

The Production and the Perception of English Vowels by Mandarin Speakers

by

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B.A., Capital Normal University, 2009

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of the Requirements for the Degree of

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Supervisory Committee

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Abstract

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This study set out to examine how correctly Mandarin speakers produced and perceived English vowels and to explore the relationship between the production and the perception of English vowels by Mandarin speakers. Fifteen native Mandarin speakers, who had lived in Canada for at least two years and received an IELTS score of 6.5 or above, participated in this study. Fifteen native speakers of Canadian English living in Vancouver at the time of the study also participated as a control group. Two experiments were conducted involving 10 English vowels: /i/, /ɪ/, /ɛ/, /æ/, /ʊ/, /u/, /ʊ/, /ɔ/, /o/, and /ʌ/. In Experiment 1, both the Mandarin speakers and the native English speakers were recorded producing the ten vowels in a /bVt/ syllable in a carrier sentence. The vowels in the recordings were then identified by four native English listeners. In Experiment 2, the Mandarin speakers did an identification test of the vowels produced by the English speakers in Experiment 1. The results showed that Mandarin speakers in this study were able to produce and perceive certain English vowels correctly, but not all of them. The results also indicated that the relationship between the production and perception of English vowels by Mandarin speakers cannot be interpreted in a straightforward way, and that that L2 experience, in terms of length of residence, age of arrival, years of learning,

and age when ESL learning starts, might also play an important role in the production and perception of English vowels by Mandarin speakers.

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Chapter One

1.1 The purpose of the present study

The study set out to examine how correctly Mandarin speakers could produce and perceive English vowels and to explore which factors might play a role in influencing Mandarin speakers' production and perception. Two experiments were conducted. The first experiment tested how correctly both native Mandarin speakers and native English speakers produced certain English vowels as judged by a group of native English listeners. It further tested whether individual differences influenced the degree of accuracy of the English vowels produced by the native Mandarin speakers. The second experiment examined how correctly Mandarin speakers perceived English vowels and whether individual differences played a role in the degree of the accuracy of English vowels perceived by the native Mandarin speakers. The study also explored the relationship between Mandarin speakers' production and perception of English vowels.

1.2 Motivation of the present study

Individuals who learned a second language (L2) after a certain age might speak with a detectable foreign accent (Flege et al., 1995). Beginning with a foundational article by Asher and Garcia (1969), a large number of studies have been conducted on the accuracy of production and perception in second language acquisition (MacKay et al., 2001; Flege et al., 1999; Munro et al., 1996; Flege et al., 1995). Thompson (1991) stated that studies on the production and perception of second language speech could help resolve the question of whether second language learning was constrained by age-related

factors. Studies concerning the production and perception of English vowels by second language learners differed in the nature of their subjects, the targeted language examined, the methods used to elicit data, the non-native speech evaluated and the controls adopted (Abu-Rabia and Kehat, 2004; Hakuta et al., 2003). Many notable second language theories, such as First Language (L1) Transfer (James, 1988), Contrastive Analysis Hypothesis (Lado, 1957), and Markedness Differential Hypothesis (Eckman, 1977) indicated that various linguistic factors played important roles in second language learners' production and perception. Therefore, divergent conclusions have been drawn, and researchers employing different methodologies have even found some opposite results. The question of whether and how correctly second language learners were able to accurately perceive and produce L2 sounds is still being actively investigated and remains one of the most persistent issues in the field of second language acquisition.

Works on non-native speech perception have shown that the accuracy of acquiring a second language system depended on several factors, including the age of acquisition, years of ESL learning, length of residence, and the quantity and quality of second language input (Flege, 2002). Previous studies have covered the elements that contribute to foreign language speech learning (e.g., Mark, 2003; DeKeyser, 2000). However, limited studies have been conducted to investigate the level of difficulty in Mandarin speakers' production and perception of English vowels. Among such studies that do include native Mandarin speakers, such as Bohn (1995), only a small number of vowels were tested in the perceptual experiment.

For the past 30 years or more, beginning with the above-mentioned study by Asher and Garcia (1969), the phenomenon of perceived foreign accent in the speech of L2

learners has been widely studied. The central concern in the study of second language acquisition (SLA) was that learners' ultimate attainment might not be consistent with the input in a number of respects (Ellis, 2006). Many studies have attempted to explain L2 segmental learning difficulties, but it seems that these explanations cannot resolve all of the complexities that have arisen in empirical works (Baker, 2003; Bohn, 1995). One view was that L2 acquisition could occur over time with increasing L2 experiences (Flege, 1995). If so, then greater experience with the L2 should result in more accurate L2 segmental production, as predicted by Flege's (1995) Speech Learning Model. Another view stated that the relationship between experience and learning was not a simple one. In fact, empirical work on the effects of L2 experience has brought complex findings, some of which appear contradictory.

In addition, the relationship between second language perception and production has been explored concerning second language acquisition. This topic has generated heated discussion over the years (Strange, 1995; Flege, 1990). Bever (1981) hypothesized that a "critical" period for L2 speech learning ended when the phonological system of the L1 was established, as it was unnecessary to align speech production and perception. Therefore, according to this view, L2 production might not be limited by L2 perception. However, it has also been hypothesized (Rochet, 1995) that native/non-native differences in perception might influence the accuracy with which L2 phonetic segments could be produced. According to SLM, learners of all ages could align their production of L2 phonetic segments to long-term memory representations for vowels and consonants in the L2. Therefore, many segmental production errors might have a perceptual basis.

In order to extend our knowledge of Mandarin speakers' production and perception of English vowels, this study explored how Mandarin speakers perceive English vowels and how native English speakers produce these vowels, as judged by native English listeners. The main goal of Experiment 1 was to understand whether the native Mandarin speakers tested were able to produce English vowels correctly and then compare this to vowels produced by native English speakers. Experiment 2 examined how native Mandarin speakers perceived English vowels, and the role of individual differences in perception. In addition, the researcher also investigated the relationship between the production and perception.

1.3 Research questions

The specific questions are as follows:

1. How correctly are the vowels produced by native Mandarin speakers to the native English listeners as compared with vowels produced by native English speakers? Are some vowels produced by Mandarin speakers better identified by native English listeners than are others? If so, which ones? What is the role of individual difference in the level of difficulties of English vowels produced by Mandarin speakers?
2. Are Mandarin speakers able to identify native English vowels correctly?
3. What is the relationship between the production and perception of English vowels by Mandarin speakers?

Two experiments on the production and perception of English vowels by experienced Mandarin speakers were carried out to answer the above questions.

1.4 Structure of the thesis

This thesis is organized as follows:

Chapter 1 provides the rationale for this study and its research purposes and questions. Chapter 2 provides a literature review of related research on aspects of the production and perception of first and second languages. The literature review discusses some important variables that may account for difficulties in second language learning. It also examines some methods used in the field. Chapter 3 describes the two experiments, provides the methods, and presents results and discussions. Chapter 4 offers the final conclusions and limitations of the study.

Chapter Two

Second language acquisition has interested researchers from both the theoretical and the applied fields, and many factors that influenced the production and the perception of the second language sounds by learners are well-documented in previous studies (MacKay et al., 2001; Flege et al., 1999; Munro et al., 1996; Flege et al., 1995). This chapter begins with sections 2.1-2.3 that provide a review of the literature on the factors that influence the production and perception of second language sounds by ESL learners. Following this, section 2.4 focuses on the methodological issues related to research on the production and the perception of the second language acquisition. Section 2.5 introduces the literature on the relationship between the production and the perception. Section 2.6 reviews the system of the Mandarin vowels. Finally, section 2.7 focuses on the production and the perception of English vowels by Mandarin speakers.

2.1 The effect of age

Age-related factors have been investigated in a large number of studies (Guion et al., 2000; Flege et al., 1999; Munro et al., 1996; Oyama, 1976). Findings from many studies supported the statement that “the younger, the better” when it came to L2 learning (Flege et al., 1999; Yamada, 1995). Individuals who began learning at an early age usually resembled native speakers of L2 more than those who began at an older age (Flege and MacKay, 2004), and children were less accented at L2 pronunciation than adults (Flege et al., 1999). The oral production of early arrivals might be judged to have less of a foreign accent by native speakers (Flege and Liu, 2001) and have better accuracy in the production and perception of both L2 vowels and consonants than late arrivals (MacKay

et al., 2001; Flege et al., 1999).

The most common explanation for child-adult differences in L2 learning was the existence of a critical period for L2 acquisition. According to this stance, the complete mastery of an L2 was no longer possible if learning began after the end of the putative critical period (Patkowski, 1980, 1990). However, other researchers referred to a “sensitive” rather than a “critical” period, arguing that early childhood represented an ideal rather than the only time when a language could be acquired with native-like accuracy (Abu-Rabia and Kehat, 2004; Hakuta et al., 2003). Early childhood represented a period when both the optimal input of the L2 and the interaction with the L2 could occur (Mack, 2003).

Critical period effects have usually been attributed to an age-related loss of neural plasticity or to some neurofunctional reorganization that occurred during the development process (Neville et al., 1992). Researchers who supported the existence of a critical period have shown the negative correlation between age of arrival (AOA) and subjects’ performance in the perception and the production of L2. The argument continued that other factors such as length of residence (LOR) and L2 input did not account for the decline (DeKeyser, 2000). Yet, even among those who supported the CPH, the question was raised regarding the specific age of early bilinguals (Birdsong and Molis, 2001), especially as related to phonetics and phonology (Guion et al., 2000; Flege et al., 1999; Munro et al., 1996; Oyama, 1976). The age factor was also a crucial component resulting in divergent conclusions of age-related research. Patkowski (1990) suggested that foreign accents would increase if an individual began learning after the age of 15. Long’s (1990) research showed that bilinguals could speak L2 in a native-like

fashion before the age of six and could be perceived with a foreign accent after the age of 12. However, Flege (1988) found that native English-speaking listeners were able to detect the foreign accent of Chinese adults who arrived in the United States from the age of eight. The diversity of these results suggested that age might not be the only factor to account for foreign accents in speech.

Some studies pointed to a paradoxical effect—“the older, the better” (Flege, 1987). For example, the accuracy of producing Dutch words increased with age in the case of English speakers ranging from the age of seven to young adulthood (Snow and Hoefnagel-hohle, 1997), and the ability of English natives to produce French words and discriminate French sound-pairs also increased with age from the first to ninth grade. However, Long (1990) argued that while late learners of L2 might have an initial advantage over younger learners, the advantage was only temporary. This advantage might persist in the early years of L2 learning and disappear gradually or become reversed later. With the increasing use of L2, age differences in the accuracy of the production and perception changed from an older-learner advantage to a younger-learner advantage. However, Long did not provide a definition for older and younger learners nor did he mention when the advantage shift would occur.

This review of existing literature regarding age-related differences in foreign accents shows that various explanations have been given to age-related differences, and age might not be the only factor leading to a foreign accent.

2.2 The effect of language transfer

It is clear that one’s first-language phonetic categories affect second-language vowel learning. For example, Spanish listeners have difficulty in discerning the difference

between English /i/ and /I/ (Escudero and Boersma, 2004; Morrison, 2002). Flege (1999) stated that L2 learners' pronunciation deviated not because they lost the ability to produce accurate L2 sounds but because the L1 knowledge affected their L2 learning in the perception studies. L1 transfer/interference theory was represented by three models: the Perceptual Assimilation Model (PAM) (Best, 1995), the Native Language Magnet Model (NLM) (Kuhl, 2000) and the Speech Learning Model (SLM) (Flege, 1995). These three models converged on the role of prior L1 learning and the use of L1 segments in L2 production and perception. In accordance with Best's theory (1995), non-L1 segments "tend to be perceived according to their similarities to, and discrepancies with, the native segmental constellation that was in the closest proximity to them in native phonological space" (Best, 1995, p. 193). This model linked the difficulties of producing and perceiving L2 sounds with their relation to the learner's native phonological system. NLM differed from other theories because it stated that in the first year of life, infants established a perceptual network through which new speech sounds were perceived or "filtered" (Kuhl, 2000, p. 56). However, SLM emphasized age-related factors in learning new speech sounds. Flege (1995) indicated that due to the strong influence of L1, late bilinguals might experience difficulties in producing and perceiving L2 sounds.

The following section discusses how different models (PAM, NLM, and SLM) and theories accounted for the language transfer in the second language speech learning.

2.2.1 Speech learning model

SLM asserted that a new category was more likely to be established if the nonnative speaker could detect the differences between the closest native sound and a

comparable L2 sound (Flege, 2003). According to SLM, if sounds in the L2 could be mapped into two different categories, they were likely to be discriminated. If sounds in the L2 were mapped into one L1 category, the nonnative speakers would not be able to produce or perceive certain L2 sounds accurately. This was also the case if the L2 learners equated an L2 sound with a sufficiently similar L1 sound because they failed to adapt to acoustic and phonetic requirements to produce or perceive the sounds.

According to Flege, interaction between L1 and L2 among bilingual individuals constrained their ability to produce sounds accurately in both languages. It has been suggested that age-related changes in terms of the L2 foreign accent resulted from the nature and extent of the interaction between a bilingual's L1 and L2 systems (Flege, 1987, 1988, 1995, 1998a). According to the interaction hypothesis (Flege, 1992, 1999), child-adult differences in second language learning can be demonstrated through the interaction (bidirectional influence) of learners' native language and the second language.

2.2.2 Perceptual assimilation model

Much research on adults' perception of L2 focused on vowels (Best et al., 2007). Vowels are significant in examining perceptual experience and are different from consonants both physically (in acoustic and articulatory properties) and linguistically (Best and Tyler, 2007). According to Best (1995), L2 vowels were perceived differently from L1 vowels, which led to larger perceptual learning differences than those perceived to be identical or similar to L1 vowels. Furthermore, experienced listeners would not differ much from native speakers in terms of perceptual dimensions to distinguish L2 vowels. Good perception of L2 vowels might indicate higher proficiency of L2. Indeed,

much research has shown that accuracy in the perception of L2 vowels was positively associated with accuracy in the production of L2 vowels (Best, 1995).

If L2 segments were sufficiently similar to L1 segments, they would be categorized as relatively good exemplars of L1 categories. If an L2 segment was sufficiently dissimilar from any L1 category, it would fail to be categorized in the L1 system (Best, 1995).

In the Perceptual Assimilation Model, Best (1995) categorized the “L2 minimal contrasts” into four situations:

(1) “Only one L2 phonological category was perceived as equivalent to a certain L1 phonological category” (p. 32). All contrasts with other L2 categories would become two-category assimilations or categorized-uncategorized assimilations. In these cases, it was predicted that subjects would have few difficulties in discriminating contrast words.

(2) “Both L2 phonological categories were perceived as equivalent to the same L1 phonological category, but one was perceived as being more deviant than the other” (p. 32). It was expected that subjects could discriminate these L2 sounds and a new L2 phonetic and phonological category would likely be formed for deviant L2 sounds.

(3) “Both L2 phonological categories were perceived as equivalent to the same L1 phonological category, but as equally good or poor instances of that category” (p. 32). It was predicted that subjects would encounter difficulties in discriminating L2 sounds that would be assimilated to a single L1 category.

(4) There was no L1-L2 phonological assimilation. It was predicted that if subjects did not perceive either of the contrasting L2 sounds as belonging to any single L2 category, then these sounds should be easily learned.

2.2.3 Native language magnet model

Kuhl's theory of prototypes was first described with reference to infants' perceptions (Kuhl, 1991). Later on, the applicability of NLM theory to L2 acquisition was made more explicit:

The NLM theory also helps explain the results of studies on adults' perception of sounds from a foreign language. [...] I would suggest that foreign contrasts are difficult to discriminate when the prototype of a native-language category closely resembles both foreign-language sounds. (Kuhl, 1993, p. 131)

Experiments conducted by Kuhl (1991) and her colleagues (Kuhl et al., 1992) have shown that the category of goodness significantly influenced the perception. Additionally, Kuhl et al. (1992) argued that the magnet effect was influenced by exposure to the target language early in life. There were three situations:

1. It was implied that L2 sounds, which most closely resembled L1 sounds, would be interpreted as prototypes. It would then be expected that prototype-like sounds should have the highest number of right identifications.
2. A new sound that resembled a prototype would be perceptually attracted to it whereas non-prototypes would not attract other sounds. Additionally, a non-prototype-like sound was easier to differentiate perceptually than a sound, which resembled a prototype.
3. When two sounds were very similar to a single prototype, there should be mutual perceptual confusions.

2.2.4 Comparison of three models

The role of the category of goodness in speech perception has become

increasingly significant in speech perception models (Flege, 1995). All these models tried to predict the speech difficulties from the category of goodness. However, they named the “assimilation” differently. Table 2.1 presents the differences between the three models.

Table 2.1

Comparison between three models

Speech learning model	Perceptual assimilation model	Native magnet model
Phonetic category assimilation	Perceptual assimilation patterns	Perceptual magnet effect
Phonetic similarity can prevent L2 learners from establishing L2 phonetic categories over time.	The similarity between two foreign categories might lead to poor discrimination due to patterns of assimilation.	L2 sounds that most closely resemble L1 sounds would be interpreted as prototypes, which are harder to discriminate from their neighboring tokens.

