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English Vowel Discrimination and Assimilation by Chinese-Speaking Learners of English

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The tense-lax vowel contrast, which is present in English but not in Mandarin, has been extensively studied in the interlanguage phonology for Chinese-speaking learners of English. Much research has been dedicated to this language production, but few studies focus on L2 learners' discriminatory and assimilatory patterns of English vowels. Experiment 1 of this study investigated Chinese-speaking learners' English vowel discrimination. Experiment 2 examined how these learners classified English vowels and assimilated them to Mandarin phonetic categories. The current findings, though supporting the Speech Learning Model (Flege 1995), were in disagreement with the Perceptual Assimilation Model (PAM) (Best 1995). To draw on the facts from markedness effects, the researcher argues that the assimilatory patterns between L1-L2 segments in PAM may not fully account for the perception saliency hierarchy and suggests one tri-dimensional model for interpreting L2 vowel perception.

Keywords: English vowels, speakers of Mandarin Chinese, Speech Learning Model, Perceptual Assimilation Model

1. Introduction

In the field of second language acquisition (SLA), the essential role of vowels in English pronunciation cannot be overemphasized (Celce-Murcia, Brinton, and Goodwin 1996). As Prator and Robinett (1985:13) note, a language learner must learn to "distinguish and make the distinction among the vowel sounds with great accuracy if s/he wishes to understand and be understood in English." Nonnative speakers, however, are often found incapable of pronouncing or perceiving English vowels in a native-like way. Especially, contrasts of tense and lax vowels, which are present in English but not in Mandarin Chinese, have been extensively studied in the interlanguage phonology for Chinese-speaking EFL (English as a foreign language) learners. During the past decades, much research has been dedicated to the English language production of native speakers of Mandarin Chinese (Chen, Robb, Gilbert, and Lerman 2001, Chen 1999, Dai 2000, Flege, Bohn, and Jang 1997, Luo 2002, Teng 2002). In these studies, Chinese speakers often confuse and mispronounce English tense/lax vowel pairs as identical segments. Such failure to distinguish between these contrasts may result in misunderstandings when they converse with native English speakers.

So far, little substantial evidence is provided for discrimination and assimilation of English vowels by Chinese speakers. To what extent they assimilate English vowels to their L1 segments and in what direction they misperceive English vowels have been

neglected. No account of their errors is made from the perspective of recent perceptual models developed from European languages, including the Speech Learning Model (SLM) (Flege 1995) and the Perceptual Assimilation Model (PAM) (Best 1995). The former (SLM) refers to L1-L2 segment inventories and adopts the terminology of "similar/old sounds" and "new sounds" in interpreting speech learning. Most L2 learners fail to articulate or discriminate some non-native contrasts because they interpret them as being equivalent, that is, the "Similarity Effect" (Flege 1987, 1988, 1995). The latter (PAM) posits that L2 learners perceptually assimilate non-native contrasts to L1 phonetic categories, and that non-native perception is often filtered by linguistic experience. PAM resembles SLM in that both consider the perceived relation between L1 and L2 sounds to be an important role in cross-speech acquisition. Different from SLM, PAM argues for a range of crosslanguage mapping patterns for predicting discrimination possibility of non-native sounds by classifying sounds into categorized types and uncategorized types. To what extent Chinese-speaking EFL learners follow these two models' predictions and to what extent the assimilatory patterns between L1 and L2 categories influence accurate perception of L2 segments await further investigation.

The present paper is dedicated to the extent to which Chinese-speaking EFL learners in Taiwan differentially discriminate English vowels and to which they classify English vowels as similar or new tokens. Two perception experiments were conducted. Experiment 1 examined Taiwanese EFL learners' English vowel discrimination. How learners discriminated English vowel pairs and which pairs posed the greatest challenges for them were addressed. Experiment 2 investigated the assimilatory patterns between English vowels and Mandarin Chinese categories. The EFL learners were asked to classify English vowels as similar or new tokens and to transcribe these vowels with Mandarin Chinese phonetic symbols (i.e., *Zhuyin Fuhao*[1]) or with IPA notations.[2] How the learners' perceptual assimilation influenced their performance in English vowel discrimination was elaborated. Also of interest is the feasibility of the two models, SLM (Flege 1995) and PAM (Best 1995), in the EFL context in Taiwan. To what extent these models account for these EFL learners' English vowel perception is discussed.

2. Literature review

In this section, some related theories and research are surveyed to provide some

[1] *Zhuyin fuhao* (Table 1) is a phonetic system used in Taiwan to teach Mandarin. Participants in the current study, who were all Mandarin speakers in Taiwan, learned this system in elementary school.

[2] The corresponding IPA notations (Table 1) were also offered on the test sheet. The listeners were free to transcribe English vowels either with Mandarin *Zhuyin Fuhao* or with IPA notations.

theoretical support for the current study. The literature review especially focuses on a phonological comparison between Mandarin and English vowels. Recent second/foreign language research of vowel perception is also discussed.

2.1 Phonological comparison among English and Mandarin vowels

According to Ladefoged (2006) and Reetz and Jongman (2009), the American English vowel system is composed of eleven monophthongs (/i, ɪ, ɛ, æ, ɑ, ɔ, ʊ, u, ʌ, ɝ, ə/) and five diphthongs (/ej, ow, aɪ, aʊ, ɔɪ/).[3] Based on features of tongue articulation, vowels can be categorized into four subgroups: [i] (high-front), [æ] (low-front), [u] (high-back), and [a] (low-back), revealing four distinct corners in the vocal tract space. In terms of tenseness, English vowels can be divided into tense vowels [i, ej, u, ow] and lax vowels [ɪ, ɛ, ʊ, ɔ] (Ladefoged 2001a, 2001b). In producing tense vowels, the root of tongue is drawn forward and the larynx is lowered. On the contrary, no advancement of the tongue root or a lowering of the larynx is found in lax vowels, which seem shorter and slightly more centralized than their tense counterparts.

Table 1. Mandarin major vowels

IPA notation	[i]	[y]	[o]	[e]	[a]	[u]	[ɤ]	[ei]	[ou]	[ai]	[au]
Zhuyin Fuhao	ㄧ	ㄩ	ㄛ	ㄝ	ㄚ	ㄨ	ㄜ	ㄟ	ㄡ	ㄞ	ㄠ

Note: *Zhuyin Fuhao* = the phonetic symbols used in the Mandarin Chinese segmental system (Chen, Robb, Gilbert, and Lerman 2001, Tung 1994)

Tenseness, however, plays a minor role in vowel inventories of Mandarin Chinese. According to Table 1, Mandarin has seven simple vowels (i.e., [i, e, y, u, o, a, ɤ]) and four major diphthongs (i.e., [ei, ou, ai, au])[4] (Tung 1994, Chen, Robb, Gilbert, and Lerman 2001). According to Luo (2002), five English vowels [i, ej, u, ow, a],[5] that Mandarin and American English share in common, are linguistically referred to as "familiar" or "similar" sounds for Mandarin speakers. By contrast, the remaining six American English vowels [ɪ, ɛ, æ, ʌ, ʊ, ɔ][6] are often viewed as "unfamiliar" or "new"

[3] This study follows Roca and Johnson (1999) to treat /ej/ and /ow/ as homogenous diphthongs, and /aɪ/, /aʊ/, and /ɔɪ/ as heterogeneous diphthongs. The former are close in articulation and share the lip gesture, while the latter may move around the vowel space.

