer involving these structures; however, when structures are different from each other, studies strive to demonstrate negative transfer of interference because learners are likely to rely on what is familiar from their L1 and this will yield predictable errors [4]. Thus, positive transfer might occur when English and Chinese have the same or similar phonemes and syllables, while their structural differences will interfere with the second language acquisition.

In the study of English-to-Chinese phonetic transfer, literature has highlighted the effect of Pinyin in Chinese learning. Because English alphabet is similar to Pinyin symbols, it might help English-speaking learners to master the Chinese phonetic system. For beginners of Chinese as a second language, Pinyin is considered as an alternative writing system for Chinese characters and used as an aid to learn the Chinese sound system [5]. An integration of character and Pinyin could help English-speaking learners to read Chinese in a second language learning context [6]. However, differences
between tonal Chinese and non-tonal English are an obstacle for English-speaking learners to acquire Chinese. Learning the use of phonetic element to pronounce novel compound characters may be difficult when Chinese-learning students are limited in their knowledge of Chinese [7]. Pinyin orthography negatively influenced Chinese pronunciation of native English learners [8]. Chinese Pinyin might present interference from English with Chinese Pinyin production because some Pinyin symbols looking the same as English phonemes were pronounced differently (e.g., the IPA of Pinyin \( x /ɕ \) that sounds like shee and English \( x /eks/ \)) [9]. Despite the familiarity of Pinyin graphemes to native English speakers, the need to suppress native language grapheme-phoneme correspondences in favor of new ones can lead to negative transfer [10].

2. Methods
2.1. Research questions
This study proposed a quantitative method to measure whether English-to-Chinese phonetic transfer was true and whether it was positive or negative. Speech recognition technology was applied to collect data for this quantitative calculation. This study has two hypothesis questions: (1) Does English pronunciation of US university students of Chinese learning have an effect on their Chinese pronunciation performance? (2) To what extent does English pronunciation of these participants influence their Chinese pronunciation performance?

2.2. Participants
Our team conducted the study with 151 English-speaking students of Chinese as a foreign language in a university in California, including 65 female and 86 male. The university gave four-hour Chinese courses and two-hour language lab every week while they studied Chinese after class following their study plan. They were requested to fill in a brief questionnaire and have three tests.

2.3. Instruments
The instruments involved were English pronunciation test, oral Chinese proficiency test, and Chinese pronunciation test. The aim of the measurements was to collect data of the scores for investigating the effect of English pronunciation on Chinese pronunciation. (a) English pronunciation test used an English wordlist containing a syllable table to assess one’s English pronunciation accuracy. Our team used all English single consonants and vowels (i.e., single vowels and diphthongs) to form an English syllable table. Because a speech recognition tool (i.e., HDecode tool from HTKv3.4.1) can discern a word as the minimum unit of a language [11], we found English words corresponding to all English syllables in the table. This English wordlist was then used in our English pronunciation test discerned and evaluated with the speech recognition tool. (b) Oral Chinese proficiency test was a speaking test of Hanyu Shuiping Kaoshi, translated as “Chinese oral proficiency test” in English, a Chinese proficiency test to evaluate learners’ oral Chinese proficiency as a second language. (c) Chinese pronunciation test used the Pinyin table in Xinhua Dictionary as the Chinese pronunciation list [12]. Chinese uses 411 Pinyin syllables for its whole vocabulary system. One’s Chinese performance was discerned and evaluated also by with the speech recognition tool.

3. Results
3.1. Descriptive analysis
A descriptive analysis was applied to describe the demographic features of US university students of Chinese. Table 1 shows main information, including their average age 20.26 years old (\( SD = 2.40 \)), Chinese-learning 1.74 years (\( SD = .76 \)), Chinese learning hours 8.23 per week (\( SD = 2.51 \)) and so on.
Table 1. Results of descriptive analysis.

| Variable                                      | M    | SD  | Min. | Max. |
|-----------------------------------------------|------|-----|------|------|
| Age                                           | 20.26| 2.40| 18   | 35   |
| Years of L2 (Chinese) Learning                | 1.74 | .76 | 1    | 5    |
| Hours of Practicing L2 per Week               | 8.23 | 2.51| 6    | 17   |
| L1 (English) Pronunciation                    | 376.21| 18.53| 329 | 404  |
| L2 Oral Proficiency                           | 2.08 | .85 | 1.01 | 5.56 |
| L2 Pronunciation                              | 344.03| 27.38| 284 | 404  |

Note. N = 151

3.2. Curve estimation

Curve estimation was applied to determine whether English and Chinese pronunciation could form a linear or quadratic shape. Table 2 shows the results of curve estimation of English pronunciation’s effects on Chinese pronunciation. The change from the linear value ($R^2 = .835$) to the quadratic value ($R^2 = .872$) was .037, 3.7% increase, which means that the increase was so substantial (> 3%) to form quadratic function. However, the change from the quadratic value ($R^2 = .872$) to the cubic value ($R^2 = .873$) was .001, 0.1% increase, which means that the increase was not substantial (< 3%) to form cubic function.