There are many similarities between SLM and PAM: First, both theories predict the relative difficulties that experienced and inexperienced learners would encounter with certain non-native contrasts. At the initial stage of L2 acquisition, the L1 and L2 shared a common phonological space because the L1 served as a template or filter to learn L2 sounds (McAllister et al., 2002; Best, 1995), and this was especially the case for adult learners whose L1 phonetic categories were fairly well formed. Both models suggested that the phonetic similarity of L1 and L2 segments could be used to predict the relative difficulties for L2 learners.

Second, both models adopted the notion that L2 segments perception was, to some extent, influenced by or “filtered through” the over-learned and automatic

perceptual strategies. In both cases, L2 segments were considered as exemplars of L1 phonological categories. Third, the two models also agreed that if contrasting L2 segments were perceptually assimilated (equivalence-classified) to the same L1 category, perceptual differentiation of the L2 categories would be difficult. Fourth, both models considered the influence of the similarities and dissimilarities between L1 and L2 speech. Fifth, neither model was developed to address both the production and the perception of L2 speech. Finally, neither model restricted its assumptions of the influence of phonological contrasts in L1.

The NLM model (Iverson and Kuhl, 1995) argued that the perceived category of goodness influenced the discriminability of exemplars identified by a single phoneme, so that a good exemplar was harder to discriminate from its neighbouring tokens than a poor exemplar. It was stated that a link existed between the perceived category of goodness differences and the discrimination (Best, 1995). Especially, in PAM, the perceived category predicted the discriminability. The traditional method that was used for determining perceptual assimilation type and was carried out within the PAM framework has been a post-hoc comparison of articulatory-phonetic descriptions of non-native sounds with the acquired closest native sounds (Ratree, 2007). This method was supported by PAM's predictions in the relationship between discrimination and perceptual assimilation patterns (Best et al., 2001). However, there was little support for PAM's predictions when assimilation patterns were derived directly from listeners' categorization patterns and the category of goodness ratings of non-native sounds (Harnsberger, 2001).

Harnsberger's study (2001) involved Malayalam, Marathi, and Oriya nasal consonants that were presented in isolation for categorization and the category of goodness rating by native listeners of Malayalam, Marathi, Punjab, Tamil, Oriya, Bengali, and American English. There was an AXB discrimination task to test the listeners' ability to discriminate pairs of the non-native nasal consonants. The categorization was based on the listeners' identification and the category of goodness rating. The findings indicated that not all of PAM's predictions were upheld.

The differences between the findings and PAM model's predictions suggested that attempts to test speech perception models might be influenced by other factors, such as different test formats in the identification and the discrimination process, the subject characteristics, the number of talkers, and the types of stimuli used. An understanding of methodological variables used in testing the theoretical models was critical not only for assessing the existing models but also for developing accurate models to predict the non-native listeners' ability to perceive and acquire non-native speech sounds.

2.3 Non-language transfer

Flege, Frieda, and Nozawa (1997) conducted the first research to test the effects of the amount of L1 use in L2 pronunciation. The results countered the CPH and supported Mack's (1986) view that early bilingualism alone did not guarantee a native-like performance. This result supports recent studies by Baker (2005). In Baker's study (2005), the production (six English and five Korean vowels) of English and Korean monolinguals was compared with that of early and late Korean-English bilinguals. The results of this study indicated that the age at the time of L2 acquisition, degrees of

cross-language similarity, and the amount of L2 input were factors that resulted in differences in the production and perception of L2 sounds between early and late bilinguals, as well as between early bilinguals and native speakers. Baker (2006) concluded that, “a number of individual differences (LOR, AOA, L1 use and learners’ abilities to accurately perceive their own speech) might underlie the development of L2 perception and production” (p. 250).

Both the “critical period” and “interference” theories implied that input plays a less effective role after a certain age. In contrast, the Speech Learning Model (Flege, 1995, 2003) claimed that L2 acquisition was available to L2 learners of all ages and L2 learners were able to detect cross-language phonetic differences and retained their original capacity acquired during L1 learning. Although there were studies showing that the influence of the L1 vowel system was often readily apparent in late learners’ production of L2 vowels, especially in the early stage of learning (Munro, 1993), other research concluded that experienced late learners also produced L2 vowels accurately (Bohn and Flege, 1992; Flege, 1987). Some research stated that adult L2 learners might circumvent L1 interference effects if they could recapitulate infants’ experience of L1 speech—that is, if they managed to receive “exaggerated acoustic cues, multiple instances by many talkers, and massed listening experience” (McCandliss, et al., 2002, p. 192).

The different conclusions made by the studies above have a direct relation to the methodologies that these studies employed to answer their research questions and test their hypotheses. In order to further explore the reasons behind the divergence of these

findings, this study has reviewed the methods used in previous research to assess the production and the perception in L2 speech.

2.4 Methodological Issues

2.4.1 Subjects Studied

With regards to L2 studies, subjects could differ in their native languages, targeted L2 languages, the amount of L2 experience, AOA, LOR, and educational backgrounds, among other individual differences.

The majority of previous studies adopt English as the target language. Other target languages may include German, Dutch, Spanish, and Thai. The native languages of participants are far more diverse: Spanish, English, Arabic, Japanese, Persian, Thai, Italian, Mandarin, Taiwanese, Russian, Swedish, Korean, Ukrainian, Croatian, Catalan, and Portuguese. Phonological systems varied widely across languages in systematic ways (Maddieson, 1984). Therefore, the adoption of diverse targeted languages might better generalize the conclusions and hypotheses concerning second language acquisition. And it has been discovered that there was research employing different targeted languages to test the conclusion drawn from subjects who were English learners (Escudero et al., 2009). These results might contribute to a developmental or universal explanation for prevalent foreign accents among L2 learners.

Furthermore, an increasing number of studies now involve subjects from different L1 backgrounds (Escudero et al, 2009; Munro and Derwing, 2008; McAllister et al., 2002). Groups with different L1 backgrounds were chosen to demonstrate comparisons among learners from unrelated language families (Munro and Derwing, 2008). Involving different subjects of L1 could also lead to a better understanding of

the relationship of the production and perception between L1 and L2. For example, Hojen and Flege (2006) compared the perception of native English speakers of Spanish vowels with the perception of native Spanish speakers of English vowels to find whether early learners were able to discriminate second-language vowels.

2.4.2 Stimulus materials used to elicit data

Researchers often employed different stimuli to elicit non-native speech samples. In such cases, subjects were asked to read sentences, paragraphs, individual words, and minimal pairs of words or carrier sentences with targeted words. Some researchers also adopted non-words as materials. Some subjects were additionally asked to recount personal experiences or to describe pictures in order to retrieve their own phonological representations. There were also direct repetitions of material produced by native speakers (Flege et al., 1999; Markham, 1997; Flege et al., 1995).

These different methodologies used to elicit data might be problematic. First, it was well known that individual differences in word familiarity might influence the accuracy of the production and perception (Walley and Flege, 1999). Munro (2008) conducted research using CVC English words as stimulus materials to examine English vowel discrimination and concluded that words with initial sounds /b/ received higher discrimination rates than those with /p/. This was due to the fact that the /b/ words were more common than their /p/ counterparts. In addition, some of the CVCs initiated by /p/ were nonsense words. Moreover, in L1 development, correct discrimination rates might differ between real words and nonsense words (Stager and Werker, 1997). To avoid the influence of word familiarity, Baker (2008) conducted

research using stimulus speech of monosyllabic English words. The participants were asked to complete a vocabulary knowledge task to minimize the influence of word familiarity. The fact that the speakers performed better on the familiar words and real words might illustrate that word familiarity enabled them to develop more accurate cognitive representations of the common items. Munro (2008) claimed that richer representations might have facilitated the production.

Second, using only one technique has disadvantages. Thompson (1991) reported that reading speech was judged to be more strongly foreign-accented than extemporaneous speech samples. This might be due to the fact that individuals differed in reading abilities. Samples of extemporaneous speech might contain morphosyntactic and lexical errors influencing the foreign accent ratings given to non-native speakers (Patkowski, 1990). In addition, participants might avoid certain difficult sounds and words or use more familiar words frequently. When words to elicit targeted sounds were used, it was difficult to rule out the influence of phonetic context on certain sounds.

There were also studies that combined both stimuli produced by native speakers of L1 and native speakers of L2 to study cross-linguistic similarity (Baker et al., 2008; Rogers et al., 2005). Some researchers used more than one elicitation technique. For example, Rogers (2005) adopted stimulus materials containing two sets of materials: a word list and a sentence list.

In addition, raters should evaluate a fixed set of material (sentences) that was elicited by employing delayed repetition tasks. For example, Munro et al. (1996) conducted research in which the talker heard a recorded stimulus sentence beginning

with the target word (“__ is the next word”), and during the pause that followed, they produced a carrier sentence containing the target word in sentence-final position (“Now I say__”). Each stimulus was also provided in written form.

Therefore, task familiarity and other psycholinguistic aspects of performance might be critical sources of inter-language variation. The issues of content, the format and the task type might interact in a problematic way which led to less valid results. The present research used the real words with the consonants, which have been subsequently eliminated.

2.4.3 Rating techniques employed

In the production and perception tests, listeners evaluated L1/L2 speech samples using a rating scale to indicate the degree of foreign-accented speech or how similar the L2 sounds were to the L1 sounds. One end of the rating scale was for native-like pronunciation and the other was non-native pronunciation.

The equal-appearing interval (EAI) scales used in previous studies have differed in resolution (e.g., Mirjam, 2009). Most employed a 5-point scale. There were studies employing 3-point scales, 4-point scales, 6-point scales and 9-point scales. There were also studies employing keywords for listeners to identify targeted sounds (Bohn et al., 1990; Flege et al., 1997), phonetic symbols to identify targeted sounds (Munro et al., 2008; Jia et al., 2006; Flege et al., 2001; Munro et al., 1996) and orthography to identify targeted sounds (Cebrian, 2005). Some studies required listeners to identify whether words were correctly or incorrectly produced (Flege et al., 2004), to judge the grammaticality by answering “yes” or “no” (Flege et al., 2004) or to rate the sentences

produced as “definitely Italian,” “probably Italian,” “probably English,” and “definitely English” (Flege et al., 1997). In addition, Flege et al. (1999) required participants to click a button marked “1”, “2” or “3” if they heard one vowel that differed from the other two, or “no” if they heard three instances of a single vowel.

Because there was no standard scale for measuring L2 speech samples, it was questionable as to whether all scales could generate valid results. Southwood and Flege (1999) argued that foreign accent was a metathetic continuum. They found that native English listeners were able to partition L2 foreign accent into equal intervals, and that it was appropriate to use the EAI scale. However, the range of scale values depended on the sensitivity of listeners. Although Southwood and Flege (1999) found that a 9-point (or 11-point) scale should be used to rate L2 speech samples for the degree of foreign accent, native listeners might differ in their criterion and backgrounds. It was expected that increasing number of immigrants have resulted in the tolerance for and the expectation of within-language variation. All above-mentioned factors might be expected to cause raters to think twice before rejecting accented English or French as definitely non-native (Long, 1990). Unfortunately, when evaluating the production of L2 learners, few studies have examined the characteristics of listeners. The individual differences of listeners might influence conclusions dramatically because the listeners might differ in their sensitivity to different foreign accents. Flege et al. (1997) raised the question of whether the results obtained for one group of listeners could generalize to another group of native English-speaking listeners. In their study, two techniques were employed to assess the generalizability of the results: listener analyses and comparison of data collected from two groups of listeners speaking different dialects.

The results indicated that listeners differed in their responses to a seven-point EAI scale. Therefore, listener levels should be controlled and inexperienced listeners should be provided with practice tasks before rating the speech sample (Rogers et al., 2005).

In some studies, native speakers or second language learners rated speech samples (Flege et al., 2004). Expert raters such as linguists or ESL teachers have been involved in other studies. Thompson (1991) stated that inexperienced raters generally perceived a higher degree of L2 foreign accent in non-native speech than experienced raters. However, Bongaerts (1997), Munro (2008), and Flege (1984) found no significant differences between experienced and inexperienced raters regarding the judgment of accent. It appeared that qualified raters should be recruited, rather than one particular type of rater, to make the conclusion more valid (Piske et al., 2001).

One major limitation was that the reliability and the validity of language measurement and non-nativeness ratings in foreign accent studies were rarely reported. It was undesirable that data collected be used for such measures to test hypotheses. This limitation should be taken seriously as sometimes the methodologies used may have a greater effect on the outcome than the variables that were supposed to determine the results of the studies.

2.5 The relationship between production and perception

Second language speech acquisition involves both production and perception, and there has been heated debate regarding the relationship between the two.

Many studies involved the production of vowels (Baker et al., 2006, 2008). The English vowels produced by late learners were more likely to be misidentified than early learners' vowels are (Munro, 1993; Munro et al., 1996). Yemi's findings (2010) investigated the production of English vowels of Mandarin speakers and found that native advanced Mandarin speakers did not produce the back vowels /o, u/ correctly.

The divergent conclusions made by different studies raised three questions: would L2 learners differ in the perception of L2 vowels from native speakers? Would age factors constrain such perception accuracy? And, could differences in perception lead to differences in the production? Rochet (1995) showed differences in the classification of a continuum of synthetic French vowels by native speakers of French, Portuguese and English. Vowels identified by the French subjects as /y/ were classified as /i/ by Portuguese participants, but as /u/ by native English subjects. Participants' imitation of vowels was consistent with the perceptual results. Other studies asserted that accurate production preceded accurate perception. At least, some learners were able to detect differences among L2 sounds that they could not perceive (Zampini and Green, 2001).

To further explore the age-related factor in production and perception, Baker (2008) conducted experiments involving 64 native Korean- and English-speaking children and adults. They found that Korean children were less likely than adults to perceive L2 vowels as instances of a single L1 vowel category, and children surpassed adults to produce certain vowels, although children equaled them in the English vowel perception. A further conclusion has been made that "age at the time of exposure to the L2 serves as a variable mediating the relationship between the two abilities: being able to perceive L1-L2 phonetic differences and being able to accurately produce L2 sounds" (p. 337). That is

to say, age of exposure to L2 played an important role in determining the degree to which these abilities were related. Younger learners were closely related, allowing early learners to both perceive L1-L2 phonetic differences and produce L2 sounds accurately, non-L1 sounds in particular. For late learners, the ability to perceive cross-language differences and the ability to produce them were only loosely associated. Although the specific relationship between perception and production remains uncertain, these two abilities enabled early learners to be more successful than late learners in L2 learning. According to Baker (2005), it has gone beyond the scope of traditional inquiries into the age factor by examining factors that influenced the ability to perceive L1-L2 differences and L2 production and perception (Baker et al., 2006, 2008). Baker et al. (2006) concluded that, “a number of individual differences (LOR, AOA and learners’ ability to accurately perceive their own speech) might underlie the development of L2 perception and production” (p. 250). These current studies have shed light on confounding factors that influenced L2 production and perception (Baker et al., 2006). Therefore, the relationship between perception and production was by no means a simple sequence problem as previous studies showed.

Some studies also showed that production and perception were interdependent and developed simultaneously (Best, 1995). Therefore, production and perception were always aligned so that perception never surpassed or preceded production and vice versa (Flege, 1997). Other studies stated that accurate production preceded accurate perception. At least, some learners were able to produce differences among L2 sounds that they cannot perceive (Zampini and Green, 2001). For instance, Japanese learners of English can produce a contrast between English /r/ and /l/ without being able to perceive it (Smith,

2001).

Conflicting results regarding the relationship between production and perception are attributable to individual differences such as AOA and LOR or other factors, as discussed above. Other studies examined the perception–production link for learners of different ages and L2 proficiency levels. For example, Sheldon and Strange (1982) examined intermediate-level Japanese learners of English while Flege et al.’s study (1999) involved advanced Italian learners of English. Furthermore, Baker et al. (2006) found that self-perception, along with other factors, played a significant role in the relationship between the production and perception of L2 sounds.

Therefore, L2 speech acquisition has resulted from, among other factors, age-related differences in the neural plasticity (Scovel, 2000) and differences in the state of development of L1 phonetic categories (Flege, 1999). Such influences also resulted from factors that were related to age (Flege, Yeni-Komshian et al., 1999).

2.6 Chinese Mandarin Vowels

Mandarin is the official language used in China, including both Mainland China and Taiwan. In Beijing, the capital of China, Mandarin is the dialect. It is a tone language where a change in the tone of a syllable leads to a change in the meaning. There are four contrastive tones: high level, high-rise, low fall, and high fall (Yang, 2001). The vowels were /i, e, y, u, o, a/, although there were reports of variations in the production of vowels in conversational Mandarin, which accounted for as many as twelve different vowel types (Flege et al., 1997). It was reported that individuals who spoke Asian languages showed phonetic inaccuracies in their production of English spoken as a second language (Yang,

1996). Phonetic inaccuracies were assumed to arise from the segmental and prosodic differences between two languages. The number of Asian immigrants to Canada has increased dramatically, with many of them speaking Mandarin. However, little is known regarding the influence of Mandarin on Canadian English, particularly regarding the discrimination and identification of English vowels performed by Mandarin speakers.