[4] There has long been a controversy in the literature over the actual number of Mandarin vowel inventories (Chao 1980, Tseng 1990, Tung 1994). These seven simple phonemes are the focus of the current study because they are the widely-agreed standard Mandarin vowels in dictionaries and textbooks. Following Tung (1994), the IPA phonetic symbols and *Zhuyin Fuhao* are given in Table 1.

[5] As indicated in Note 3, English vowels [ej] and [ow] are referred to as homogenous diphthongs, making them resemble Mandarin diphthongs [ei] and [ou] to a great degree.

[6] Luo (2002) classified English [ɔ] as an unfamiliar or new sound. But, controversy remains. In Wan

sounds (Luo 2002). Since tenseness does not play a significant role in distinguishing phonemes, native speakers of Mandarin Chinese may encounter extreme difficulty in producing or perceiving some English vowels, which contain the marked, uncommon lax feature.

Such an abstract phonological prediction, however, is not without criticism. Recent perceptual theories claim that the ability to discriminate L2 sounds accurately is linked to the ability to discern differences between the L1 and L2 (Best 1995, 1999, Flege 1995). In western contexts, it has been argued that L2 perception cannot be predicted by an abstract phonological cross-language comparison, but by learners' assimilation results of L1 categories (Cebrian 2007, Lengeris and Hazan 2007). Whether phonological predictions or assimilation predictions hold true for Chinese-speaking EFL learners in Taiwan needs further verification by means of well-designed research.

2.2 Second/foreign language phonology of vowel perception

Native language transfer and universal factors have been extensively identified in explaining production errors made by L2/FL learners in the field of second/foreign language acquisition. Following the language acquisition device in Generative Grammar (Chomsky 1965), the template of Mandarin tense-only vowels has been internalized and further becomes filters when native speakers of Mandarin begin to acquire English as a foreign language (Lado 1957, Weinreich 1953). Consequently, Chinese-speaking learners often tend to mispronounce lax vowels for tense counterparts or fail to distinguish tense/lax contrasts (Chen 1999, Dai 2000, Luo 2002, Teng 2002).

Although much recent research has been dedicated to English production by native speakers of Mandarin Chinese (Chen, Robb, Gilbert, and Lerman 2001, Chen 1999, Dai 2000, Flege, Bohn, and Jang 1997, Luo 2002, Teng 2002), few studies have focused on their perception of English vowels (Luo 2002, Wang 1997). Wang (1997) examined the effect of the L1 vowel system on Mandarin speakers' production and perception of English vowels. Results of the perception test did not support the prediction of positive L1 transfer; that is, Mandarin speakers would be assumed to perform better in their identification of English vowels [i, ej], which had Mandarin analogs, than [ɪ, ɛ, æ], which carried no Mandarin correspondents. Instead, a tendency toward better perception than production was observed for [ɪ, ɛ, æ], and better production than perception for [i, ej].

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and Jaeger (2003), 12 surface Mandarin vowels are identified, /i, y, ɨ, e, ɛ, ə, ɤ, a, ɑ, ɔ, o, u/. It follows that [ɔ] is a sound shared by English and Mandarin.

Luo (2002) conducted an experimental study of English high vowels [i, ɪ, u, ʊ] produced by Mandarin adult speakers. Results showed that Mandarin speakers mainly contrasted similar/new pairs of vowels by length, while English speakers distinguished these pairs by more parameters (i.e., duration and the first two formants). Despite the difficulty in articulating new vowels, Mandarin speakers showed excellent perception of English high vowels in the listening task. Among these above-mentioned studies, Wang (1997) addressed Mandarin Chinese speakers' perception of English front vowels only, and Luo (2002) mainly investigated English high vowels. More research needs to be done to explore Chinese-speaking EFL learners' perception of English tense-lax contrasts.

So far, two recent perceptual models, the Speech Learning Model (SLM) (Flege 1995) and the Perceptual Assimilation Model (PAM) (Best 1995), have not been fully elaborated in the Chinese-speaking EFL context. SLM (Flege 1995) refers to L1-L2 segment inventories and adopts the terminology of "similar/old sounds" and "new sounds" in interpreting speech learning. The labels "new" and "similar" can be assigned only after evaluating listeners' judgments of similarity. Most L2 learners fail to articulate or discriminate some non-native contrasts because they interpret them as being equivalent, that is, the "Similarity Effect" (Flege 1987, 1988, 1995). On the contrary, when a greater dissimilarity between L1 and L2 sounds is perceived, the easier it might be for L2 learners to acquire L2 sounds.

Best (1995, 1999) constructed the Perceptual Assimilation Model (PAM), in which L2 vowel discriminability might improve with increasing L2 experience. It is hypothesized that L2 learners may perceptually assimilate non-native contrasts to their L1 phonemic categories. Discrimination is expected to be excellent when two non-native categories are assimilated to two different native categories. By contrast, poor discrimination occurs when two non-native categories are assimilated to a single native category. Take English tense-lax vowels for example. Since no tense-lax contrast (e.g., [i]-[ɪ]) is found in Spanish, it is assumed that Spanish learners of English would have perceptual equivalence in the case of the English [i]-[ɪ] pair. For native Spanish speakers, these two sounds would usually be assimilated to Spanish [i]. This assumption was later substantiated by Fox, Flege, and Munro (1995), who examined the perception of English and Spanish vowels by native English and Spanish listeners. They concluded that Spanish speakers were incapable of discriminating between English tense/lax vowel contrasts owing to the influence of their native language (e.g., a lack of duration cues in L1 and different spectral cues in the two vowel systems). Besides, PAM has been empirically supported in several studies on the perceptual assimilation of L2 segments by Japanese speakers (cf., Aoyama 2003, Best, McRoberts, and Goodell 2001, Guion, Flege, Akahane-Yamada,

and Pruitt 2000, Lengeris and Hazan 2007, Strange, Akahane-Yamada, Fitzgerald, and Kubo 1998). Most recently, Ho (2009) conducted a perceptual mapping between English and Mandarin front vowels by EFL learners in Taiwan. It was found that L2 new sounds were assimilated to familiar sounds found in the L1 and that these EFL learners' assimilation patterns supported the predictions of the Perceptual Assimilation Model.

To sum up, a limited number of studies have provided both discrimination and assimilation results (cf., Guion, Flege, Akahane-Yamada, and Pruitt 2000, Ingram and Park 1997, Lengeris and Hazan 2007). Also, most studies addressed English front vowels (cf., Ho 2009, Luo 2002); back vowels are frequently ignored in these assimilatory and discriminatory patterns. Furthermore, to what extent Chinese-speaking EFL learners follow the assumptions in current perceptual models and to what extent the perceptual assimilation between L1 and L2 categories influence the accurate perception of L2 segments remain unknown. Inspired by the preceding studies, the present research thus aims to investigate Chinese-speaking EFL learners' perception of English tense/lax distinctions and to elaborate these learners' interlanguage phonology within the perceptual models developed from European languages.