Table 2. Results of curve estimation.

| Chinese Pronunciation | R Square | F    |
|-----------------------|----------|------|
| Linear                | .835**   | 755.16|
| Quadratic             | .872**   | 503.90|
| Cubic                 | .873**   | 506.77|

Note. N = 151. **p < .01.

3.3. Polynomial regression analysis for the quadratic model

To confirm whether English and Chinese pronunciation formed a quadratic relationship, English pronunciation and its square value were analyzed and evaluated in polynomial regression analysis. The model would be quadratic when both English pronunciation and its square presented a significant value or when only its square proved statistically significant. Table 3 displays the results of the English-to-Chinese transfer model that English pronunciation presented a significant value ($B = -6.70$, $p < .05$) and its square was also statistically significant ($B = .01$, $p < .05$). Because English pronunciation and its square presented a significant value, the pattern of the model confirmed the result of curve estimation that they formed a quadratic curve.

Table 3. Results of polynomial regression analysis.

| Variable                                      | Chinese Pronunciation |
|-----------------------------------------------|-----------------------|
| Constant                                      | 1328.78**             |
|                                               | 306.10                |
| Gender                                        | -.56                  |
| Age                                           | 1.66                  |
| Years of L2 (Chinese) Learning                | -.01                  |
|                                               | .32                   |
|                                               | -.03                  |
|                                               | .53                   |
|                                               | 1.05                  |
|                                               | .02                   |
Hours of Practicing L2 per Week 

L1 (English) Pronunciation  

L1 Pronunciation Square

L2 Oral Proficiency

$R^2$/Adj. $R^2$  

$F$ (df)

Note. $N = 151$. Gender (0 female+, 1 male). *$p < .05$. **$p < .01$.

Figure 1 displays a quadratic relationship between the participants’ English and Chinese pronunciation. The scatter plots indicated that the bottom of the quadratic was roughly -1.4, a standardized value. For about 15% of the participants whose the standardized value of English pronunciation was below -1.4, both English and Chinese pronunciation established a negative relation. Their English pronunciation had a negative effect on predicting Chinese pronunciation and it caused negative transfer. A possible explanation might be that Pinyin words are too difficult to pronounce.

4. Discussion

The results showed that the participants’ English pronunciation had a limited effect on their Chinese pronunciation performance. For the participants whose English pronunciation was the top 85%, English and Chinese pronunciation had a linear and positive relation, which indicated that English pronunciation positively influenced Chinese pronunciation. On the contrary, for the rest of 15% participants, English pronunciation negatively influenced Chinese pronunciation. Because negative phonetic transfer was too statistically significant to be neglected in the study, our team analyzed and classified it into three categories. The structure of Chinese Pinyin has an optional onset, an optional medial, a nucleus, and an optional coda (e.g., the Pinyin word *pian*, $p$ onset, *i* medial, *a* nucleus, and *n* coda). A Chinese Pinyin word comprises an initial and a final: an initial (i.e., an onset) is a consonant or a semivowel (e.g., *y*, *w*, or *ü*); a final has four types in Table 4. Unlike English syllables, Chinese Pinyin has an optional medial between an initial and a nucleus. Finals with a medial increase pronunciation difficulty as Chinese-learning speakers have difficult in merging Pinyin phonemes into a sound.

### Table 4. Types of pinyin finals.

| Final types       | Structure with consonant and vowel | Pinyin Finals |
|------------------|------------------------------------|---------------|
| Nucleus          | Basic vowel (V)                    | a o e u ü i   |
| Diphthong (VV)   | ai ei ao ou                        |               |
| Nucleus + coda (VC) | an ang en eng in ing ong          |               |
### 4.1. Type I: Unfamiliar Pinyin finals

Although English and Chinese Pinyin have the same or similar phonemes and even share the same pronunciation rules, some Pinyin finals are new to Chinese learning participants, as they had never heard the sounds in English and might not pronounce them. Unlike the other similar finals, like *ang* (e.g., English *bang* and *pang*) and *ing* (e.g., *ink* and *morning*), Pinyin finals *eng* /ɔŋ/ and *ong* /ɔŋ/ do not match any English syllable. Table 5 presents 32 Pinyin words including these finals. The participants reported to have difficulty in producing these words.