There were studies concerning the comparison between Canadian and Mandarin vowels, the majority of which conducted an acoustic analysis (Wang, 2009). Flege et al. (2005) conducted research on the production and the perception of English vowels by Mandarin speakers. They included three groups of native Mandarin speakers – with varying amounts of L2 exposure – to assess the contribution of the variables AOA and other potential predictor variables in L2 acquisition. They came to the conclusion that with increasing L2 use, age differences in performance accuracy changed from an older-learner advantage to a younger-learner advantage for both the perception and the production. For the recent arrivals (ESL learners who came to L2 speaking country at an early age), AOA was not related to performance at all, and for the past arrivals, a younger AOA predicted significantly better discrimination accuracy for three vowel contrasts, as well as better production. Flege et al. (2005) claimed that the theories should explain not only the long-term younger learner advantage but also the short-term older learner advantage and the processes of change involved. Nevertheless, these theories were not powerful enough to explain the age-related differences shown before a long-term time period. Flege's research also concluded that at the individual level, better perception performance significantly predicted better production performance. As for the group level, the vowel contrasts that were better distinguished were also produced with

accuracy. However, this study had limitations; first, the performance of native speakers of Mandarin in China could not be compared with that of Chinese speakers in the USA. Second, the criterion to classify past arrivals and recent arrivals mainly depended on the LOR. Moreover, the difference between the LOR of the two groups was only two years. A short time span in LOR might undermine the conclusion to some extent as more and more researchers concluded that LOR was not a necessary index to L2 experiences (Cebrian, 2006; Piske, 2001).

2.7 The Production and the Perception of English Vowels by Mandarin Speakers

In Jia's study (2001), the experimenter assessed age-related differences in the production and the perception of American English vowels by native Mandarin speakers as a function of the amount of exposure to the target language. Discrimination of six AE vowel pairs /i-I/, /i-e/, /ε-æ/, /æ-a/, /a-Λ/, and /u-a/, and production of the seven vowels / i, I, e, ε, æ, Λ, u/ was assessed with an immediate imitation task. Age-related differences in performance accuracy changed from an older-learner advantage to no age differences among recent arrivals and to a younger-learner advantage among past arrivals. The research concluded that there were significant positive correlations between the production and perception regarding the performance for all participants together. For the past arrivals, the research concluded that AOA predicted significantly better discrimination accuracy "the earlier, the better". It also concluded that some Mandarin speakers were able to distinguish some vowel pairs accurately but confused them in the production, showing that production lagged behind perception. And, perception abilities improved faster than production abilities.

However, the research has some limitations. First, participants in China and those in the United States might not be comparable in terms of dialect background. Therefore, my research focused on subjects from the same language background (e.g., Mandarin). Second, the research used AOA (Age of Arrival) as the main criteria to categorize subjects. AOA did not necessarily show the level of proficiency of ESL learners' English level. Therefore, my research used both the length of residence and the score of Standard English test to recruit participants. Third, the above research concluded that the more experienced subjects' performance predicted the positive relationship between the production and the perception. The majority of studies conducted the perception test first and the production test second, concluding that the perception lagged behind the production. In order to examine the relationship between the perception and production, my research conducted the identification test (production) first and then the perception test to see if the sequence of the experiment might influence the results.

In the Wang's study (1997) on the acquisition of English vowels by Mandarin ESL learners, the research concluded that adult L2 speech learning was strongly influenced by the learners' L1. This study examined the effect of the L1 vowel system on native Mandarin speakers' production and perception of English vowels. The research focused on whether the acoustic properties can account for the success or failure of the Mandarin speakers' performance in their production and perception of the English vowels. The tendency was that Mandarin speakers' production of English vowels which have Mandarin counterparts were more intelligible than that those which did not. And, it was also the case that the perception had a positive relationship with acoustic analysis. The perception tasks, however, did not completely support those of the production tasks. It

indicated that L2 production might not always be related to perception in an obvious way and the relationship between production and perception was a complex matter. However, this research did not mention specifically whether having counterparts in L1 would have any influence on the relationship between the production and the perception.

In Wang's study (1997), the researcher examined the effects of perceptual training on the production and the perception of English L2 vowels contrasts under lab conditions. The subjects were asked to identify synthesized continua and naturally produced minimal pairs contrasting three vowel pairs. The results showed that the participants who had perceptual difficulties might rely on duration cues for the /i/-/I/ but not for other contrasts. The research suggested that training only in perception was not enough for the improvement in the production.

Flege's study (1997) assessed the effect of English-language experience on non-native speakers' production and the perception of English vowels. There were 20 speakers each of German, Spanish, Mandarin, and Korean languages, as well as a control group of ten native English speakers. The subjects were categorized as experienced and inexperienced participants. LOR was used as the criteria to categorize experienced (lived in the targeted country more than three years) and inexperienced subjects. The 90 subjects' performance in producing the English vowels /I, i, ε, æ/ were assessed through native English-speaking listeners who attempted to identify which vowels were spoken. The researcher concluded that the accuracy of the production and perception depended on the ESL learners' perception of the relation between English vowels and vowels in the L1 inventory.

A crucial problem with previous cross-linguistic studies was the lack of dialectal control over the subjects. For example, in the research on Arabic speakers' accented English vowels, Munro (1993) considered certain Arabic dialectal differences in long and short vowels contrasts while analyzing the duration effects on English vowel productions. Likewise, speakers and contextual variability in the target language influenced Mandarin speakers' perception and production.

In order to avoid similar problems to the above-mentioned studies on vowel perception and production issues, the current study minimized these variations by conducting the experiments under limited conditions: First, the L1 subjects' dialectal differences were controlled, and L1 subjects were native Mandarin speakers. Second, the production data collected were isolated natural vowels. The experiment limited the influence of the consonant context on the foreign accent. Third, a group of native English speakers are included as a control group in the experiment to compare the performance of native English speakers with Mandarin speakers. Fourth, an attempt was made to explore the relationship between the production and the perception by comparing data from the identification tasks conducted by both Mandarin speakers and native English speakers. The current study explores how Mandarin speakers perceive and produce English vowels and what roles individual differences (AOA, LOR, age that ESL starts, and years of ESL learning) play in the perception and production of English vowels by Mandarin speakers.

Chapter Three

This chapter describes the design used to achieve the aims and objectives stated in Section 1.3. Sections 3.1 and 3.2 provide the methods, the stages by which the methods are implemented, the results, and discussions, respectively. Section 3.3 offers the comparison of the findings from Experiment 1 and Experiment 2.

3.1 Experiment 1

The purpose of this experiment was to find out how correctly native Mandarin speakers were able to produce the ten English vowels /i/, /ɪ/, /ɛ/, /e/, /æ/, /u/, /ʊ/, /ɔ/, /o/, and /ʌ/. The production of these vowels by 15 native Mandarin speakers and 15 native English speakers was judged by four native English-speaking listeners. If the four English listeners were able to correctly identify the English vowels produced by the Mandarin speakers, the production was considered to be successful. Specifically, this experiment first reveals how correctly the vowels were produced by native Mandarin speakers as judged by the native English listeners when compared with vowels produced by native English speakers. Second, the experiment was designed to examine whether some vowels produced by Mandarin speakers were better identified by native English speakers than others and if so, which ones. Third, the experiment aimed to investigate whether the differences in the production of English vowels by Mandarin speakers were explicable in the differences between L1 and L2 vowel systems.

3.1.1 Methods

3.1.1.1 Participants

The researcher recruited 15 native Mandarin-speaking undergraduate and graduate students who had been living in Canada for at least two years at the time of the study. All are from a Canadian university in B.C., with a mean age of 26, and an average of 9 years of English-learning experience. The participants' mean age of arrival in Canada was 22. The age at which they began learning English varied from 7 to 12. All participants were proficient in English, with an IELTS (International English Language Testing System) score of 6.5 or above. Table 3.1 presents the background information of the Mandarin speaking participants.

Table 3.1

The Background Information for the 15 Mandarin Speakers

Speaker	Age	Years of English learning	Age that ESL learning started	Age of arrival	Length of residence
M1	24	15	9	22	2
M2	26	18	8	24	2
M3	25	16	9	22	3
M4	28	16	12	26	2
M5	25	16	9	22	3
M6	24	16	8	20	4
M7	26	17	9	22	4
M8	27	18	9	24	3
M9	30	18	12	26	4
M10	35	23	12	27	8
M11	28	19	9	22	6
M12	24	16	8	20	4
M13	23	14	9	20	3
M14	22	13	9	19	3
M15	20	13	7	18	2
Mean	26	17	9	22	4

Fifteen native speakers of English participated as the control group. The native English-speaking participants were all born and grew up in Vancouver, B.C. Four additional native speakers of Canadian English (not included in the 15 native English-speaking participants in the control group) were recruited as listeners (judges). They were graduate or undergraduate students from the same Canadian university in B.C. They have no linguistic background and have a mean age of 26, ranging from 20 to 35.

3.1.1.2 Data Collection

Data collection involved the following procedures:

First, an ethics committee approved the researcher to recruit subjects, and subjects were subsequently recruited from an advertisement.

Second, individual recordings were made with a UR-P632FM Aigo digital recorder in a quiet room in Nanaimo, B.C.. The Mandarin speakers first completed a Language Background Questionnaire (see Appendix 1). The researcher then explained the reading tasks to them.

Third, the 15 native English and the 15 native Mandarin speakers individually read the list of the ten English vowels in /bVt/ words. In this research, the targeted vowels were all single vowels and the vowel schwa, which was a reduced vowel, was excluded. The subjects produced the words in a /bVt/ frame in the carrier sentence “Now I say the word _.” This frame was used by many researchers in similar studies (Flege et al., 1995). The Mandarin speakers were asked to read at a normal speed. Table 3.2 shows the targeted English vowels used in the Experiment 1. Table 3.2 presents the targeted English vowels used in the experiments.

Fourth, all chosen words were common words. It had been assumed that all subjects have no difficulties in pronouncing these words, since participants were all experienced English learners. Before the experiment, the researcher also made sure that all subjects were familiar with the words. For consistency, all the chosen words except “book” ended in /t/. The word “*book*” was chosen because it is a common word in daily communication, and there is no real word in English that is pronounced as /bʊt/. The data have been analysed through correlational calculation.

Table 3.2

The Targeted English Vowels

Vowels	Key words	Sentence
/i/	Beat	Now I say the word beat.
/ɪ/	Bit	Now I say the word bit.
/ɛ/	Bet	Now I say the word bet.
/e/	Bait	Now I say the word bait.
/æ/	Bat	Now I say the word bat.
/u/	Boot	Now I say the word boot.
/ʊ/	Book	Now I say the word book.
/o/	Boat	Now I say the word boat.
/ɔ/	Bot	Now I say the word bot.
/ʌ/	But	Now I say the word but.

A total of 300 vowel tokens (10 vowels x 30 speakers) were recorded and used for an identification test administered to the four native English-speaking judges. Before the tokens were presented to the native English judges, the final consonant in each syllable was deleted. The resulting tokens were all of /bV/ syllables. The English listeners were tested individually in a quiet room on a personal computer. On each judgment trial, a random stimulus was played through a headphone. Each listener completed the tasks in a self-paced way; namely, the listeners controlled the speed at which the stimuli were presented. The listeners were instructed to listen to each stimulus word and then select

one of the ten English vowels on a specifically prepared response sheet (see Appendix 2).

The listeners were not told which vowel the subjects produced.

3.1.2 Results

Table 3.3 presents the mean percentage of errors, as judged by the four native English-speaking judges, of the ten vowels produced by the 15 native English-speaking and the 15 native Mandarin-speaking speakers.

Table 3.3

Error Rate (%) of the English Vowels Produced by the English and Mandarin Speakers (Perceived by Four English Judges).

Native judges	English speakers' production					Mandarin speakers' production				
	1	2	3	4	Mean	1	2	3	4	Mean
/i/	0	0	0	0	0	10	1	5	3	5
/ɪ/	7	10	9	8	9	30	60	62	65	54
/e/	0	0	0	0	0	7	6	9	2	6
/ɛ/	2	20	15	13	13	40	30	35	30	37
/æ/	0	3	0	2	1	55	50	43	40	47
/ʊ/	5	5	3	5	5	45	50	45	60	50
/u/	0	0	1	1	1	10	15	1	14	10
/ɔ/	20	30	24	15	22	32	54	63	50	42
/o/	0	0	0	0	0	10	2	1	1	4
/ʌ/	10	20	15	15	15	17	25	25	21	22
Mean					7					30

Overall, native English speakers' vowels were better identified by the four English listeners than those produced by Mandarin speakers. The English speakers' vowels had an average error rate of 7% while the Mandarin speakers' vowels had an average error rate of 30%. The English speakers' production of /i, e, o/ had no errors, and a mere error

rate of 1% for /æ/ and /u/. The rest of the vowels had an error rate ranging from 5% for /ʊ/, 9% for /ɪ/, 13% for /ɛ/, 15% for /ʌ/, to 22% for /ɔ/. Figure 3.1 shows the order of the error rate, as judged by the native listeners, of the native English production of the 10 English vowels from the lowest to the highest.

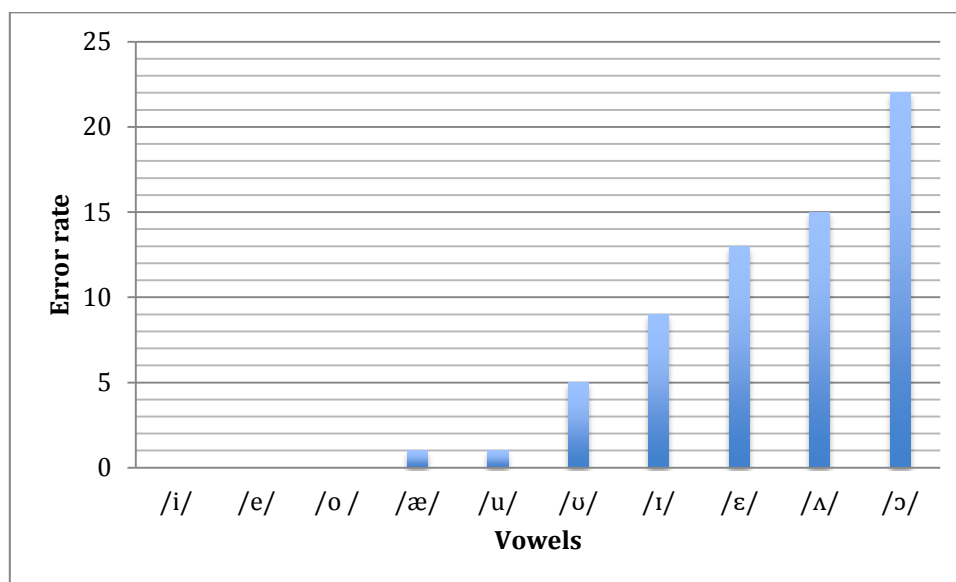


Figure 3.1. English speakers' mean error rate of the English vowel production.

For Mandarin speakers' production, the error rate ranged from a low of 4% for /o/ to a high of 54% for /ɪ/. Four vowels, /i, e, o, u/, were more or less correctly identified by native judges with an error rate of 5% for /i/, 6% for /e/, and 10% for /u/. The error rates for /ɪ, ɛ, æ, ʊ, ɔ, ʌ / produced by the Mandarin speakers present a different story. Among those vowels, the production of /ɪ/ (with an error rate of 54%) was least correctly identified among all the other vowels, followed by /ʊ/ (50%) and /æ/ (47%). The error rates for /ɔ/ and /ɛ/ were 42% and 37%, respectively. The sixth vowel was /ʌ/ (22%). The

order of the error rate from the lowest to the highest for the Mandarin speakers' production as judged by the native listeners is shown in Figure 3.2.

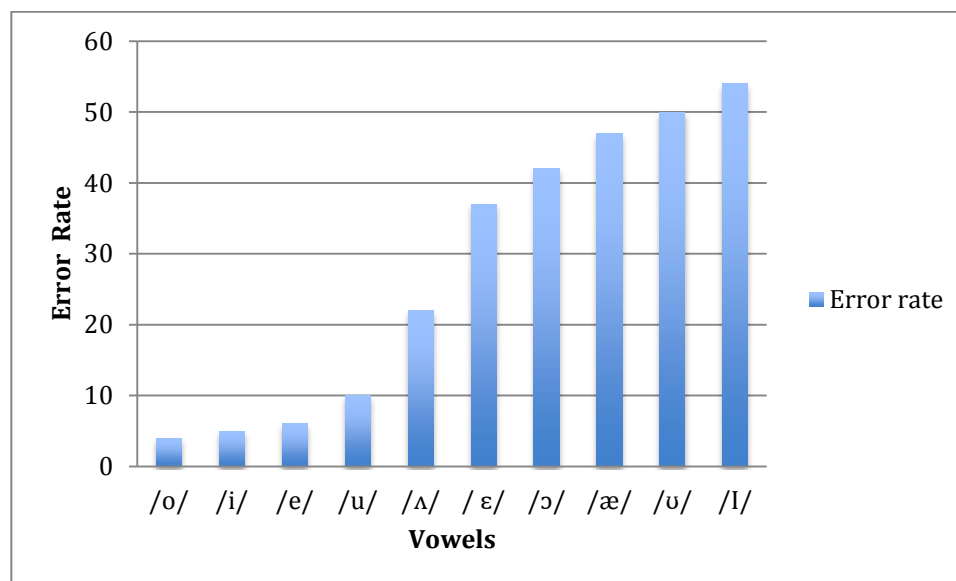


Figure 3.2. Mean error rates in the Mandarin speakers' production.