3. Method

In this section, the design of the current research is introduced. Description of the research questions, participants, two perception experiments and data analysis is explicitly presented.

3.1 Research questions

The main purpose of the current study was to investigate how Chinese-speaking EFL learners in Taiwan discriminated and assimilated English vowels.[7] Learners of different English proficiency levels participated in perception experiments to examine whether they perceptually processed English vowel segments in a significantly different way. This study aimed to address the following questions:

[7] In the current study, English vowels were examined in pairs. Most pairs were based on the tense-lax distinction. Some were challenging pairs for EFL learners, as indicated in previous relevant studies (Flege 1995, Flege, Bohn, and Jang 1997, Ho 2009). The pairings of /hat/-/hæt/, /hæt/-/hʌt/, /hʌt/-/hʊt/, or /hʌt/-/hɔt/ are not discussed here. These pairings will require investigation in the future.

(1) How did Taiwanese EFL learners discriminate English vowels? To what extent did learners of high English proficiency differ from those of low English proficiency?
(2) How did Taiwanese EFL learners assimilate English vowels to their L1 Mandarin phonetic categories? To what extent did learners of high English proficiency differ from those of low English proficiency?

3.2 Participants

Participants in the present study included ninety speakers of Mandarin Chinese in Taiwan who learned English as a foreign language. These EFL learners were college students, with ages ranging from nineteen to twenty-two years old. They had been studying English for at least six years, including three years in junior high school and three years in senior high school. None of them had lived in an English-speaking country.

The learners were further divided into two groups in terms of their TOEIC[8] scores (Reading and Listening Sections). One simulated TOEIC test (Loungheed 2003) was administered as a standardized pre-test to all participants to divide them on the basis of the test scores. The first group comprised 45 English-majors (10 males and 35 females) with the mean score of 530 (SD=36) on the TOEIC test. The second group contained 45 non-English-majors (20 males and 25 females) whose mean score on the TOEIC test was 352 (SD=33). These two groups differed significantly in terms of their TOEIC test scores (t=23.8***, p <.000). From the perspective of English proficiency, the first group was labeled as the high proficiency group (HEFL),[9] and the second group as the low proficiency group (LEFL). Whether these two groups would perceive English vowels in a different way would be examined in the current investigation.

3.3 Two perception experiments

The current study addressed how Taiwanese EFL learners discriminated English vowel pairs and to what extent and in which categories they assimilated English vowels to L1 segments. Two perception experiments were conducted.

[8] The TOEIC (Test of English for International Communication), first developed and published in the United States by the Educational Testing Service (ETS) in 1979, includes a 200 question norm referenced multiple choice listening and reading comprehension test with a full score of 900. It is now administered all over the world, especially in the contexts of English as a Second/Foreign Language (ESL/EFL) (cf., Robb and Ercanbrack 1999, Sewell 2005).
[9] HEFL refers to EFL learners with high English proficiency levels, while LEFL refers to EFL learners with low English proficiency levels.

3.3.1 Experiment 1: English vowel discrimination

Experiment 1 examined Taiwanese EFL learners' English vowel discrimination. Perceptual stimuli were eleven English vowel segments (i.e., [i, ɪ, ej, ɛ, æ, ʌ, u, ʊ, ow, ɔ, a]) (Peterson and Barney 1952) in the context of [h_t]. The rationale for putting the stimuli in the context of [h_t] was that it helped eliminate the duration cue provided by the voiced stop in the coda position. These speech stimuli were produced by two male native speakers of American English[10] who were teaching English in Taiwan. These stimuli were neither synthetic tokens nor tape-spliced segments. To ensure the intended words were clearly recorded, two other native speakers of American English listened to the recording and confirmed the clarity.

In Experiment 1, these eleven English vowels in the context of [h_t] were put in seven English minimal pairs (i.e., Pair 1 [hit]-[hɪt], Pair 2 [hejt]-[hɛt], Pair 3 [hæt]-[hɛt], Pair 4 [hæt]-[hejt], Pair 5 [howt]-[hɔt], Pair 6 [hut]-[hʊt], and Pair 7 [hat]-[hʌt])[11], presented in three trial-types (i.e., A-A/B-B, A-B, and B-A) and then repeated twice by the two male English teachers (7 pairs*3 trials*2 voices=42). They were then put in forty-two multiple choice questions, each of which was specified with the English phonetic symbols. These listeners had studied English phonetic symbols for six years and had no problem with these symbols. In addition to these forty-two target pairs, eight irrelevant pairs (e.g., hit-hid, heed-heat, hate-hayed, hood-who'd) were also selected as distracters. All together, there were fifty test questions in the discrimination task. Stimuli presentation was randomized across groups to avoid order effects.

Participants in the current study were tested in groups in a language lab free from noise. Before the formal experiment, a brief introduction of the perception experiment was given. In Experiment 1, the participants did the discrimination task of English vowel pairs. They listened carefully to the pre-recorded auditory sounds. They heard two sounds of the pair in each trial (i.e., A-A/B-B, A-B, and B-A) and had to decide whether these two sounds were the same or different. If the same, listeners had to circle SAME and circle the word they considered matching the segment they heard. If different, listeners had to identify which word was the first speech sound they heard and which word was the second speech sound by specification of number (i.e., 1 for the first stimulus and 2 for the second). For example, if the incoming pair was [hit]-[hit], the correct answer was to circle SAME and [hit]. If the listeners heard

[10] In the current investigation, multi-talker stimuli were adopted to avoid the possible effect of a single voice.

[11] Pairs 1, 2, 5, 6 were based on the tense-lax distinction. Pairs, 3, 4, and 7 were the challenging pairs for EFL learners, as indicated in previous relevant studies (Flege 1995, Flege, Bohn, and Jang 1997, Ho 2009). Pairing of /hat/-/hæt/, /hæt/-/hʌt/, /hʌt/-/hʊt/, or /hʌt/-/hɔt/ was not discussed here. These pairings will require investigation in the future.

[hit]-[hɪt], they should mark [hit] as 1, and [hɪt] as 2. In this task, each test stimulus was repeated twice. Enough time was left for participants to make responses on the answer sheet. The whole test session lasted for one hour.

3.3.2 Experiment 2: English vowel assimilation

Experiment 2[12] investigated the assimilatory patterns between English vowels and Mandarin Chinese categories. Perceptual stimuli in the second experiment were taken from those in the first experiment; they were eleven English vowel segments (i.e., [i, ɪ, ej, ɛ, æ, ʌ, u, ʊ, ow, ɔ, a]) (Peterson and Barney 1952) in the context of [h_t].