Table 5. Pinyin with the finals (*eng* and *ong*).

| Pinyin Words | Finals | Initial + medial + nucleus | Initial + medial + nucleus + coda |
|--------------|--------|----------------------------|----------------------------------|
| eng | eng | beng | cheng | deng | feng | geng | heng | keng | leng | meng |
| ong | / | / | chong | dong | / | gong | hong | kong | long | / |
| Finals | n | p | r | s | sh | t | w | y | z | zh |
| eng | neng | peng | reng | seng | sheng | teng | weng | / | zeng | zheng |
| ong | nong | / | rong | song | / | tong | / | yong | zong | zhong |

### 4.2. Type II: Different pronunciation rules

Although English syllables and Chinese Pinyin share most of the pronunciation rules, some rules between them are different to interfere with English-to-Chinese transfer. These syllables with transferrable phonemes but different pronunciation rules might cause Pinyin mispronunciation. Our team summed up two groups of Pinyin words. Pinyin initial *c* might cause negative transfer. In English, *c* /ts/ is used as coda *ts* (English *cats* and *bits*) and placed at the end of a word. When the phoneme *ts* is placed at the beginning of a Pinyin word, the participants might fail to pronounce it because they were unfamiliar with its position as an initial and found it hard to combine *ts* with a vowel behind it. Table 6 shows the group of 16 Pinyin words with initial *c*.

Table 6. Pinyin with the Initial (*c*).

| Initial | Pinyin words |
|---------|--------------|
| c | ca | ce | cai | cao | cou | can | cen | cang |
|       | cu | cuo | cui | cuan | cun | ci | ceng | cong |

The other group of Pinyin initials (i.e., *j*, *q*, and *x*) intervenes with phonetic transfer. Pinyin *j* sounds like *jee* in *jeep*; *q* sounds like *chee* in *cheap*; *x* sounds like *shee* in *sheet*. These initials have two features: only two vowels (i.e., *i* or *u*) follows the initials; their orthography is different from their English form (i.e., Pinyin *j* is not English /j/ in *yes*; *q* not /kw/ in *quick*; *x* but not /ks/ in *X-ray*). Thus, the participants might confuse the Pinyin initials with their English letters. Moreover, they were not familiar with their Pinyin rules. In English, the sound *jee*, an onset and a nucleus, can add a coda to form a word (e.g., *jeep*). In Chinese, Pinyin *j* can be used as English sound, but it has another structure, i.e., an onset and a medial. Then, a vowel nucleus (e.g., Pinyin *jia* sounds like *jeear*) or a nucleus and a coda (e.g., Pinyin *jian* sounds like *jeearn*) can be placed after it. Table 7 presents 21 Pinyin words that the participants might mispronounce easily.

Table 7. Pinyin with Initial (*j*, *q*, and *x*).

| Initial | Initial + medial + nucleus | Initial + medial + nucleus + coda |
|---------|----------------------------|----------------------------------|
| j | jia | jie | jiao | jiu | jian | jiang | jiong |
| q | qia | qie | qiao | qiu | qian | qiang | qiong |
| x | xia | xie | xiao | xiu | xian | xiang | xiong |
4.3. Type III: New Pinyin phonemes
Pinyin phonemes ü are new to English-speaking learners and they do not have the same or similar sounds in English. Pinyin ü starts /i/ and moves to /u/, while the participants usually confused ü with English you. Pinyin ü plays the role of a nucleus (e.g., lü) or a medial (e.g., lüe). When ü meets j, q, x, and y, it is written as u. Pinyin ü as a medial is combined with a nucleus and a coda to make Pinyin words pronounce difficult (e.g., juan sounds like jee-ü-arn). Our team concluded that because 20 Pinyin words in Table 8 were regarded as the most difficult to learn, their transferability was the lowest.

Table 8. Pinyin with the sound ü

| Pinyin | Initial+nucleus | Initial+nucleus+coda | Initial+medial | Initial+medial+nucleus+coda |
|--------|-----------------|----------------------|----------------|-----------------------------|
| ü (yu) | ün (yun)        | üe (yue)            | üan (yuan)     |                             |
| n      | nü              | /                    | /üe            | üan                          |
| l      | lü              | /                    | lüe            | /                            |
| j      | ju              | jun                  | jue            | juan                         |
| q      | qu              | qun                  | que            | quan                         |
| x      | xu              | xun                  | xue            | xuan                         |
| y      | yu              | yun                  | yue            | yuan                         |

To sum up, these Pinyin words that might cause mispronunciation are 89 of the total 411 Pinyin words, about 22% of Chinese Pinyin words. The participants reported that these Pinyin words were so difficult in producing as to mainly contribute to English-to-Chinese negative transfer.

5. Conclusions
When English-speaking learners study Chinese as a second language, both positive and negative transfer will occur. Pinyin in positive transfer can be acquired easily as Pinyin words can also be found in English syllables. However, Pinyin in negative transfer gives much trouble to English-speaking learners. This study has investigated the difficult Pinyin groups to remind learners paying more attention to them and more time in practicing them. This study also finds that the differences of structures and sounds between English syllables and Chinese Pinyin might negatively interfere with Pinyin pronunciation of English-speaking learners. Thus, it's recommended to learn transfer knowledge and phonetic differences between English and Chinese for their Chinese-learning.

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