A notable aspect of the results is that the error rates for /ʌ, ɛ, ɔ/ were high for both native English and Mandarin speakers' production. Comparing the production by both groups, the English speakers' production of /ɪ, æ, ʊ/ was much better identified than the Mandarin speakers' production. The error rate of /ɪ/ and /ʊ/ in the English speakers' production was 45% lower than that in the Mandarin speakers' production. The error rate of /æ/ in the English speakers' production was 46%, lower than the that of Mandarin speakers'.

Another observation about the results is that there were differences in the error ratings among the individual native judges (the four English listeners). In the English

speakers' production, all four listeners identified the vowels /I, o/ uniformly, and the listeners did not differ much in identifying /I, æ, u, ʊ/. However, for the production of /ɛ/, the error rates varied dramatically, from 2% to 20%. The error rate of /ɔ/ also varied ranging from 15% to 30%, while the error rates of /ʌ/ differed only a little, ranging from 15% to 20%.

In the Mandarin speakers' production, there were differences among the four judges as well. The error rate for /i/ and /o/ ranged from 1% to 10%. The biggest difference in error rate among the Mandarin speakers' production of vowels was /I/, with error rates ranging from 30% to 65% among the four listeners. The error rate of /ɔ/ also differed, ranging from 32% to 63%. For the Mandarin speakers' production of /ɛ, æ, ʊ, ʌ /, it seemed that the English listeners had relatively fewer differences in judging these vowels. For the Mandarin speakers' production of /u/, one listener had only 1% of error identification rate while another had 15%. Note also that there were no listeners who were able to identify all productions correctly regardless of native or Mandarin speakers' production.

Table 3.4 provides the confusion matrix for English speakers' production of English vowels judged by the four English listeners. The horizontal vowel list contains the original vowels, while the vertical list on the left has the identical vowels.

Table 3.4

Confusion Matrix (%) for the English Speakers' Production of the English Vowels (Perceived by the Four English Listeners)

	/i/	/ɪ/	/e/	/ɛ/	/æ/	/ʊ/	/u/	/ɔ/	/o/	/ʌ/
/i/	100	8		3						
/ɪ/		91		10						
/e/			100							
/ɛ/		1		87	1					
/æ/					99					10
/ʊ/						95	1	2		
/u/						2	99	7		5
/ɔ/						1		78		
/o/						2		9	100	
/ʌ/								3		85

Note: For example, /ɪ/ was heard as /i/ 8% of the time and /ɛ/ 1% of the time.

Overall, there was a high success rate of the identification of these vowels produced by native speakers. All vowels were correctly identified 78% of the time, or higher. Among the ten vowels produced by native speakers, /i, ɪ, e, æ, ʊ, u, o/ were correctly identified by English-speaking judges, with vowels /i, e, o/ heard correctly 100% of the time. Very close to these were /æ/ and /u/, which were heard correctly 99% of the time, /ʊ/ was heard correctly 95% of the time, as /u/ (2%) and /o/ (2%), respectively and as /ɔ/ (1%). Closer observation showed that three English vowels /ɛ, ɔ, ʌ/ were more or less misidentified. Among the three, the most frequently misidentified was /ɔ/, which was heard by the native judges correctly 78% of the time, but incorrectly heard by them as /o/

(9%), as /u/ (7%), as /ʌ/ (3%), and as /ʊ/ (2%). The second most frequently misidentified vowel was /ʌ/, which was heard as /ʌ/ (85%), but, as /æ/ (10%) and as /u/ (5%). Following /ʌ/ was /ɛ/, which was heard as /ɛ/ (87%), but as /I/ and /i/ 10% and 3% of the time, respectively.

Table 3.5 shows the confusion matrix for Mandarin speakers' production of English vowels judged by the four English listeners.

Table 3.5

Confusion Matrix (%) for Mandarin Speakers' Production of the English Vowels (Perceived by the Four English Listeners).

	/i/	/ɪ/	/e/	/ɛ/	/æ/	/ʊ/	/u/	/ɔ/	/o/	/ʌ/
/i/	95	38	1	7						
/ɪ/	2	45	3	10						
/e/			94							
/ɛ/	3	17	2	63	39					
/æ/				19	53					2
/ʊ/						50	10	1	1	
/u/						12	90	5	2	5
/ɔ/						4		58	1	15
/o/						34		28	96	
/ʌ/					8			9		78

Note: The horizon vowel list contained the original vowels while the vertical list had the identical vowels.

Table 3.5 shows that, if 70% or more was used as the rate at which a vowel was considered correctly identified, five of the 10 English vowels, /I, ɛ, æ, ʊ, ɔ/ by the Mandarin speakers were not correctly identified. Among the five, the most frequently misidentified English vowel produced by the Mandarin speakers was /I/, which was heard by the native judges as /I/ (45%), but it was incorrectly heard as /i/ (38%) and as /ɛ/ (17%). The second most frequently misidentified vowel was /ʊ/, which was heard as /ʊ/

only half of the time, but as /o/ (34%), and as /u/ (12%) and /ɔ/ (4%), respectively. The third most frequently misidentified vowel produced by the Mandarin speakers was /æ/, which was heard as /æ/ (53%), but as /ɛ/ and /ʌ/ (39%) and (8%), respectively. Following /æ/ was /ɔ/, which was correctly heard as /ɔ/ (58%), but was confused as /o/ (28%) and occasionally as /ʌ/ or /u/ other times. Among the five vowels, /ɛ/ fared better than all the others and was heard as /ɛ/ (63%), but was otherwise confused as /æ/ (19%), /ɪ/ (10%) or /i/ (7%).

Among the ten vowels produced by the Mandarin speakers, five (/i, e, u, o, ʌ/) were correctly identified using the “70% or more” criterion. The vowels /i/, /o/, and /e/ were heard correctly 94% to 96% of the time. Following these three vowels, /u/ (90%), which was heard as /ʊ/ (10%). The correct rate for /ʌ/ was 78%. The only notable confusion for /ʌ/ was /ɔ/. For 15% of the time, /ʌ/ was misheard as /ɔ/.

An analysis was also conducted at the individual level.

Table 3.6 shows the error rate in the 15 Mandarin speakers’ production of the 10 English vowels judged by the 4 native English-speaking listeners.

Table 3.6

Error Rate (%) in the 15 Mandarin Speakers' Production of the 10 English Vowels Heard by the 4 Native English Listeners.

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	Mean
/i/	2	3	5	10	15	0	2	0	2	5	0	3	4	10	6	5
/ɪ/	20	50	45	60	70	25	70	85	90	25	21	55	56	85	50	54
/e/	3	4	6	5	15	0	0	5	8	10	3	5	4	8	10	6
/ɛ/	55	25	25	40	55	25	10	5	65	30	55	25	16	55	65	37
/æ/	85	75	70	55	45	35	45	30	25	55	65	76	15	10	15	47
/ʊ/	90	60	45	23	34	66	56	65	70	50	40	35	63	43	15	50
/u/	8	2	10	5	5	6	15	25	30	0	0	23	5	6	7	10
/ɔ/	35	42	60	42	32	32	28	15	18	17	23	75	85	79	50	42
/o/	0	0	2	0	4	5	10	0	0	12	15	1	3	0	5	4
/ʌ/	25	25	42	10	11	12	5	25	35	23	26	15	18	25	35	22
	32	29	31	25	29	21	24	26	34	23	28	31	27	32	26	

Figure 3.3 presents the mean error rate (%) in 15 Mandarin speakers' production of 10 English vowels heard by Native English listeners.

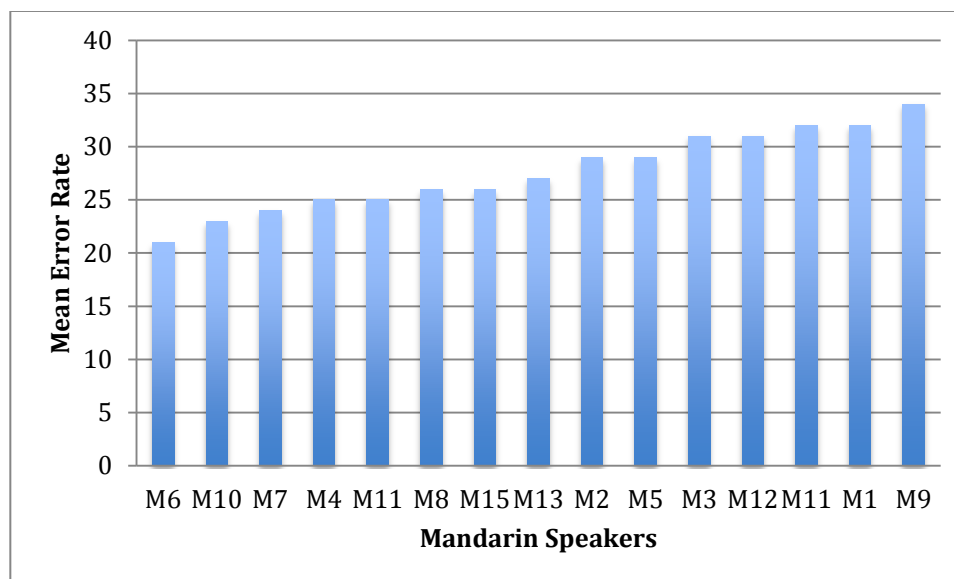


Figure 3.3. Mean error rate (%) in 15 Mandarin speakers' production of 10 English vowels heard by native English listeners.

The average error rate of the 15 Mandarin speakers' English vowel production was 28%. There were variances among Mandarin speakers regarding the mean error rate of the production. The lowest error rate was 21% (M6) and the highest was 34% (M9). The 15 Mandarin speakers got the higher error rate in producing /I, u/, respectively. Of the 15 listeners, six Mandarin speakers performed worst on /I/, with the error rate ranging from 60% to 90%. Among the 15 participants, two Mandarin speakers (M1 and M5) received the highest error rate in producing /u/. M2, M3, M10, M11, and M12 had the highest

error rate in the production of /æ/. M15 performed worst in the production of /ɛ/, and M13 performed worst in the production of /ɔ/. Some Mandarin speakers were able to produce certain vowels correctly. M1, M2, M4, M8, and M9 produced /o/ correctly. M6, M8, and M11 all produced /i/ correctly. M6 and M7 received 0% error rate in producing /e/. M10 and M11 also got 0% error rate in producing /u/. Finally, there were also considerable individual differences between speakers that were observed in the overall production rate. No speaker performed best on all ten English vowels. M6 gained the lowest mean error rate heard all /i/ and /e/ correctly. M1 and M14 who received the highest mean error rate, heard all /o/ correctly.

3.1.3 Discussion

In the discussion session, Mandarin speakers' individual differences and their performance in vowels were discussed.

3.1.3.1 /i, e, o, u/

The results of the Experiment 1 show that native Mandarin speakers in this study were not able to produce all ten English vowels correctly. In general, the Mandarin speakers' production of /i, e, o, u/ is correctly identified by the native judges and is almost as good as the English speakers' production of /i, e, o, u/. This indicates that Mandarin speakers have few difficulties in producing these four English vowels. The result does not support Yemi's findings (2010), which also investigated the production of English vowels of Mandarin speakers. Yemi found that native advanced Mandarin speakers did not produce the back vowels /o, u/ correctly. The difference between the

present study and Yemi's may be because Yemi's study was not a study based on native speakers judgement of the vowel production but was based on calculating format frequencies (F1, F2)¹ of the vowel production. As to why this is the case, further studies are needed to find out.

3.1.3.2 /I/ and /ʊ/

In comparison to English speakers' production of these vowels (/I, ʊ/), the Mandarin speakers' production caused much confusion for native English speakers when they tried to identify them. The English speakers' production of /I/ and /ʊ/ is correctly identified by the native judges with a 91% or more correct rate. The Mandarin speakers' production of /I/, on the other hand, is most often confused as its tense vowel counterpart /i/ (error rate: 38%) and secondarily as the lax vowel /ɛ/ (error rate: 17%). Jia's study (2006) showed a similar result in which /I/ was most frequently heard as /i/. These findings support the notion that a considerable number of Mandarin speakers have difficulties in producing the lax vowel and they confuse it with its tense vowel counterpart of /i/ of the same height and backness. The tendency for lax vowels to be confused with a nearby tense vowel can also be seen in the Mandarin speakers' production of the lax vowel /ʊ/ which was heard as the tense vowel /u/ (12%) and as the tense vowel /o/ (34%). There are no lax vowels in Mandarin, and Mandarin speakers have no linguistic cues to rely on to produce these "new vowels." Although /ɛ/ is also a lax vowel, the fact that some of the non-native /I/ is heard as the lax vowel /ɛ/ could be due to the fact that Mandarin has a surface form of /ɛ/ derived from its diphthong /aj/ which on the surface is /ɛj/ in longer-toned syllables,

¹ Formats are defined as the spectral peaks of the sound spectrum of the voice.

but /ɛ/ in shorter-toned syllables (Lin, 2011). Between /I/ and /ɛ/, the present experiment finds little difference in the error rate /ʊ/ (50% for /ʊ/) and (45% for /I/). This result is different from Wang's (1997), which found that there were more Mandarin speakers producing more misidentified /ʊ/ than /I/. Wang concluded that the difference might be attributed to the varying orthography representing the lax back vowel /ʊ/ as compared to the relatively simple orthography which represented the front lax vowel /I/. In view of the results from the present study, Wang's claim needs further research to validate. A possible explanation for the difference between the result of the present study and Wang's could be that the present study has included only experienced ESL learners while Wang's study (1997) involved inexperienced ESL learners with short lengths of residence.

3.1.3.3 /ɛ/ and /æ/

A discovery was found in the bidirectional confusion pattern between /ɛ/ and /æ/. Quite a few /æ/s were heard as /ɛ/s (39%) and 19% of /ɛ/s were confused as /æ/. The direction of confusion is not of equal weight, with more /æ/s heard as /ɛ/s than the other way around. It can be concluded that a surface /ɛ/ in Mandarin exists and that /æ/ is a new category for Mandarin speakers. It indicates that the Mandarin speakers prefer the vowel /ɛ/, which they have experience with in their L1 over /æ/s, and which have no counterparts in their L1. The confusion between the two vowels by Mandarin ESL learners was also found in Jia's study (2006) which found that /ɛ/ and /æ/ were confused as each other: 17% of /ɛ/ was heard as /æ/ and 23% of /æ/ was heard as /ɛ/.

3.1.3.4 /ɔ/ and /ʌ/

The confusion pattern for /ɔ/ indicates that the misidentified /ɔ/ is mostly misheard as /o/ (28% of the time), and between /ɔ/ and /o/ the confusion is uni-directional with /ɔ/ being confused as /o/ but not vice versa (/o/ was heard as /ɔ/ only 1% of the time). There seems to be minor confusion between /ɔ/ and /ʌ/. The latter was misidentified as /ɔ/ 15% of the time while 9% of the time /ɔ/ was misidentified as /ʌ/.

Another discovery is that the native judges did not correctly identify the English speakers' production of these two vowels. As shown by Assmann et al.'s study (1982), among the same ten English vowels tested in this research, /ʌ/ had the highest error rate produced by western Canadian English speakers. The vowel was tested under various conditions, such as consonant environment, isolated vowels, orthographic effect in labelling, speaker information, and so on. The results show that /ʌ/ received the highest error rate under almost all conditions. Wang's study (1997) also found similar results, which showed that the error rate of identification for this vowel was 24% for the native Mandarin speakers and 22% for the native English speakers.

3.1.3.5 Factors that might help explain the results

Several factors including LOR, AOA, Age when ESL learning starts and years of English learning were examined to see if they played a role in the success of the vowel production by the Mandarin speakers. Table 3.7 presents the information of the language background of the Mandarin speakers and their ESL production error rates.

Table 3.7

Language Backgrounds of the Mandarin Speakers and the Error Rates in Their English Production.

Speaker	Age	Years of English learning	Age that ESL learning started	Age of arrival	Length of residence	Error rate of production
M1	24	15	9	22	2	32%
M2	26	18	8	24	2	29%
M3	25	16	9	22	3	31%
M4	28	16	12	26	2	25%
M5	25	16	9	22	3	29%
M6	24	16	8	20	4	21%
M7	26	17	9	22	4	24%
M8	27	18	9	24	3	26%
M9	30	18	12	26	4	34%
M10	35	23	12	27	8	23%
M11	28	19	9	22	6	28%
M12	24	16	8	20	4	31%
M13	23	14	9	20	3	27%
M14	22	13	9	19	3	32%
M15	20	13	7	18	2	26%
Mean	26	17	9	22	4	28%

Length of residence (LOR)

Figure 3.4 shows the Mandarin speakers' length of residence and the error rate of production of each individual. The LOR rates were arranged from the lowest to the highest after the error rates were averaged out for each LOR figure.