In Experiment 2, listeners were tested in groups in a language lab free from noise. They did the perceptual classification of eleven English vowel segments in the context of /h_t/.[13] Each token was repeated twice in the formal testing. Listeners had to complete two tasks. First, they were asked to label each of eleven English vowels (i.e., [i, ɪ, ej, ɛ, æ, ʌ, u, ʊ, ow, ɔ, a]) as "Similar" or "New" vowels. The second task was transcribing each English vowel with Mandarin vowel categories. If they considered an English vowel "Similar", they had to transcribe this vowel with Mandarin Chinese *Zhuyin Fuhao* or with IPA transcriptions. If they classified an English vowel as "New", then they did not have to respond with the corresponding transcription. The perceptual assimilation between English vowels and Mandarin Chinese categories took approximately twenty minutes to examine.

3.4 Data analysis

Scoring and statistical analyses were conducted in terms of mean scores on the discrimination task and classification on the perceptual rating. Scores on the discrimination task depended on the total number of correct responses. Zero points were given either to those who failed to distinguish the English vowel pairs as two separate segments and circled SAME, or to those who could perceptually distinguish vowel pairs as two separate segments, but failed in identification judgment. One point was given to those who succeeded in both distinguishing and identifying English vowel pairs. For each target pair (i.e., Pair 1 [hit]-[hɪt], Pair 2 [hejt]-[hɛt], Pair 3 [hæt]-[hɛt], Pair 4 [hæt]-[hejt], Pair 5 [howt]-[hɔt], Pair 6 [hut]-[hʊt], and Pair 7

[12] The design in Experiment 2 was adapted from Harnsberger (2001) and Aoyama (2003), both of which examined English final nasals perceived by L2 learners of English. But, the focus of the current study was on English vowels perceived by Taiwanese EFL learners.

[13] The original manuscript adopted the segmented vowel in the context of /h_t/. As one reviewer suggested, it was difficult for listeners to determine a truncated vowel out of the syllable context. The experiment was conducted again, embedding the vowels in CVC syllables, as the reviewer suggested. The author would like to express her thanks to the reviewer for this suggestion.

[hat]-[hʌt]), there were three trials (i.e., A-A/B-B, A-B, and B-A); hence the highest score was 3. Besides mean scores, error frequency and error rates were also calculated in order to examine to what extent and in which direction these EFL learners misperceived English vowels and perceptually processed the foreign vowel tokens.

In general, the present study addresses two research questions, displayed in the previous sub-section. In response to these research questions, current data analysis focuses on two major dimensions: (a) perceptual discrimination of English vowel pairs, and (b) perceptual assimilation of English vowels to Mandarin Chinese vowel categories. Additionally, discussion on universality of current perceptual models in the Taiwanese EFL context will be made. Statistical results and discussion on these research questions are presented in the following section.

4. Results and discussion

This section displays results of Taiwanese EFL learners' performance on English perception experiments. Statistical results of the perception tests are first shown, followed by a general discussion on the application of current perceptual models developed from European languages.

4.1 English vowel discrimination

In Experiment 1, EFL learners in Taiwan discriminated seven English vowel pairs. Statistical results of English vowel discrimination between two groups (i.e., HEFL and LEFL) in ANOVA are summarized in Table 2.

Table 2. Statistical results of English vowel discrimination

Pair	Group	N	M	SD	F
Pair-1 [i]-[ɪ]	**HEFL**	**45**	**1.87**	**0.34**	1.25
	LEFL	45	1.71	0.87	
Pair-2 [ej]-[ɛ]	**HEFL**	**45**	**2.49**	**0.54**	9.91**
	LEFL	45	1.98	0.94	
Pair-3 [æ]-[ɛ]	**HEFL**	**45**	**2.87**	**0.34**	26.57***
	LEFL	45	2.33	0.60	
Pair-4 [æ]-[ej]	**HEFL**	**45**	**2.60**	**0.58**	4.10**
	LEFL	45	2.27	0.94	
Pair-5 [ow]-[ɔ]	**HEFL**	**45**	**2.44**	**0.50**	18.39***
	LEFL	45	1.82	0.83	
Pair-6 [u]-[ʊ]	**HEFL**	**45**	**2.38**	**0.72**	9.47***
	LEFL	45	1.80	1.03	
Pair-7 [a]-[ʌ]	**HEFL**	**45**	**2.53**	**0.50**	13.55***
	LEFL	45	2.02	0.78	

Note: N = number; M = mean (The highest possible mean score was 3.); SD = standard deviations; *p< 0.05; **p< 0.01; ***p< 0.001

Several findings can be drawn from Table 2. First of all, the effect of English proficiency was significant in discriminating most English vowel pairs. Significant distinction was shown in six pairs: Pair 2 [ej]-[ɛ], Pair 3 [æ]-[ɛ], Pair 4 [æ]-[e], Pair 5 [ow]-[ɔ], Pair 6 [u]-[ʊ], and Pair 7 [a]-[ʌ]. Learners in the LEFL group was significantly more erroneous in these pairs than the HEFL group. In a word, the language experience between two different groups (i.e., HEFL vs. LEFL) acted as a significant factor in distinguishing English vowel contrasts.

Secondly, these groups expressed similar patterns, but with different degrees of sensitiveness to English vowel pairs. The perception saliency hierarchy was [æ]-[ɛ] > [æ]-[ej] > [a]-[ʌ] > [ej]-[ɛ] > [ow]-[ɔ] > [u]-[ʊ] > [i]-[ɪ] for HEFL learners, and was [æ]-[ɛ] > [æ]-[ej] > [a]-[ʌ] > [ej]-[ɛ] > [ow]-[ɔ] > [u]-[ʊ] > [i]-[ɪ] for LEFL learners. This hierarchy reflected some similar patterns shared by Taiwanese EFL learners of different proficiency levels. For example, Pair 3 [æ]-[ɛ] (M=2.87 for HEFL; M=2.33 for LEFL) and Pair 4 [æ]-[ej] (M=2.60 for HEFL; M=2.27 for LEFL) were easier for both groups to discriminate. Also, both groups were least accurate in distinguishing Pair 1 [i]-[ɪ] (M=1.87 for HEFL; M=1.71 for LEFL). The finding for Pair 1 [i]-[ɪ], however, was in disagreement with Luo (2002), in which speakers of Mandarin Chinese had excellent perception of English high vowels. Such a different empirical finding might be a result of different phonetic settings and different processing burdens used in the investigations. In Luo (2002), only English high vowels were examined, which imposed less of a processing burden for the participants. With more English vowels, the processing burden in the current study was more complex than that in Luo's study. So, it was expected that learners' perception of English high

vowels would be worse. Other possible reasons for such a discrepancy would be addressed in the design of Experiment 2, which examined these listeners' perceptual assimilation between L1 and L2 sounds.

It was interesting to note that different degrees of sensitiveness to Pair 5 [ow]-[ɔ] were demonstrated in learners with different English proficiency levels. Students in the LEFL group had more difficulty with perception for Pair 5 [ow]-[ɔ] (M=1.82), implying that this English vowel pair posed greater challenges for them to distinguish. HEFL learners, however, were more sensitive to English [ow]-[ɔ] distinction, as indicated in the significantly higher mean score (M=2.44).