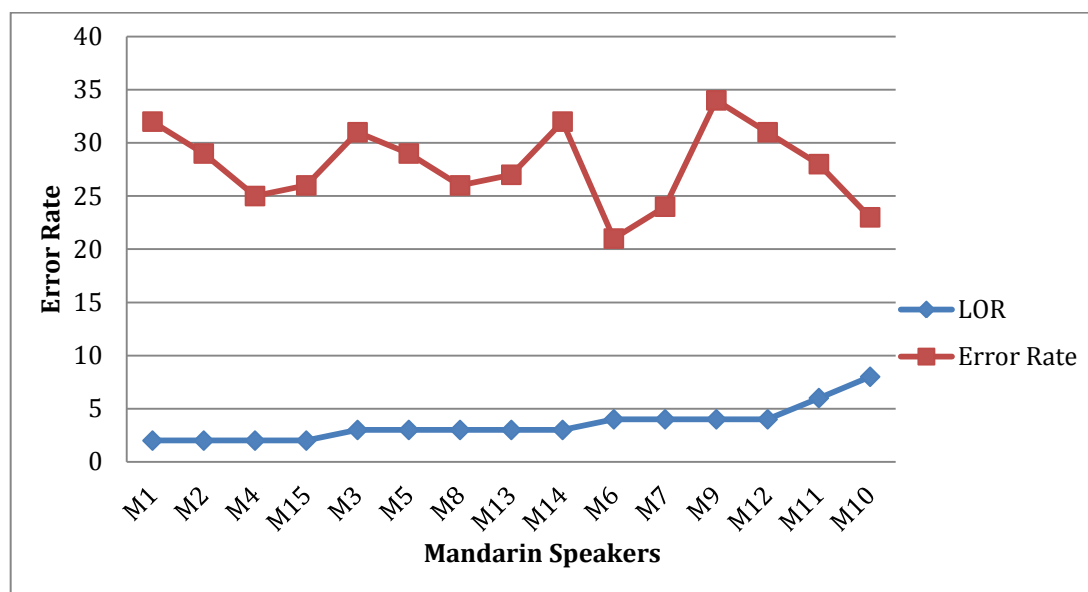


Figure 3.4. Length of residence and error rate of the production of Mandarin speakers.

Figure 3.5 represents the averaged LOR figure.

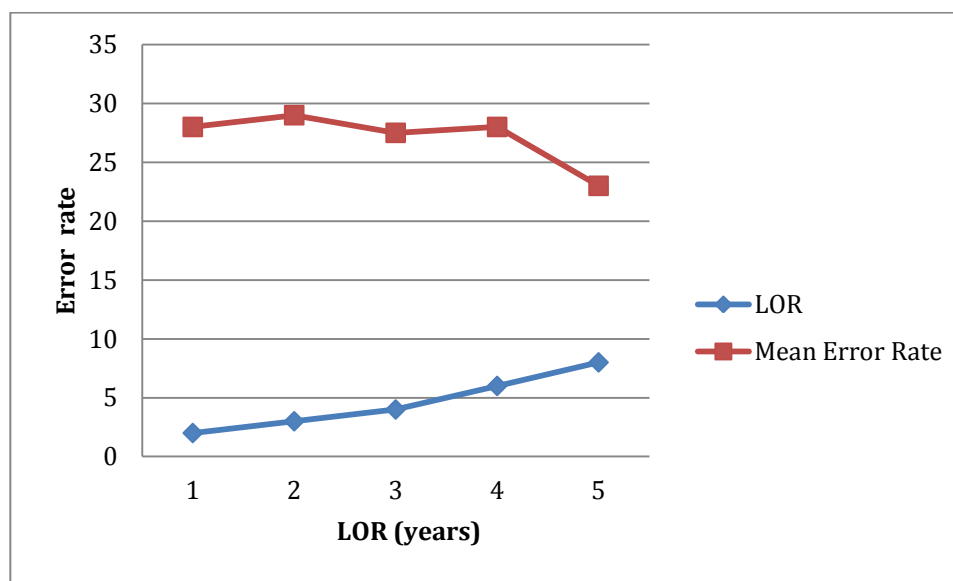


Figure 3.5. Averaged length of residence and error rate of the production of Mandarin speakers.

Correlational analysis of the relationship between LOR and the error rate shows that LOR and the error rate are reversely correlated ($r(15) = -0.81$). This seems to confirm that the longer the LOR, the lower the error rate, or the better the ESL speech production. This finding is both intuitive and supports the general hypothesis that the longer the LOR, the better the ESL speech production. This result was supported by Meador et al. (2000), which stated the longer the LOR, the better the production.

Age when ESL learning started

Figure 3.6 shows the relationship between the age when ESL learning starts for individual Mandarin speakers and their mean error rate.

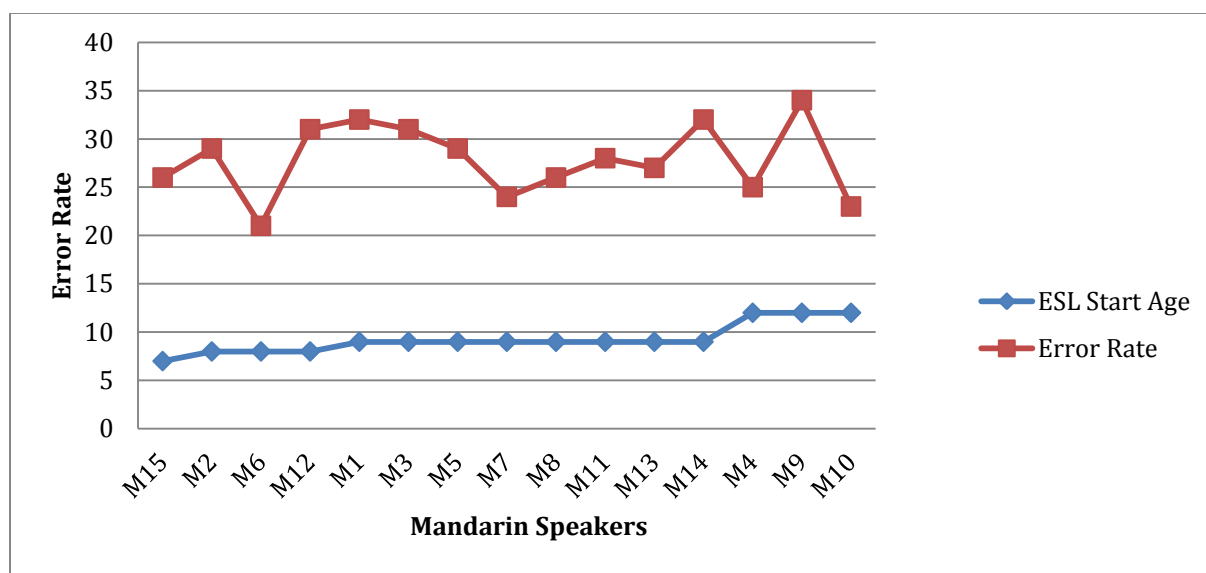


Figure 3.6. Age when ESL learning starts and Mandarin speakers' error rate of the production of Mandarin speakers.

Figure 3.7 shows the averaged error rates for every age when ESL learning starts:

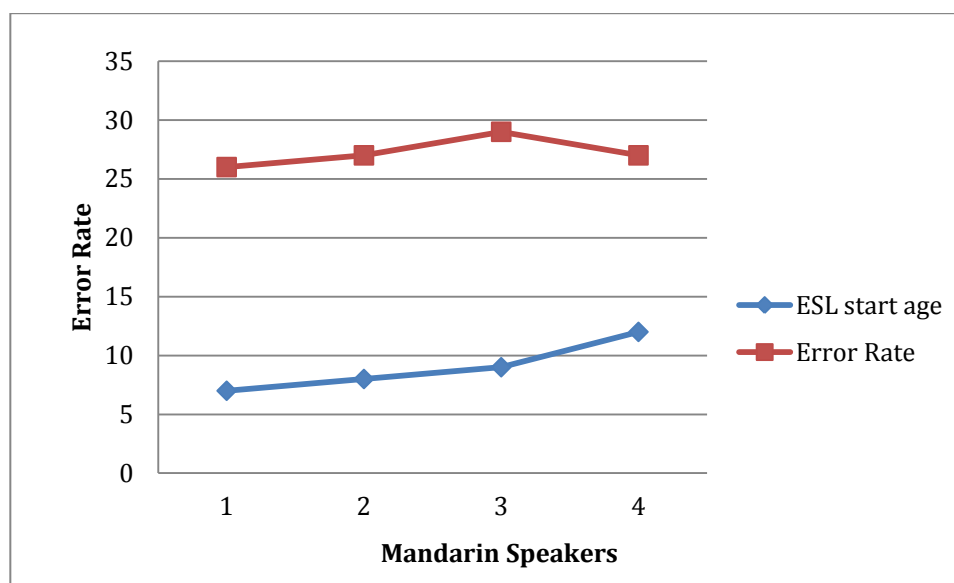


Figure 3.7. Averaged age when ESL learning starts and error rate of the production of Mandarin speakers.

Correlational analysis of these rates indicates a small positive correlation between the age at which the ESL learning started and the error rate ($r = 0.09$, $p > .05$). This seems to be in line with the previous findings that the higher the age at which ESL learning starts, the higher the error rate (Flege, 1997).

Number of years of ESL learning

Figure 3.8 is arranged with the years of ESL learning rates from the lowest to the highest.

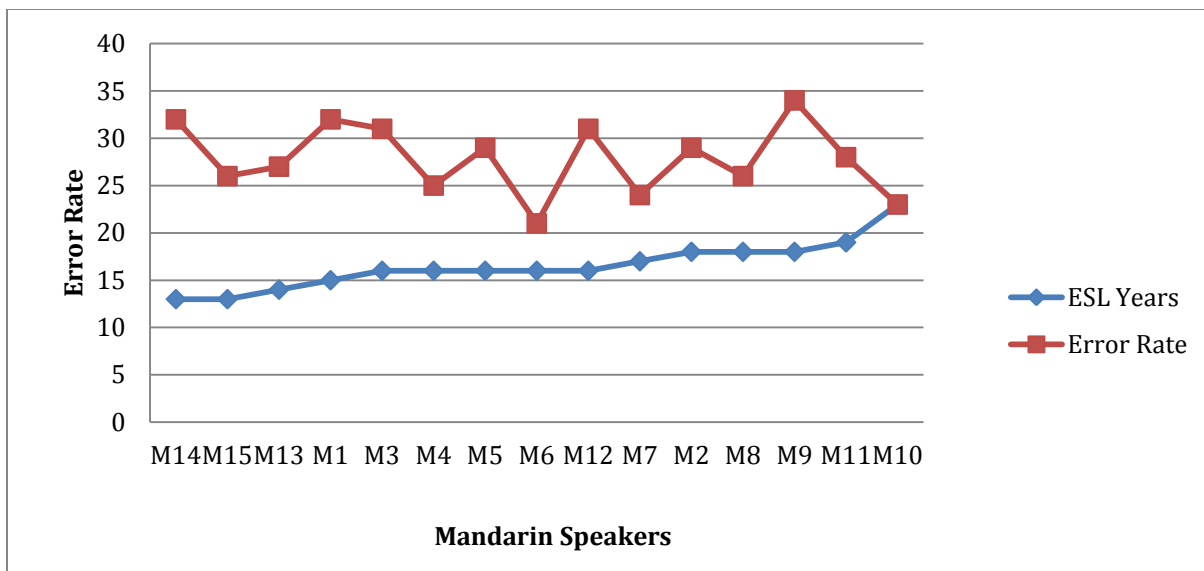


Figure 3.8. Number of years of ESL learning and error rate of the production of individual Mandarin speakers.

Figure 3.9 shows the error rates that are averaged out for each number of the years.

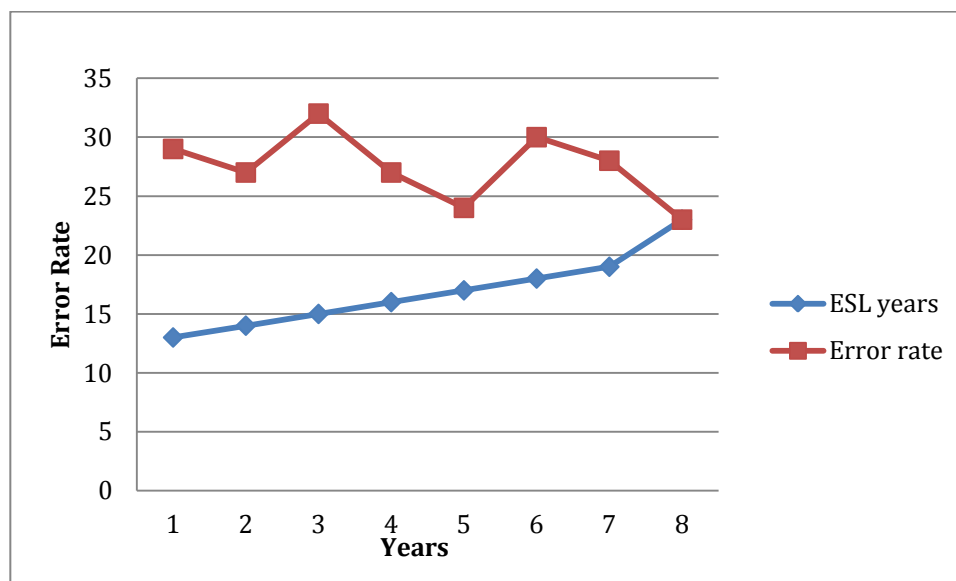


Figure 3.9. Averaged number of years of ESL learning and error rate of the production of individual Mandarin speakers.

Correlational analysis shows a small negative correlation between the number of years of ESL learning and the error rate ($r(15) = -0.55$). This finding suggests that the years of ESL learning is related to the error rate. This finding is consistent with Flege et al.'s findings (1997) that learners with more years of ESL learning tended to produce and perceive English vowels more accurately than those with fewer years.

Age of arrival

In terms of age of arrival, Figure 3.10 shows the relationship between age of arrival and the error rate of the production of Mandarin speakers with AOA numbers from the lowest to the highest. The figure shows that the error rate is not in line with the AOA.

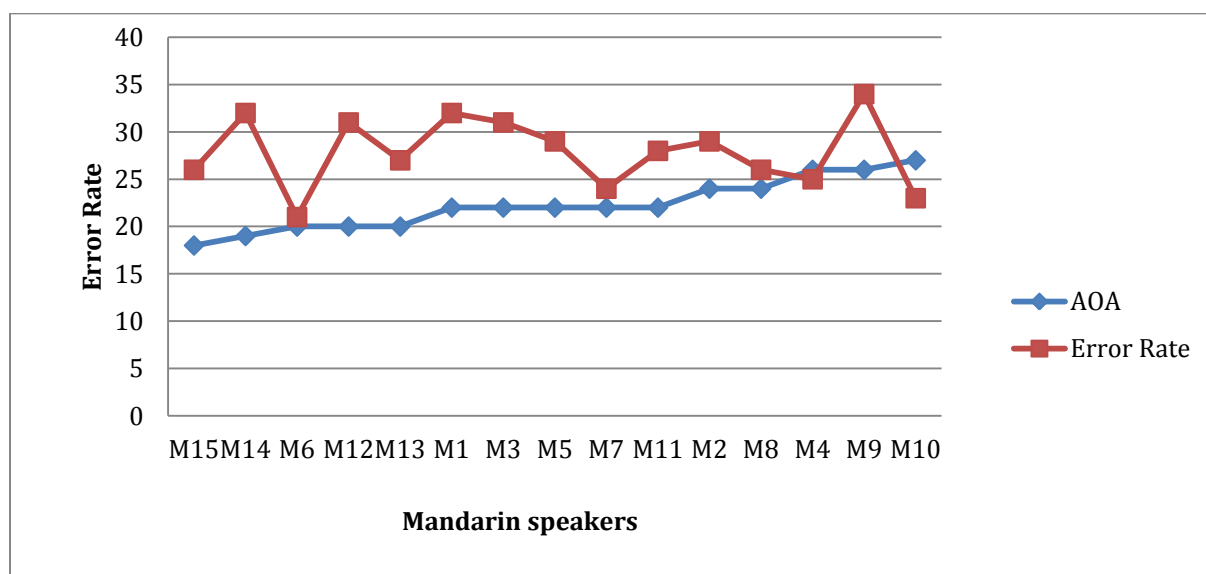


Figure 3.10. Age of arrival and error rate of the production of Mandarin speakers.

Figure 3.11 shows the error rates that are averaged out for each age of arrival. The figure shows that as AOA is increasing, the error rate is decreasing.

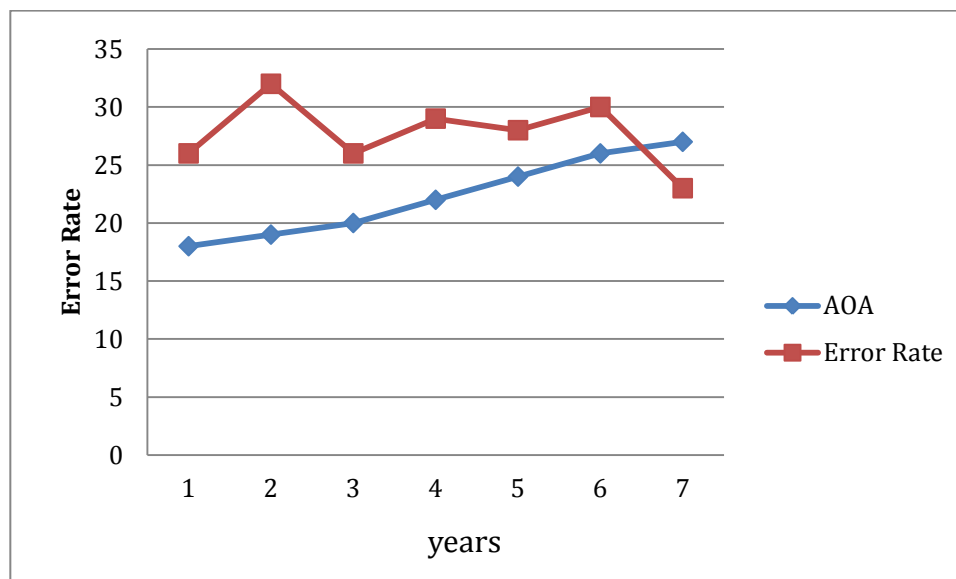


Figure 3.11. Averaged age of arrival and error rate of the production of Mandarin speakers.

The figure shows a negative correlation, which is confirmed with statistic calculation. The correlation between AOA and error rate is: $r(15) = -0.33$. This suggests that the higher the age of arrival, the lower the error rate, a result that goes against the general understanding that the reverse is true. An explanation for this seems to be that subjects' ages were all 18 or older. Perhaps, the younger the age of arrival, the better is only a factor when the learner's age is younger than 18 years.

3.2 Experiment 2

Experiment 1 aimed to find out how correctly Mandarin speakers could produce English vowels and whether the differences between L1 and L2 vowel system had an influence on Mandarin speakers' production of the English vowels. It was not clear whether the results of Experiment 1 were related to Mandarin speakers' perception of English vowels. Experiment 2 was conducted to examine how the production of English vowels by Mandarin speakers was related to the perception.

It was often assumed that good perception preceded good production (Flege, 1997) and that failure to produce an L2 sound tended to reflect the lack of a good perceptual representation for that sound. Therefore, it was expected that the accurate production might not guarantee the accurate perception of L2 sounds. For Experiment 2, it was hypothesized that the Mandarin speakers' performance in producing English vowels reflected their performance in perceiving English vowels, as the perception and production were interdependent (Best, 1995). That is to say: the lower or higher the error rate of production of English vowels by Mandarin speakers should reflect the lower or higher error rate of perception of English vowels by Mandarin speakers.

3.2.1 Methods

3.2.1.1 Participants

The same 15 native Mandarin speakers who participated in Experiment 1 participated in Experiment 2 as listeners.

3.2.1.2 Materials and procedures

Recordings produced by the native English speakers in Experiment 1 were used as listening material (10 English vowels x 5 speakers). The words for identification were printed in an answer sheet (the same answer sheet used in Experiment 1) with the final consonant in braces: bea (t), /i/; be (t), /ɛ/; bai (t) /e/; bo (t), /ɔ/; bi (t), /I/; ba (t), /æ/; boo (k), /ʊ/; boo (t), /u/, boa (t), /o/; and bu (t), /ʌ/. The listeners were each asked to circle the word that he/she heard on the answer sheet. Five samples (randomly selected) were given before this task to ensure that the subjects were familiar with the instructions. The listening task was carried out in the same room used in Experiment 1 immediately after Experiment 1.

3.2.2 Results

Table 3.8 shows the error rate in the 15 Mandarin listeners' identification of the 10 English vowels produced by the 15 native English speakers.

Table 3.8

Error Rate (%) in the 15 Mandarin Listeners' Identification of the 10 English Vowels
Produced by the 15 Native English Speakers

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	Mean
/i/	11	25	40	35	5	20	20	4	0	10	0	5	15	20	10	15
/ɛ/	25	30	45	20	33	18	55	18	15	5	18	35	15	40	15	26
/e/	40	35	25	45	50	40	25	20	35	26	55	57	30	35	20	37
/ɔ/	10	20	10	30	35	30	15	10	10	20	0	5	20	40	30	19
/I/	30	10	40	5	30	20	40	28	40	15	5	20	20	35	10	23
/æ/	20	35	17	20	40	0	5	10	0	30	2	35	25	15	15	18
/ʊ/	50	55	40	20	60	50	65	55	30	40	35	55	50	45	40	46
/u/	30	15	10	5	15	20	25	40	20	10	25	20	10	10	5	17
/ʌ/	20	10	0	5	20	10	0	5	10	15	20	25	15	5	10	11
/o/	10	15	20	5	10	15	20	25	30	20	15	10	5	20	0	15
Mean	23	24	25	16	30	20	27	22	17	18	13	23	19	26	15	

Figure 3.12 shows the order of the error rate in the Mandarin speakers' perception of the English vowels. If 70% is regarded as the rate at which a vowel is correctly identified, Figure 3.12 shows that the success rate is high for the Mandarin speakers' identification of the English vowels.

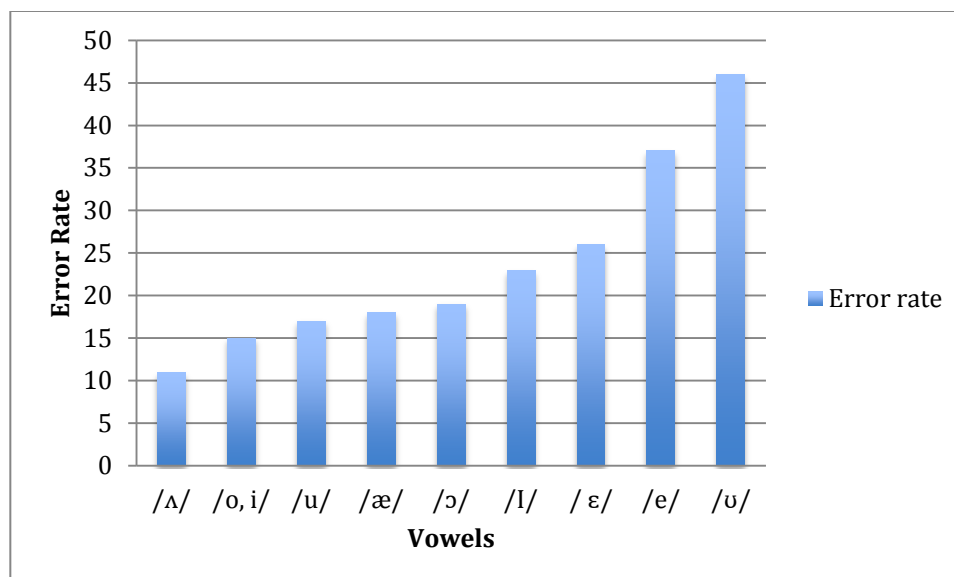


Figure 3.12. Mean error rate of perception of English vowels by Mandarin speakers.

Eight of the 10 English vowels /ʌ, i, o, u, æ, ɔ, ɪ, ɛ/ were all correctly identified by the Mandarin speakers. Among the eight, the best-identified English vowel was /ʌ/ (with an error rate of 11%), followed by /i/ (15%) and /o/ (15%). The vowels /u, æ, ɔ/, which had an error rate of 17%, 18%, and 19%, respectively, were similarly correctly identified, followed by /ɪ/ and /ɛ/, which had error rates of 23% and 26%, respectively.

Two vowels, /ʊ/ and /e/, were not correctly identified with the least correctly identified being /ʊ/, which had an error rate of 46% and the second least correctly identified English vowel /e/, which had an error rate of 37%.

The confusion matrix (Table 3.9) of these vowels is given below:

Table 3.9.

Confusion Matrix (%) for Mandarin Speakers' Perception of English Vowels.

	/i/	/ɛ/	/e/	/ɔ/	/ɪ/	/æ/	/ʊ/	/u/	/ʌ/	/o/
/i/	85		20		3	2				
/ɛ/	1	74	15		10	12			1	
/e/	2	5	63		8	2				
/ɔ/			1	81					5	10
/ɪ/	12	6			77	2				
/æ/		15	1	4	2	82				
/ʊ/							54	12		
/u/							42	83		
/ʌ/				10			2		89	5
/o/				5			2	5	5	85

According to the data, /e/ was perceived correctly only 63% of the time. The confusion matrix revealed that /e/ was perceived as /i/ (20%) and as /ɛ/ (15%). The other incorrectly identified vowel was /ʊ/, which was correctly identified only 54% of the time and was mistakenly identified primarily as /u/ (42%).

The Mandarin listeners' error rates varied considerably, and the range of the error rates was from 0% to 65%. On some of the vowels, the rates varied greatly. For instance, for the English speakers' production of /i, ɔ, æ/, the best-performing Mandarin listener received an error rate of 0%, while the worst performed received an error rate of 40%. M10 obtained the lowest error rate in /ɛ/, which was 5%, 40% lower than M4, who received the highest error rate. Similarly, for /ɪ/ the lowest error rate was 5% (M4 and M11) while the highest was 40% (M3 and M9). For the English speakers' production of /e, ʊ, u, ʌ, o/, the individual differences were relatively less obvious. The lowest error rate in identifying the English speakers' production of /o/ and /ʌ/ was 0% while the

highest rates were 30% and 25%, respectively. The lowest error rate for /u/ was 5% while the highest was 30%. However, the lowest error rates for the English speakers' production of /e/ and /ɔ/ were both 20%, and highest were 57% and 65%, respectively.

Figure 3.13 presents the error rates in the English vowel perception by individual Mandarin listeners.

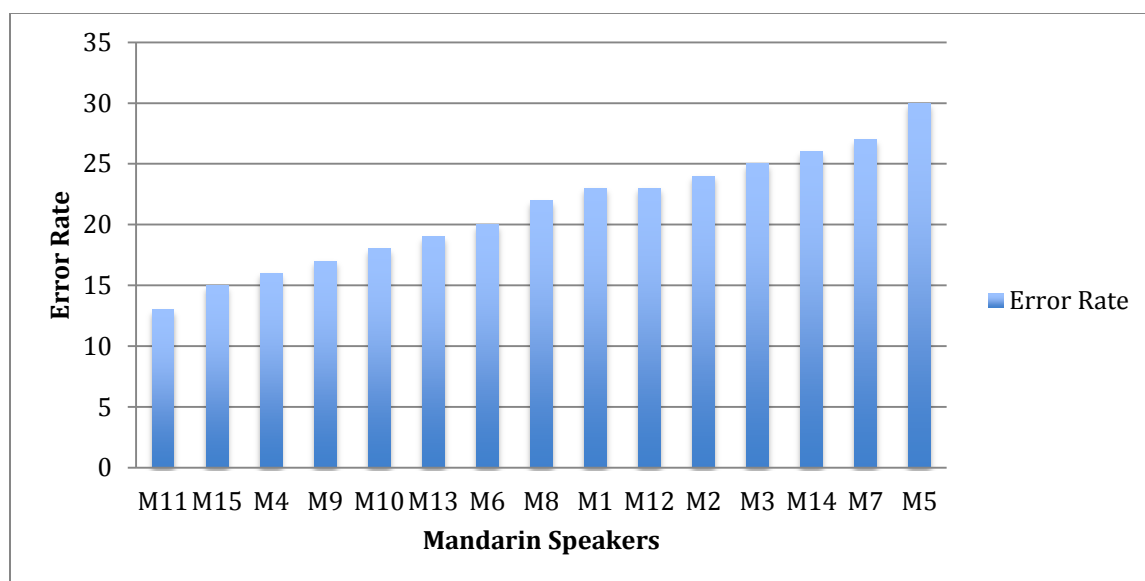


Figure 3.13. The error rate in the English vowel perception by individual Mandarin listeners.

The average error rate of the 15 Mandarin speakers' English vowel perception was 21.2%. There were considerable differences among listeners regarding the mean error rates of identification. The lowest error rate among 15 Mandarin listeners was 13% (M11). There was not much difference in the average error rate of identification from the second to the seventh speaker. M15 received an error rate of 15%, which was the second lowest. Following this, M4, M9, M10, M13, and M6 obtained error rates of 16%, 17%, 18%, 19%, and 20%, respectively. The eighth speaker (M8) received an error rate of

22%, 1% lower (23%) than the ninth (M12) and tenth (M1) speakers. The error rate of the next four speakers did not differ much either. The eleventh to fourteenth Mandarin speakers (M2, M3, M14, and M7) received error rates of 24%, 25%, 26% and 27%, respectively. The highest error rate among the 15 Mandarin speakers was 30% (M5).

The 15 Mandarin listeners had the highest error rates in identifying /ʊ, e/. Among the listeners, nine Mandarin listeners performed worst on /ʊ/, with the error rates ranging from 40% to 60%. Four obtained the highest error rates in /e/, ranging from 40% to 57%. There were Mandarin listeners who were able to identify all productions of certain vowels correctly. Two listeners (M9 and M11) identified the English speakers' production of /i/ correctly. And two listeners (M6 and M9) received 0% error rate in identifying the English vowel /æ/. M3 and M6 each identified all English speakers' production of /ʌ/ correctly. M11 identified the English vowel /ɔ/ all correctly, and M15 had 0% error rate in identifying /o/.

There were also considerable listeners' differences observed in the overall perception rates. No listener performed best on all ten English vowels. The listener (M11) who had the lowest average error rate heard /i/ and /ɔ/ correctly. And, M5, who had the highest error rate, did not perform worst on every vowel.

3.2.3 Discussion

A great deal of recent research has studied the perception of vowels in a second language (Flege, 2005). In many but not all instances, adults who learned a second language have been shown to perceive differently than monolingual native speakers of the target L2 (Lei, 2007). A number of studies reported that Mandarin learners of

English perceived English vowels with varying degrees of accuracy (Wang, 1997, 2007). Wang (1997) studied the identification of five English front vowels /i, I, e, ε, æ/. Among these, /I/ was the best-identified vowel while /e/ was the worst identified vowel. The results from the present study only partially support Wang's study: that is, among these five vowels, /e/ was the worst identified vowel among five front vowels. In Wang's study (1997), only five vowels /i, I, e, ε, æ/ were involved in the identification study while the present study included ten vowels. Limited tokens might contribute to the different results generated from the two studies. Furthermore, the participants were recruited from different regions. Wang's study (1997) involved English speakers from British Columbia to Ontario. While the present study recruited English speakers from British Columbia only. One may postulate that speakers from different regions might show considerable variations in the production of the same vowel, even under the same speaking conditions.

3.2.3.1 /ʌ, i, o, u, æ, ɔ, I, ε/

The results of the Experiment 2 showed that the English speakers' production of /ʌ, i, o, u, æ, ɔ, I, ε/ was correctly identified by the Mandarin speakers in the present study. This result indicates that the Mandarin speakers were able to perceive these vowels fairly correctly. However, the results did not support Wang's findings (2007) which concluded that Mandarin learners had the most difficulties in identifying /ʌ, ɔ/.

3.2.3.2 /ʊ, e/

The English speakers' production of /ʊ, e/ caused identification difficulties for the Mandarin speakers in the present study. It was surprising to note that /e/, which is a

tense vowel, received a higher error rate than other tense vowels that were tested in this study. The results lead to the following question: Why are certain English vowels more difficult for Mandarin learners of English to perceive than others?

Two models of cross-language speech perception have attempted to account for this difference: PAM developed by Best (1997) and colleagues and SLM developed by Flege (1995). Both models, as mentioned in the literature review, stated the degree of success listeners would have in perceiving non-native sounds and concluded that success would depend on the perceived relationship by Mandarin speakers between phonetic elements found in L1 and L2 system. PAM described several patterns of perceptual assimilation of L2 segments to L1 phonological categories, which were determined by perceived phonetic similarity between L1 and L2 segments (Best, 1994, 1995). Flege (1995) claimed that continuing problems with “accented” production of phonetic segments can be attributed in large part to L2 learners’ representation of the L2 segments as equal to similar segments in L1. That is to say, L2 phones, which were perceptually distinct from any L1 category, were not assimilated to an L1 category. With experience, these L2 phonetic segments were represented as distinct from all L1 categories and were produced and perceived accurately. Further study will be needed to explore the answer.

3.2.3.3 Possible factors that might explain the results

The following paragraphs discuss factors that might have contributed to individual differences in the perceptual test. Table 3.10 shows the individual differences and the error rate of identification of English vowels by Mandarin speakers.