Additionally, it can be inferred from Table 2 that both HEFL and LEFL tended to misperceive English vowel pairs to some extent, for neither groups obtained the possible highest mean scores (M=3) for each vowel pair. Overall error frequency of these English vowel pairs and the misperceiving direction are shown in Table 3.

Table 3. Error frequency and error rates of English vowel discrimination

Pair	Group	EF	1st	2nd
Pair-1 [i]-[ɪ]	**HEFL**	**51**	**31(61%)**	**20(39%)**
	LEFL	58	36(62%)	22(38%)
Pair-2 [ej]-[ɛ]	**HEFL**	**23**	**14(61%)**	**9(39%)**
	LEFL	46	18(39%)	28(61%)
Pair-3 [æ]-[ɛ]	**HEFL**	**6**	**3(50%)**	**3(50%)**
	LEFL	30	14(47%)	16(53%)
Pair-4 [æ]-[ej]	**HEFL**	**16**	**8(50%)**	**8(50%)**
	LEFL	33	15(45%)	18(55%)
Pair-5 [ow]-[ɔ]	**HEFL**	**25**	**15(60%)**	**10(40%)**
	LEFL	53	34(64%)	19(36%)
Pair-6 [u]-[ʊ]	**HEFL**	**28**	**17(61%)**	**11(39%)**
	LEFL	54	31(57%)	23(43%)
Pair-7 [a]-[ʌ]	**HEFL**	**21**	**10(48%)**	**11(52%)**
	LEFL	44	23(52%)	21(48%)

Note: EF = error frequency (from Table 2); 1st = the first segment in each pair; 2nd = the second segment in each pair

Table 3 concerns the issue of misperceiving directions.[14] Among the seven English vowel pairs, both groups misjudged Pair 1 [i]-[ɪ] with the largest number of errors (HEFL: EF=51; LEFL: EF=58). It was of great interest to find that these groups misperceived this pair as the tense vowel [i] (HEFL: 60%; LEFL: 62%) more than vice versa. A similar pattern was observed for Pair 5 [ow]-[ɔ] and Pair 6 [u]-[ʊ], in which both groups misperceived the tense-lax contrast respectively as the tense segments [ow] (HEFL: 60%; LEFL: 64%) and [u] (HEFL: 61%; LEFL: 57%) with

[14] Misperceiving direction was discussed in terms of error rates. Fifty percent was used in Table 3 as the criterion to decide the possible merging tendency. Significance tests should be conducted in further studies to prove if there was any significant difference.

more frequency. It can be argued that most tense-lax vowel contrasts displayed a greater tendency to be misperceived as tense by EFL learners in Taiwan. This direction followed the markedness statements (Maddieson 1984), in which unmarked tense vowels were more accurately perceived or more easily acquired than comparatively more marked lax counterparts.

Interestingly, learners of different English proficiency levels responded with slight difference to one tense-lax vowel pair, Pair 2 [ej]-[ɛ]. Judging from the error rates, the HEFL group followed the unmarked pattern and misperceived the lax vowel [ɛ] more as the tense vowel [ej] (61%). Behaving contradictorily to this pattern, the LEFL group misperceived the tense-lax contrast as the lax segment [ɛ] (61%) with more frequency. One possible account for this exception was that these LEFL learners might experience different assimilation processes in which they transcribed English vowels with Mandarin Chinese categories. This issue was manifestly addressed in the design of Experiment 2.

As for the remaining pairs, no dominant misperceiving direction was identified. In Pair 3 [æ]-[ɛ], Pair 4 [æ]-[ej], and Pair 7 [a]-[ʌ], errors made by both HEFL and LEFL seemed to be bi-directional with the percentage falling between 45% and 55%. Take Pair 3 [æ]-[ɛ] for example. This pair was misheard as [æ] (HEFL: 50%; LEFL: 46%), and was misheard as [ɛ] (HEFL: 50%; LEFL: 53%). With such close percentages, it was difficult to determine the dominant misperceiving direction.

4.2 English vowel assimilation

Experiment 2 addressed how EFL learners in Taiwan classified English vowels and how they assimilated English vowels to Mandarin Chinese phonetic categories. Statistical results of EFL learners' classification of English vowels are summarized in Table 4. Frequency and percentage for learners of different proficiency levels (i.e., HEFL vs. LEFL) are calculated and listed. χ^2 in *SPSS* software was performed to compute the observed data and to investigate significant results between these two groups of Taiwanese EFL learners.

Table 4. EFL learners' classification of English vowels (Similar vs. New)

Vowel	Group	N	Similar	New	χ^2	df
1. [i]	**HEFL** LEFL	**45** 45	**35(78%)** 34(76%)	**10(22%)** 11(24%)	0.062**	1
2. [ɪ]	**HEFL** LEFL	**45** 45	**15(33%)** 12(27%)	**30(67%)** 33(73%)	0.476**	1
3. [ej]	**HEFL** LEFL	**45** 45	**37(82%)** 36(80%)	**8(18%)** 9(20%)	0.073**	1
4. [ɛ]	**HEFL** LEFL	**45** 45	**22(49%)** 35(78%)	**23(51%)** 10(22%)	8.086**	1
5.[u]	**HEFL** LEFL	**45** 45	**37(82%)** 29(64%)	**8(18%)** 16(36%)	3.036**	1
6. [ʊ]	**HEFL** LEFL	**45** 45	**10(22%)** 21(47%)	**35(78%)** 24(53%)	6.627**	1
7. [ow]	**HEFL** LEFL	**45** 45	**36(80%)** 34(76%)	**9(20%)** 11(24%)	0.257**	1
8. [ɔ]	**HEFL** LEFL	**45** 45	**29(64%)** 33(73%)	**16(36%)** 12(27%)	1.591**	1
9. [æ]	**HEFL** LEFL	**45** 45	**13(29%)** 21(47%)	**32(71%)** 24(53%)	3.025**	1
10. [a]	**HEFL** LEFL	**45** 45	**30(67%)** 35(78%)	**15(33%)** 10(22%)	1.385**	1
11. [ʌ]	**HEFL** LEFL	**45** 45	**18(40%)** 29(64%)	**27(60%)** 16(36%)	5.388**	1

Note: N = number; frequency (percentage); *p< 0.05; **p< 0.01

In Table 4, Taiwanese EFL learners of different proficiency levels varied to some extent in perceptually classifying English vowels. For the HEFL group, they rated English vowels [i, ej, ow, u, ɔ, a] more as similar tokens to their L1 with the percentage larger than fifty (>50%). The other vowels [ɪ, ɛ, ʊ, æ, ʌ] were perceived as new segments with more than fifty percent. For the most part, this finding was consistent with the abstract phonological predictions based on L1-L2 segmental inventories (i.e., Mandarin-English), as previously reviewed. HEFL learners perceived most tense English vowels as similar tokens, but lax counterparts as new ones. One unexpected finding to the theoretical assumption was observed in the English vowel [ɔ]. Because major Mandarin vowels (Table 1) are all considered "tense" (Chen 1999, Howie 1976, Tung 1994, Chen, Robb, Gilbert, and Lerman 2001), the lax vowel [ɔ] was assumed to be a new token. It was thus interesting to note that these HEFL learners judged the English [ɔ] vowel as a similar token. How they perceived this vowel and to which Mandarin phonetic category they assimilated [ɔ], as examined in Experiment 2, would offer a possible account for this finding.

As for the LEFL group, they regarded English vowels [i, ej, ɛ, ow, u, a, ʌ, ɔ] as similar segments, while the remaining vowels [ɪ, ʊ, æ] were viewed as new sounds. Like HEFL, learners in the LEFL group perceived English [ɔ] as a similar vowel and referred to all English tense vowels [i, ej, u, ow] as similar tokens. But, different from

HEFL, learners in the LEFL group perceptually classified three English vowels [ɛ, ʊ, ʌ] with significant distinction (p<.05). HEFL learners rated these tokens as new, while LEFL perceived the vowels [ɛ, ʌ] as similar sounds to their L1 categories. In which Mandarin phonetic symbols (i.e., *Zhuyin Fuhao*) Taiwanese EFL learners of different proficiency levels transcribed these English vowels is revealed in the following tables.

Table 5. *Zhuyin Fuhao* transcription of English vowels by HEFL

Transcription / Vowel	[i] ㄧ	[y] ㄩ	[o] ㄛ	[ou] ㄡ	[e] ㄝ	[ei] ㄟ	[a] ㄚ	[ɤ] ㄜ	[u] ㄨ	U/C
1. [i] (S=35)	34 **(97%)**				1 (3%)					**C**
2. [ɪ] (S=15)	9 (60%)	2 (13%)			4 (27%)					**U**
3. [ej] (S=37)					3 (8%)	34 **(92%)**				**C**
4. [ɛ] (S=22)					18 (82%)	4 (18%)				**U**
5. [u] (S=37)				1 (3%)					36 **(97%)**	**C**
6. [ʊ] (S=10)		1 (10%)		2 (20%)					7 (70%)	**U**
7. [ow] (S=36)			2 (6%)	34 **(94%)**						**C**
8. [ɔ] (S=29)			22 (76%)	7 (24%)						**U**
9. [æ] (S=13)					10 (77%)	2 (15%)	1 (8%)			**U**
10. [a] (S=30)							28 **(93%)**	2 (7%)		**C**
11. [ʌ] (S=18)							14 (78%)	4 (22%)		**U**

Note: frequency (percentage); U = Uncategorized type; C = Categorized type; The total number of transcriptions for each stimulus was based on HEFL classification responses of “Similar” (S) (Table 4).

Table 5 shows the frequency and percentage of times each Mandarin *Zhuyin Fuhao* sound was adopted by the HEFL group for the English vowels. Each frequency was based on the classification responses of “Similar” (Table 4). The modal response category is indicated with percentages in boldface. The present discussion follows Harnsberger (2001) and Aoyama (2003) to use a 90% criterion for a stimulus being “categorized” as a particular L1 category. The categorized type (C) refers to the sound being assimilated to a native category with more than 90% of listener responses. Uncategorized type (U), by contrast, is made when the L2 segment fails to pass the 90% criterion and is not dominantly assimilated to a native category.

In the HEFL group, Mandarin [ㄧ] ([i]) and [ㄝ] ([e]) were used for English [i] in 97% and in 3% of instances respectively. For English [ɪ], Mandarin [ㄧ] ([i]) was adopted most of the time (60%), but [ㄝ] ([e]) and [ㄩ] ([y]) were also used in 27% and 13% of the instances respectively. English [i] was one example of the categorized

type (C), while English [ɪ] was typical of the uncategorized type (U). In a similar vein, the other tense vowels [ej, ow, u] and unmarked [a] were classified as the categorized type (C), while their lax counterparts [ɛ, ɔ, ʊ] and marked [æ], [ʌ] belonged to the uncategorized type (U).

Table 6. *Zhuyin Fuhao* transcription of English vowels by LEFL

Transcription / Vowel	[i] ㄧ	[y] ㄩ	[o] ㄛ	[ou] ㄡ	[e] ㄝ	[ei] ㄟ	[a] ㄚ	[ɤ] ㄜ	[u] ㄨ	U/C
1. [i] (S=34)	**32 (94%)**				2 (6%)					C
2. [ɪ] (S=12)	**11 (92%)**				1 (8%)					C
3. [ej] (S=36)					**33 (92%)**	3 (8%)				C
4. [ɛ] (S=35)					**32 (91%)**	3 (9%)				C
5. [u] (S=29)				2 (7%)					**27 (93%)**	C
6. [ʊ] (S=21)		1 (5%)		1 (5%)					**19 (90%)**	C
7. [ow] (S=34)			**32 (94%)**	2 (6%)						C
8. [ɔ] (S=33)			**30 (91%)**	3 (9%)						C
9. [æ] (S=21)					17 (81%)	3 (14%)	1 (5%)			U
10. [a] (S=35)							**32 (91%)**	3 (9%)		C
11. [ʌ] (S=29)							23 (79%)	6 (21%)		U

Note: frequency (percentage); U = Uncategorized type; C=Categorized type; The total number of transcriptions for each stimulus was based on LEFL classification responses of "Similar" (S) (Table 4).

The frequency and percentage of times each Mandarin *Zhuyin Fuhao* sound was transcribed by LEFL learners for the English vowels are indicated in Table 6. Like HEFL, the LEFL group classified all tense vowels [i, ej, ow, u] and unmarked [a] as the categorized type (C), and the marked [æ] and [ʌ] as the uncategorized type (U). Additionally, the pattern of transcription also helped account for why Chinese speakers made most errors in discriminating the English vowel pair [i-ɪ] (Table 2). Both HEFL and LEFL learners were inclined to assimilate English [i] and [ɪ] to the Mandarin vowel category [ㄧ] at high percentages (HEFL: 97% for [i] and 60% for [ɪ]; LEFL: 94% for [i] and 92% for [ɪ]). Failure to discern the possible phonetic differences between English [i]-[ɪ] and the Mandarin counterpart [ㄧ] ([i]), as pointed out in several acoustic studies (Howie 1976, Svantesson 1984), might ultimately lead to poor discrimination results for the English vowel pair [i-ɪ].

But, different from HEFL, English lax vowels [ɪ, ɛ, ʊ, ɔ] were referred to as the categorized type (C) in the LEFL group. As demonstrated for English [ɪ], Mandarin

[ㄧ] ([i]) was used most of the time (92%). Mandarin [ㄝ] ([e]) was also adopted, but only in 8% of the instances. In this case, LEFL learners assimilated English [i] and [ɪ] to one L1 segment, that is, Mandarin [ㄧ] ([i]). For the English [ej]-[ɛ] pair, it was classified as the Mandarin vowel [ㄝ] ([e]). Mandarin [ㄨ] ([u]) and [ㄛ] ([o]) were respectively used to transcribe English [u]-[ʊ] and [ow]-[ɔ] pairs. From the *Zhuyin Fuhao* transcription of English vowels, it can be argued that English tense-lax vowel contrasts seem to be lost for Taiwanese EFL learners with lower English proficiency levels.