Table 3.10

Individual Information and Error Rate of Perception for Each Mandarin Speaker

Speaker	Age	Years of English learning	Age when ESL learning starts	Age of arrival	Length of residence	Error rate of perception
M1	24	15	9	22	2	23%
M2	26	18	8	24	2	24%
M3	25	16	9	22	3	25%
M4	28	16	12	26	2	16%
M5	25	16	9	22	3	30%
M6	24	16	8	20	4	20%
M7	26	17	9	22	4	27%
M8	27	18	9	24	3	22%
M9	30	18	12	26	4	17%
M10	35	23	12	27	8	18%
M11	28	19	9	22	6	13%
M12	24	16	8	20	4	23%
M13	23	14	9	20	3	19%
M14	22	13	9	19	3	26%
M15	20	13	7	18	2	15%
Mean	26	17	9	22	4	21%

Length of residence

The following figure provides a visual representation of the error rates relating to LOR.

In Figures 3.14 and 3.15, LOR rates are ranked from the lowest to the highest.

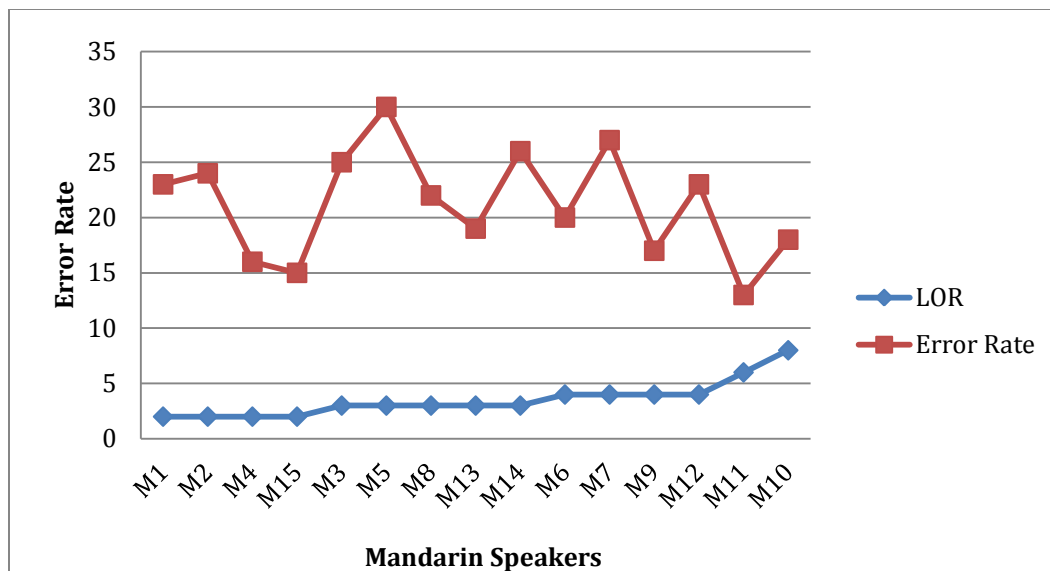


Figure 3.14. Length of residence and the error rates of the perception of Mandarin speakers

Figure 3.15 shows the error rates averaged out for each figure for the length of residence.

It can be seen from the graph that as LOR goes up, the error rate changes accordingly

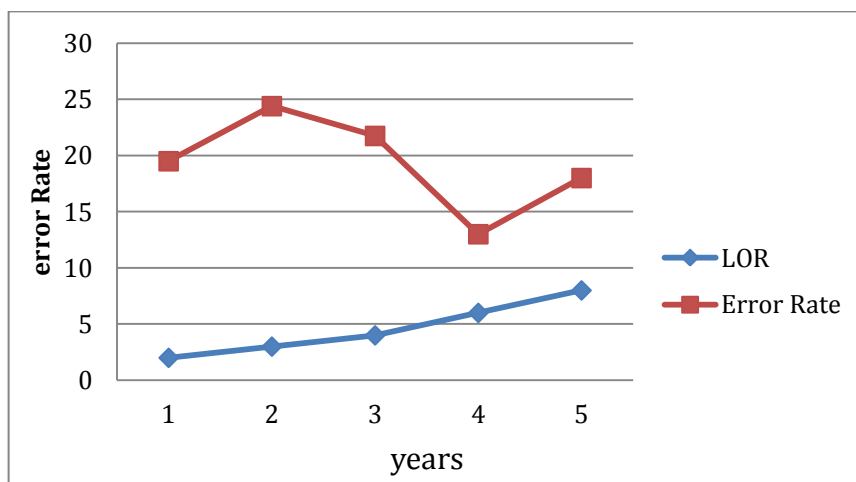


Figure 3.15. Averaged length of residence and the error rate of the perception of Mandarin speakers

The correlation between the LOR and the error rate is $r(15) = -0.57$. This seems to indicate that the longer the length of residence, the lower the error rates. This result is supported by a number of studies that suggested that LOR had an influence on the perception and production of L2 (Flege and Fletcher 1992). The length of residence between three and six years is responsible for the negative correlation ($r(15) = -0.99$) since there is almost a perfect correlation. The result could be interpreted as follows: while L2 speech perception may improve as the length of residence increases, one may expect a more dramatic drop in error rate in L2 speech perception of the L2 after living in the L2 environment for three years.

Years of ESL learning

Figure 3.16 presents the results of the years of the subjects' ESL learning and their error rates in ESL vowel perception.

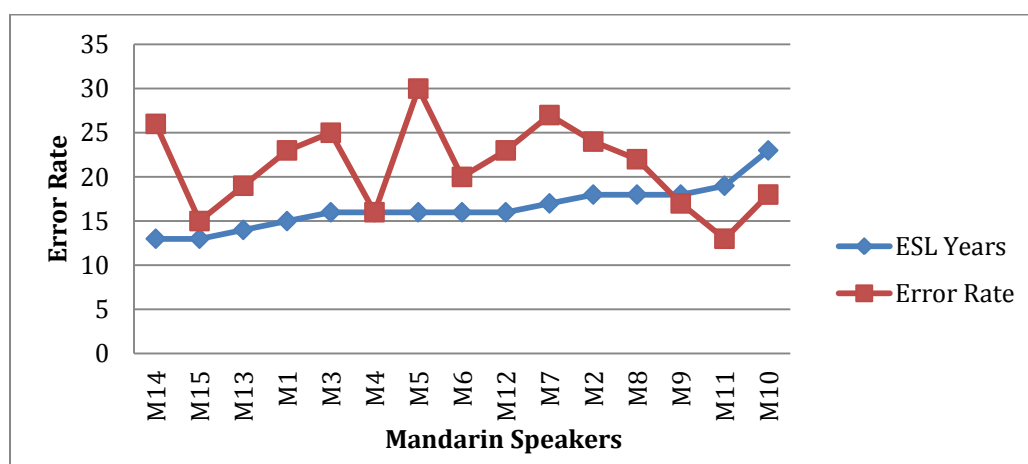


Figure 3.16. Years of ESL learning and the error rate of the perception of Mandarin speakers

In figure 3.16, the ESL learning years of the subjects are arranged from the fewest to the most. Figure 3.17 shows the perception error rates averaged over each number of the ESL years.

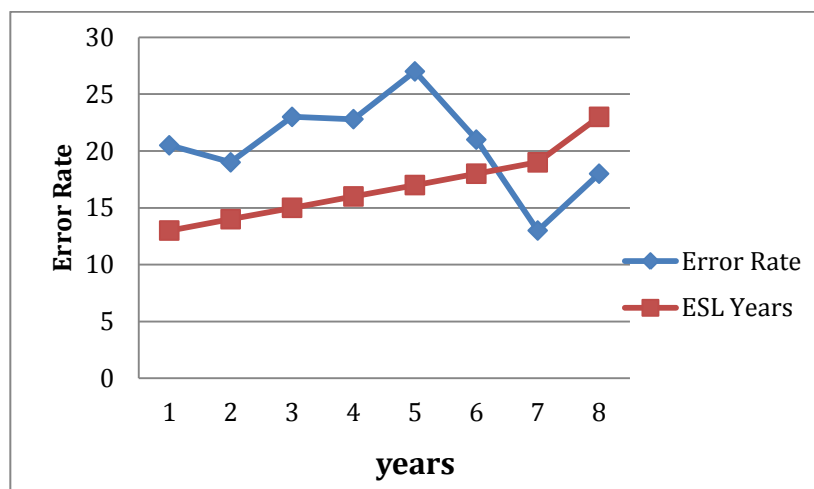


Figure 3.17. Averaged years of ESL learning and the error rate of the perception of Mandarin speakers

A calculation of the correlation between the two sets of numbers shows that there was a correlation between the two variables in a reverse way ($r(15) = -0.49$). This suggests that as years of ESL learning increase, the vowel perception error decreases. Flege and Fletcher (1992) stated that the number of years of English-language learning was a critical factor for L2 accuracy. A closer look at the results shows that there is a perfect negative correlation between the ESL learning years and the error rates between years 17 and 19 ($r(15) = -1$). This could suggest that an ESL learner might expect a drop in error rate in their perception of ESL speech once he/she has been learning English for 17 years.

Age when ESL learning starts

Figure 3.18 presents the results of the age when the subject started ESL learning and their error rates in ESL vowel perception.

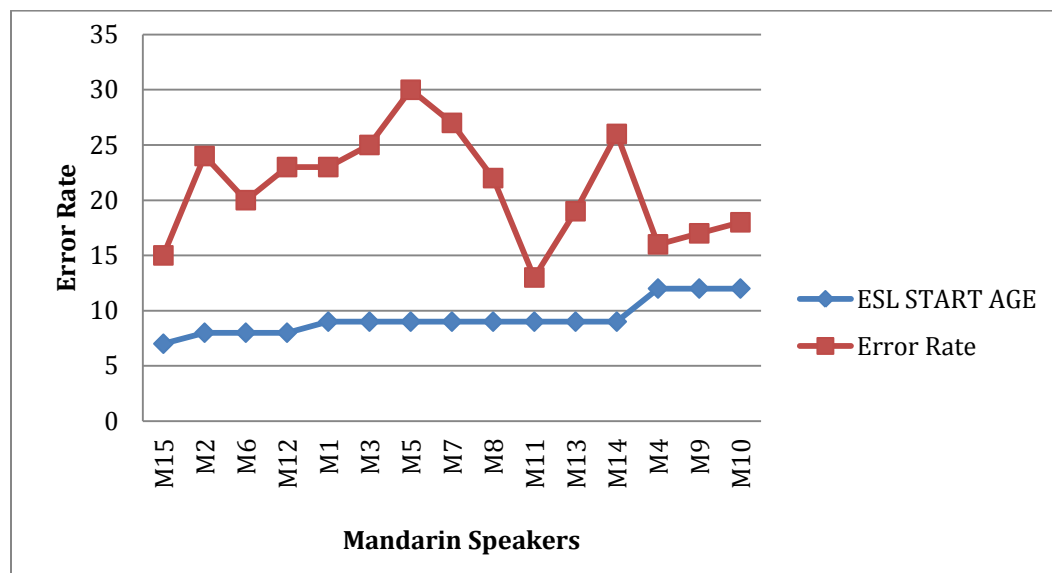


Figure 3.18. Age when ESL learning starts and the perception error rate of individual Mandarin speakers

Figure 3.19 indicates the error rates that are averaged out for each age of ESL start.

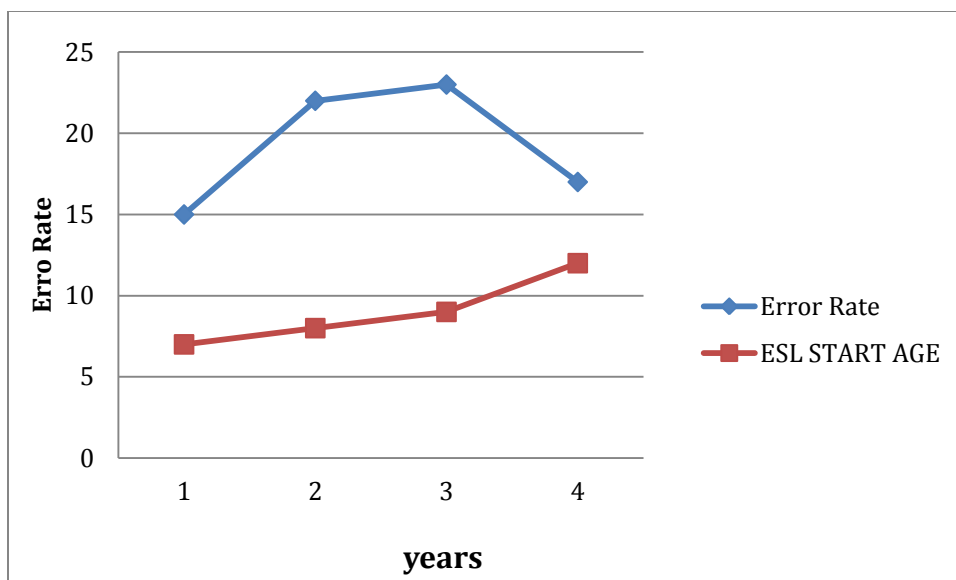


Figure 3.19. Averaged age when ESL learning starts and the error rate of the perception of Mandarin speakers

The correlational analysis shows a weak reverse correlation between the age when ESL learning starts and the error rates ($r = -0.05$). This result seems to suggest that the age when ESL learning starts is not a main factor in the prediction of the vowel perception error rates. This result is contrary to a number of studies (Flege et al., 1999; Moyer, 1999), which concluded that the earlier one learned an L2, the better vowels could be perceived and produced.

Age of arrival

Figure 3.20 presents the results of the ages when the subjects arrived in Canada and their error rates in ESL vowel perception.

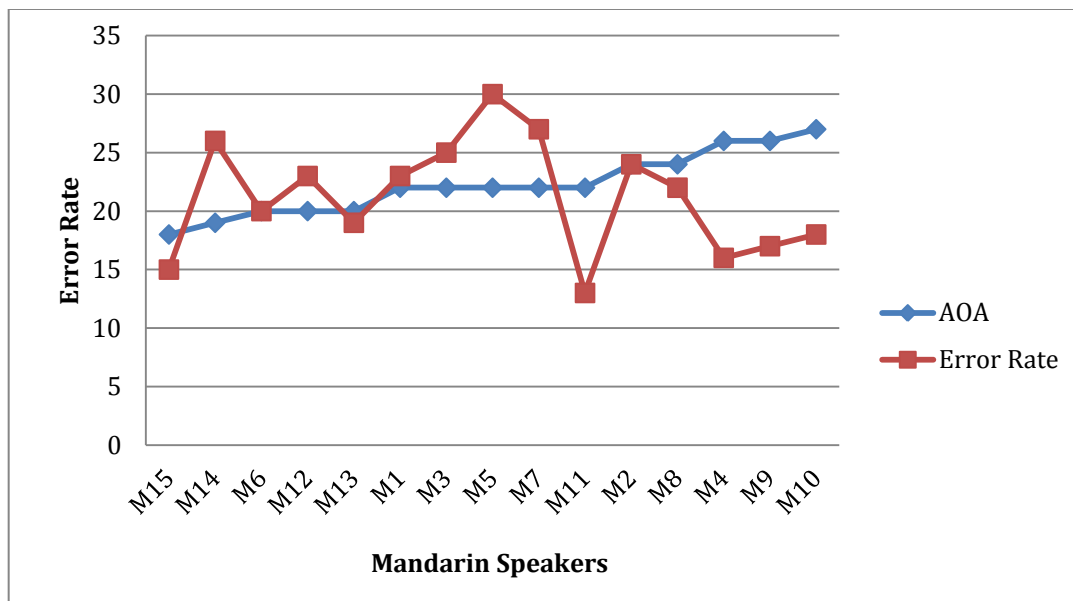


Figure 3.20. Ages of arrival (AOA) and the error rates of the perception of individual Mandarin speakers

Figure 3.21 shows the error rates that are averaged out for each age of arrival.

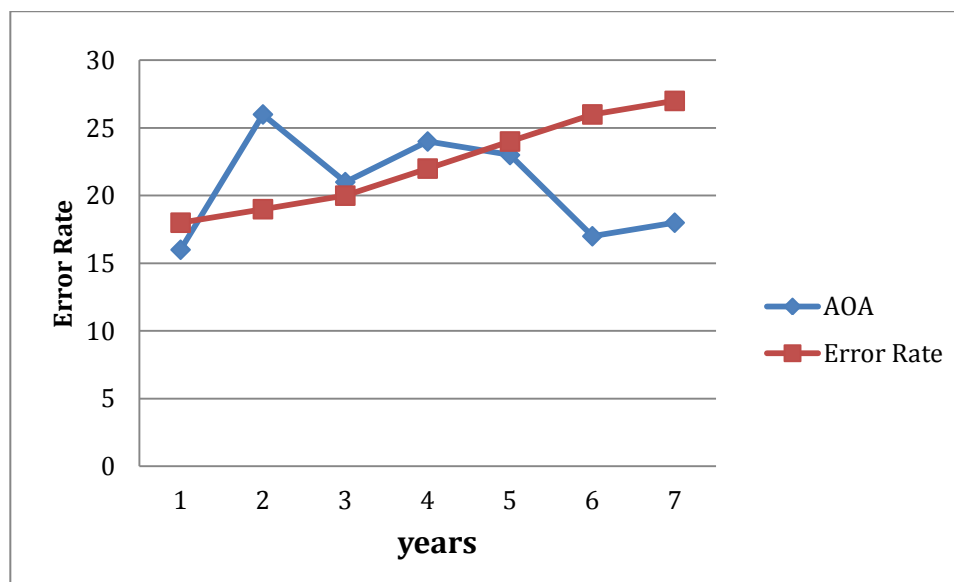


Figure 3.21. Averaged ages of arrival and the error rates of the perception of Mandarin speakers.