4.3 Discussion

General discussion on English vowel perception is organized around two research questions. Results outlined in previous sections are discussed with perceptual theories developed from European languages.

The current investigation revealed several asymmetrical dimensions of English vowels perceived by Taiwanese EFL learners with different English proficiency levels. Results in Experiment 1 demonstrated that the HEFL group performed significantly better than the LEFL group in discriminating most English vowel pairs, for example, [ej]-[ɛ], [æ]-[ɛ], [æ]-[ej], [ow]-[ɔ], [u]-[ʊ], and [a]-[ʌ]. As for the misperceiving direction, most English tense-lax vowel contrasts displayed a greater tendency to be perceived as tense. That is, the tense-lax distinction was lost and misperceived as the tense segments for most Taiwanese EFL learners in the current study. Contrary to this unmarked trend, LEFL misperceived English [ej]-[ɛ] pair as the lax segment [ɛ] with more frequency. The driving force for this marked misperceiving direction for LEFL was the perceptual equivalence between English vowels [ej]-[ɛ] and Mandarin vowel [ㄝ] ([e]), as revealed in Experiment 2. The LEFL students assimilated English [ej] and [ɛ] to one Mandarin vowel category [ㄝ] [e] (Table 2), making it difficult for them to discriminate the English [ej]-[ɛ] pair.

Taiwanese EFL learners with different English proficiency levels displayed different perceptual assimilation patterns in Experiment 2. For the HEFL group, there was little overlap between English tense vowels and their lax counterparts. Learners in the HEFL group classified English tense-lax pairs into two different categories. Tense vowels [i, ej, u, ow] belonged to the categorized types (C) (i.e., Mandarin [ㄧ], [ㄟ], [ㄨ], [ㄡ] respectively), but lax vowels [ɪ, ɛ, ʊ, ɔ] were uncategorized (U). The LEFL group, by contrast, had a relatively high degree of overlap in classification between English tense and lax vowels. In LEFL group, both tense vowels and lax vowels were perceived as single categorized types (C). A greater majority of the LEFL learners tended to assimilate English tense and lax vowels into one Mandarin category. Take

the English [i]-[ɪ] pair for example. Both were categorized as one Mandarin phoneme [一]. Similar assimilatory patterns occurred in English [ej]-[ɛ], [ow]-[ɔ], and [u]-[ʊ] pairs.

Findings in the perception experiments of English vowels added some empirical support to the Speech Learning Model (Flege 1995), one of the perceptual models developed in European languages. Adopting the terminology of the Speech Learning Model (Flege 1995), most English lax vowels (e.g., [ɪ, ɛ, ʊ]) were all rated as "new" phones and tense vowels (e.g., [i, ej, ow, u]) as "similar" phones for Taiwanese HEFL learners. For LEFL learners, they classified English [ej] and [ɛ] as "similar," and thus scored lower in discriminating the English [ej]-[ɛ] pair. In this case, Taiwanese EFL learners' perception of English vowels substantiated the key assumptions of the Similarity Effect, in which the more an L2 segment was perceptually similar to that of an L1 segment, the more challenges it posed for L2 learners to acquire that segment.

Additionally, the current finding was also in agreement with the importance of L2 learning experience in speech sound discriminability. As in the LEFL group, learners may initially assimilate English tense-lax vowel contrasts to their L1 tense counterpart in view of the perceived similarity. As learners upgrade their English proficiency levels, they become aware of the discernable difference between tense and lax vowels. The gradual realization results in more accurate discrimination of English vowel pairs, as observed in the HEFL group. In sum, non-native perception can be filtered by linguistic experience, and accurate L2 perception can ultimately be acquired as learners improve their L2 proficiency.

The present findings, though in line with some previous studies, were somewhat in disagreement with the Perceptual Assimilation Model (PAM) (Best 1995, 1999). In PAM, Best (1995) outlined three perceptual assimilation patterns of non-native segments: (a) being assimilated to a native category, (b) being assimilated as uncategorizable speech sound, and (c) not being assimilated to speech. Discrimination is expected to be excellent when two non-native categories are assimilated to two different native categories [i.e., two-category assimilation types (TC Type)]. By contrast, poor discrimination occurs when two non-native categories are assimilated to a single native category [i.e., single-category assimilation (SC Type)] The case when two sounds cannot be easily assimilated to any native category is called the both uncategorizable type (UU Type), in which discrimination may be good or poor depending on the closeness of the two sounds.

In the current investigation, the categorized types in the perception saliency hierarchy were [æ]-[ɛ] (UU)[15] > [æ]-[ej] (UC) > [a]-[ʌ] (CU) > [ej]-[ɛ] (CU) >

[15] U = Uncategorized type; C = Categorized type. As shown in Table 5, both [æ] and [ɛ] were uncategorized (U) for HEFL learners, so they formed the UU group. As for the [æ]-[ej] pair, [æ] was

[ow]-[ɔ] (CU) > [u]-[ʊ] (CU) > [i]-[ɪ] (CU) for HEFL learners (Table 5), and [æ]-[ɛ] (UC) > [æ]-[ej] (UC) > [a]-[ʌ] (CU) > [ej]-[ɛ] (SC)[16] > [ow]-[ɔ] (SC) > [u]-[ʊ] (SC) > [i]-[ɪ] (SC) for LEFL learners (Table 6). PAM is helpful in two ways. First, it is advantageous in accounting for the discrimination of SC types (i.e., [ej]-[ɛ], [ow]-[ɔ], [u]-[ʊ], [i]-[ɪ]) was worse in the LEFL group. Second, PAM offers an appropriate explanation for different performance on the English [ow]-[ɔ] pair for learners of different proficiency levels. In SLM terminology (Flege 1995), both HEFL and LEFL learners judged English [ow] and [ɔ] as "similar" tokens (Table 4), which were theoretically assumed to be more difficult for them to discriminate. This prediction was verified in LEFL (M=1.82), but not in HEFL (M=2.44), who showed significantly greater sensitivity to English [ow]-[ɔ] distinction (Table 2). Besides the effect of L2 proficiency levels, PAM provides another plausible account why the English [ow]-[ɔ] pair poses fewer challenges for HEFL than for LEFL. In the assimilatory patterns, HEFL classified English [ow]-[ɔ] pair as the CU type (Table 5), while LEFL classified this pair as the SC type (Table 6). As PAM predicts, the discrimination of SC type (i.e., [ow]-[ɔ] pair for LEFL) was worse.

But, the assimilatory patterns in PAM fail to address two questions: (a) Why did the HEFL group perform the best on the UU pair (i.e., [æ]-[ɛ]) than the CU or UC pairs (i.e., [æ]-[ej], [a]-[ʌ], [ow]-[ɔ], [ej]-[ɛ], [u]-[ʊ], [i]-[ɪ])? (b) What were the possible driving forces in this perception saliency hierarchy? Under which effect did these learners experience different degrees of difficulty in L2 vowel discrimination?