The correlational analysis between the two variables showed a mild negative correlation: $r(15) = -0.29$. Like the results involving age of arrival in the production test, this result does not support the younger the better hypothesis, since the results from the present study show the older the age of arrival the lower the error rate. The vowel production result may suggest that the subjects in this study were all 18 years or older. Since the subjects are all 18 years or older, they have long passed the critical age at which age of arrival would be expected to play a major role.

This study provides some evidence that those adults who learn L2 would likely perceive certain vowels in L2 more accurately as they gain experience in L2 (Flege, 1997).

3.3 Comparison between the Experiment 1 and Experiment 2

This study has revealed some discrepancies between the Mandarin speakers' production and perception of the ten English vowels. The results of production are not consistent with the results of perception; the perception study matches the production results. The English vowels /i, e, o, u, / better produced by the Mandarin speakers are not all perceived correctly, and the better-perceived English vowels /ʌ, i, o, u, æ, ɔ, ɪ, ε/ are not all produced correctly by the Mandarin speakers. Figure 3.22 shows the error rates of the production and the perception of ten English vowels by Mandarin speakers.

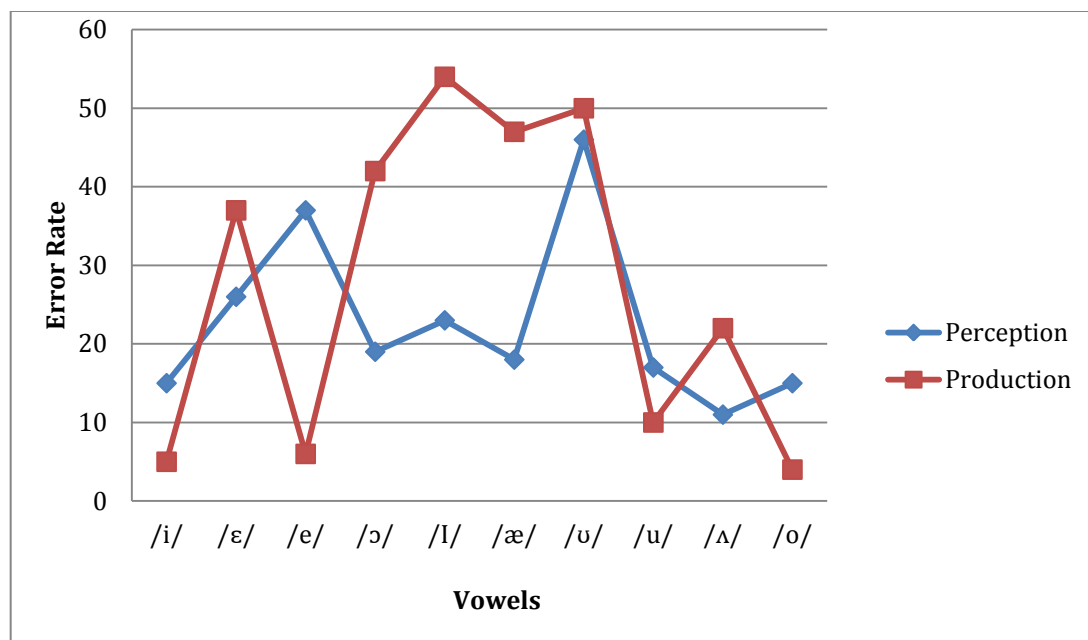


Figure 3.22. The error rates of the production and the perception of the ten English vowels by Mandarin speakers

Overall, the mean error rate of English vowels perceived by Mandarin speakers is lower than that of English vowels produced. In other words, ESL vowel perception is better than ESL production by the Mandarin speakers.

Figure 3.23 has the production error rates arranged from the vowel with the lowest error rate to the vowel with the highest error rate.

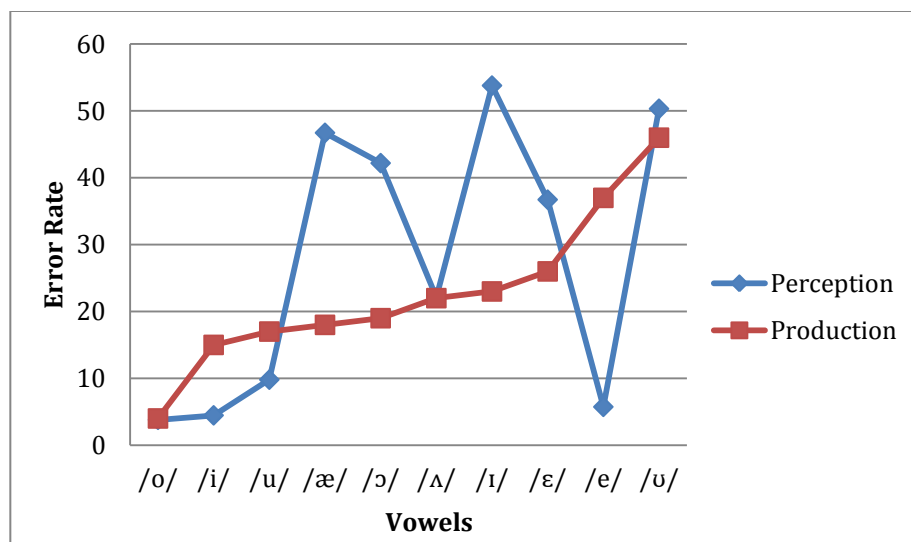


Figure 3.23. The production error rate and the perception error rate of each English vowel

Figure 3.24 has the vowel perception data arrange from the vowel with the lowest perception error rate to the vowel with the highest perception error rate.

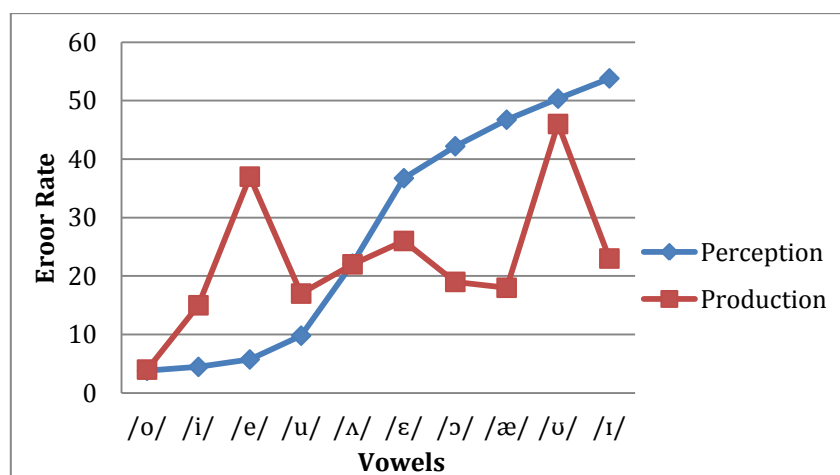


Figure 3.24. The production error rate and the perception error rate of Mandarin speakers

It is clear from the two figures that perception and production are not identical. The current research does not support the view that production and perception are always

aligned so that perception never surpasses or precedes production and vice versa (Flege, 1997).

3.3.1 Discussions of vowels

/u/, /i/, and /o/

The error rates of the production and the perception of /u, i, o/ (see table 3.7 and table 3.10) are quite low, indicating that the Mandarin speakers are able to both perceive and produce these vowels correctly.

/ʊ/

In contrast, the error rate of the production and the perception of /ʊ/ (see table 3.7 and table 3.10) is quite high, showing that Mandarin speakers in the study have difficulties in both producing and perceiving this vowel.

/ɛ, ɔ, ɪ, æ, ʌ/

A comparison of both experiments indicates that Mandarin speakers in the study are able to better perceive English vowels /ɛ, ɔ, ɪ, æ, ʌ/ (see table 3.7 and table 3.10) than to produce them. The error rate of the production of these vowels is much higher than that of the perception.

/e/

A different trend is shown in the production and the perception of English vowel /e/ (see table 3.7 and table 3.10). Mandarin speakers are able to produce this vowel better than they perceive it.

3.3.2 Conclusion

The confusion matrix of the production and perception of English vowels has shown some significant discoveries.

- The production of /i/ by Mandarin speakers is misidentified as /I/ and /ε/. In the perception test, Mandarin speakers in this study also misidentify English speakers' production of /i/ as /I/ (12%) and /ε/ (1%). The Mandarin speakers' production of /I/ is identified as /i/ and /ε/ while Mandarin speakers also have difficulties in distinguishing /I/ from /i/ or /ε/.
- The Mandarin speakers' production of /ɔ/ is mostly misidentified as /o/ and /ʌ/ and Mandarin speakers mostly misidentify /ɔ/ as /o/ and /ʌ/ as well.
- The Mandarin speakers' production of /æ/ is mostly heard as /ε/ and majority of /æ/ is misidentified as /ε/ as well. It is the same case for /u/.
- There were exceptions. Although most Mandarin speakers' production of /ʊ/ is identified as /o/, the majority of Mandarin speakers perceive /ʊ/ as /u/.

The results of these two experiments show that the relationship between the perception and the production cannot be explained in a straightforward way. Good production cannot guarantee good perception and vice versa.

One interesting finding is that the perception of all lax vowels (except /ε/) is better than the production of these vowels, and the production of all tense vowels is better than the perception of these vowels.

According to the Speech Learning Model (Flege, 1995), phonetic segments in an L2 could be produced in a native-like fashion only if they were perceived in a native-like fashion. However, the results of the present study do not support this. If L2 vowel

production is limited by L2 vowel perception accuracy, then the Mandarin speakers in this study should have a higher error rate of the production of /e/, as they have a higher error rate of identifying this vowel. And, Mandarin speakers should have a lower error rate of production of /ʌ/ as they have a lower error rate of perception.

Bradlow et al. (1997) concluded that perceptual learning was not a “necessary or sufficient condition” for improved production (p. 2307), which may lag behind perceptual changes. If some perceptual changes were never “transported” to production, this might explain the lack of perfect correlation between the production and perception observed in the present study.

Until now, there have been very few studies regarding Mandarin speakers’ production and perception of English vowels. This study provides significant data and analysis about Mandarin speakers’ ability to correctly produce and perceive certain English vowels, (/i/, /ɪ/, /ε/, /æ/, /ʊ/, /u/, /ʊ/, /ɔ/, /o/, and /ʌ/). A key strength of this study is the use of a large number of English vowels and its examination of the relationship between the perception and production of English vowels by Mandarin speakers. In addition, the study also provides the identification rate of English vowels produced by English speakers. Previous studies regarding L2 vowels perception have been carried out without involving production tests or vice versa. The present study avoids this drawback by including both the perception and the production tests. Furthermore, the assumption that the production has a perceptual basis is not fully supported by the conclusions of the present study. Blankenship (1991) reported that ESL learners produced L2 vowels without being able to perceive them accurately. The results of the current study partially

support this, as no firm conclusion can be made regarding the relationship between production and perception. More studies are needed to further examine the issue.

While the previous study is limited by overlooking the speakers' differences, the current study examines the individual variations in both experiments. The current study contributes to the field through examination of key variables in order to minimize such drawbacks.

With regard to the second language segmental learning, As Flege (1995) stated, the greater experience with the L2 sound resulted in more accurate L2 segment production, and many segmental production errors may have a perceptual basis. The results suggest that there are considerable inconsistencies in the success between Mandarin speakers' production and perception of the ten English vowels tested. The expectation that accurate production of L2 sounds has a clear perceptual basis is not supported by this study. The experiments conclude that the perception and the production patterns may be related to the tenseness or laxness of the vowel. The tendency for lax vowels to be confused with a nearby tense vowel can be seen in the Mandarin speakers' production of the lax vowel /ʊ/. This may be due to the fact that Mandarin speakers had no linguistic cue to rely on to produce these "new vowels."

Overall, native English speakers' vowels were better identified by the four English listeners than those of Mandarin speakers. Several factors may help to explain the results. The conclusions of both experiments have stated that LOR, age at which ESL learning started, number of years of ESL learning, and AOA correlate with the results of the perception and production results. This study has provided evidence that those adults who learn L2 would come to perceive certain vowels in L2 more accurately as they gain

experience in L2. However, this study also has a number of limitations. First, the size of the subject population is too small. Thus any generalization about the results of the study is limited to the subjects only. Further studies should involve a larger sample size to validate the findings. Second, the subjects were only experienced English learners. Further studies may involve recruiting inexperienced ESL learners. Third, acoustic analysis was not included in this study. To better understand the difference between the native and non-native production of English, acoustic analysis of the results may shed more light on the matter. Fourth, the present research was primarily a qualitative study, and no serious statistic analysis was conducted. Future studies with a much larger population may look into the interaction of the different factors through carefully conducted statistical analysis.

3.3.2.1 The pedagogical implication

It is a concern that the production of ESL learners on L2 does not match the input in several ways. The foreign-accent may be attributable to the incomplete acquisition of the segmental and prosodic aspects of the L2 phonological system (Major, 2001). The present study found that L2 experiences play a role in the accuracy of the production and the perception of Mandarin participants. The exposure to the second language environment related to the variables (e.g., LOR, AOA) may help with language learning. The study also found that there are certain vowels that are much easier than others to confuse with other vowels. Therefore, for ESL learners, it is important to not only learn the pronunciation of English segments, but also to know the differences between second

language segments. They should also be aware of the difference between first language segments and second language segments. The comparison of the articulatory movement between the ESL learners and native speakers should be provided so that ESL learners can pronounce English words more accurately. A key pedagogical implication is borne out from the present study: the differences between segments and segmental pronunciations in the second language should be taught and learned.

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Appendices

Appendix 1 Language Background Questionnaire

Note: All information will be kept confidential and participants may choose not answer all questions.

1 Name _____ 2 Phone _____ 3 Age _____

4 Birthplace _____ The place you grew up _____

5 Gender _____ 6 Length of residence in Canada _____

7 Age of arrival (Canada) _____

8 Is your hearing normal? _____

9 Native language _____ (Mandarin or other dialects in China)

10 Other languages spoken fluently _____

11 Age at first exposure to English _____ Years of learning
English _____

12 IELTS Score _____ IELTS Speaking Score _____

13 How would you rate your pronunciation?

1 2 3 4 5 (strong accent----native-like)

14 How often do you use English in your daily life?

1 2 3 4 5 (never----use ONLY English)

15 How often do you use your Native Language in your daily life?

1 2 3 4 5 (never----use ONLY native language)

Appendix 2

Answer Sheet

Name _____

- 1 bea(t) /i/ be(t) /ε/ bo(t) /ɔ/ bi(t) /I/ ba(t) /æ/ boo(k) /ʊ/ boo(t) /u/
boa(t) /o/ bu(t) /ʌ/
- 2 bea(t) /i/ be(t) /ε/ bo(t) /ɔ/ bi(t) /I/ ba(t) /æ/ boo(k) /ʊ/ boo(t) /u/ boa(t) /o/
bu(t) /ʌ/
- 3 bea(t) /i/ be(t) /ε/ bo(t) /ɔ/ bi(t) /I/ ba(t) /æ/ boo(k) /ʊ/ boo(t) /u/ boa(t) /o/
bu(t) /ʌ/
- 4 bea(t) /i/ be(t) /ε/ bo(t) /ɔ/ bi(t) /I/ ba(t) /æ/ boo(k) /ʊ/ boo(t) /u/ boa(t) /o/
bu(t) /ʌ/
- 5 bea(t) /i/ be(t) /ε/ bo(t) /ɔ/ bi(t) /I/ ba(t) /æ/ boo(k) /ʊ/ boo(t) /u/ boa(t) /o/
bu(t) /ʌ/
- 6 bea(t) /i/ be(t) /ε/ bo(t) /ɔ/ bi(t) /I/ ba(t) /æ/ boo(k) /ʊ/ boo(t) /u/
boa(t) /o/ bu(t) /ʌ/
- 7 bea(t) /i/ be(t) /ε/ bo(t) /ɔ/ bi(t) /I/ ba(t) /æ/ boo(k) /ʊ/ boo(t) /u/ boa(t) /o/
bu(t) /ʌ/
- 8 bea(t) /i/ be(t) /ε/ bo(t) /ɔ/ bi(t) /I/ ba(t) /æ/ boo(k) /ʊ/ boo(t) /u/ boa(t) /o/
bu(t) /ʌ/
- 9 bea(t) /i/ be(t) /ε/ bo(t) /ɔ/ bi(t) /I/ ba(t) /æ/ boo(k) /ʊ/ boo(t) /u/ boa(t) /o/
bu(t) /ʌ/
- 10 bea(t) /i/ be(t) /ε/ bo(t) /ɔ/ bi(t) /I/ ba(t) /æ/ boo(k) /ʊ/ boo(t) /u/ boa(t) /o/
bu(t) /ʌ/