To account for these unexpected findings, the researcher drew on the facts from markedness effects in world languages (i.e., sonority scale and sonority distance) and suggested a tri-dimensional model for L2 vowel perception (Figure 1). Ranking in perception saliency in English vowel discrimination might be a major result of the sonority scale. According to the sonority profiles of vowels "low vowels (i.e., [a], [æ]) > mid vowels (i.e., [ej], [ow]) > high vowels (i.e., [i], [u])" (Kiparsky 1982). Low vowels are claimed to be most sonorous, while high vowels are least sonorous. Having the lowest sonority, the vowel [i] context might be comparatively less salient to the ear and be more challenging for listeners. The current findings strongly confirmed the universal pattern of vowel sonority, in which low vowel pairs were discriminated with greater accuracy (i.e., [æ]-[ɛ], [æ]-[ej], [a]-[ʌ]), followed by mid vowel pairs (i.e., [ow]-[ɔ], [ej]-[ɛ]). These learners were most inaccurate in discriminating high vowel pairs (i.e., [u]-[ʊ], [i]-[ɪ]).

Distance in the sonority scale offers another explanation. Following the Minimal

uncategorized (U), and [ej] was categorized (C), resulting in the UC group.

[16] As shown in Table 6, LEFL learners assimilated English [ej] and [ɛ] to one Mandarin category [e]. Hence, the English [ej]-[ɛ] pair was marked as the SC type. A similar pattern occurred in [ow]-[ɔ], [u]-[ʊ], and [i]-[ɪ] for LEFL learners.

Sonority Distance (MSD) Model[17] (Broselow and Finer 1991), sonority values were respectively assigned to vowels on different sonority scales. For example, 1 was given to high vowels, 2 to mid vowels, and 3 to low vowels. Given the values on the sonority scale, sonority distances in the [æ]-[ɛ] pair and in the [ow]-[ɔ] pair were respectively 1 (3-2=1) and 0 (2-2=0). For each vowel pair in the perception saliency hierarchy, the sonority distance was put in parentheses: [æ]-[ɛ] (1) > [æ]-[ej] (1) > [a]-[ʌ] (1) > [ej]-[ɛ] (0) > [ow]-[ɔ] (0) > [u]-[ʊ] (0) > [i]-[ɪ] (0) for HEFL learners, and [æ]-[ɛ] (1) > [æ]-[ej] (1) > [a]-[ʌ] (1) > [ej]-[ɛ] (0) > [ow]-[ɔ] (0) > [u]-[ʊ] (0) > [i]-[ɪ] (0) for LEFL learners. From the perspective of minimal sonority distance, pairs with members closer in sonority are more marked than those whose members are further apart on the sonority scale. Accordingly, vowel pairs with higher MSD settings (i.e., [æ]-[ɛ], [æ]-[ej], [a]-[ʌ]) were easier to discriminate than those with lower MSD settings (i.e., [ej]-[ɛ], [ow]-[ɔ], [u]-[ʊ], [i]-[ɪ]).

To conclude, it can be argued that the assimilatory patterns between L1 and L2 segments in PAM helped might only be a part of the explanation in English vowel discrimination. In the current findings, it was limited in accounting for (a) why Taiwanese learners of English performed the best on the UU pair as compared to the CU or UC pairs, and (b) what determined the perception saliency hierarchy for these learners. The researcher argued that markedness effects in the universal grammar had to be involved in analyzing L2 perception and proposed a tri-dimensional model for L2 vowel perception (Figure 1). In the tri-dimensional model, the driving force was exactly of language and markedness background. The close interaction in perceptual assimilation between L1 and L2 segments and markedness effects (i.e., sonority scale and sonority distance) modulated the generalization in English vowel discrimination. In sum, the present empirical findings support accounts of multiple dimensions from language factors and markedness effects were clearly favored over pure comparisons of L1-L2 segment inventories.

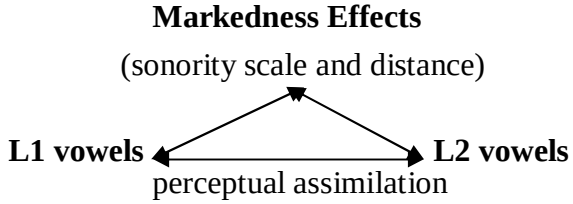

Figure 1. Tri-dimensional model for L2 vowel perception

[17] The Minimal Sonority Distance (MSD) Model (Broselow and Finer 1991) was originally proposed to characterize the possible types of onset consonants clusters in different languages and as a criterion in determining the degree of difficulty in L2 syllable acquisition.

5. Conclusion

The current investigation proceeded from the perceptual discrimination of English vowels to the assimilatory patterns between L1 and L2 vowels for Taiwanese EFL learners. It was found that learners of different English proficiency levels demonstrated similar patterns, but with different degrees of sensitiveness in perceiving English vowel pairs. Slightly different misperceiving directions were also identified. It was the perceptual equivalence between English vowels and Mandarin vowels that led to misperceiving differences. But, the perceptual assimilation between L1 and L2 segments in PAM (Best 1995, 1999) was limited in interpreting the perception saliency hierarchy for Taiwanese EFL learners. To draw on the facts from markedness effects in universal grammar (i.e., sonority scale and sonority distance), the researcher argued that perceptual assimilation alone might not fully account for the current findings. One tri-dimensional model for L2 vowel perception (Figure 1), in which language factors and markedness effects were actively involved, was thus suggested.

The present study elaborates the issue of English vowel perception from empirical and theoretical perspectives. For the former, the current findings can be directly or indirectly applied to pedagogy. Learners should be informed of significant differences between their native language and the target language. As suggested in Chan and Li (2000), a heightened awareness of contrastive differences between two phonological systems would be beneficial in facilitating phonological acquisition and in overcoming pronunciation problems. In the current research, contrasts of tense and lax vowels, being present in English but not in Mandarin, were observed to pose serious problems for EFL learners in Taiwan. Tense/lax distinctions in English should thus be made explicit to EFL learners. Besides abstract phonological structures, the perceptual assimilation between L1 and L2 categories and the tri-dimensional model can also be adopted as a tool to assist learners in achieving competence at segmental levels. Furthermore, it is widely acknowledged that discrimination ability in L2/FL phonemic categories can be enhanced with auditory training (Celce-Murcia, Brinton, and Goodwin 1996, Prator and Robinett 1985). One of the most widely-adopted auditory training is minimal pairs, in which specific contrastive vowel qualities (e.g., ‘hate-hete’ or other perceptual stimuli in Experiment 1) could be presented to L2/FL learners. Their attention could be drawn systematically to the confusing segments in perception, as revealed in the perceptual saliency hierarchy in the current investigation.

For the theoretical perspective, the present experiment indicates that the complicated cognitive processing of L2 vowel perception cannot be simply portrayed

or interpreted within the L1-L2 distinction. Drawing on multi-dimensional factors, the Interactive Model (Figure 1) seems advantageous in illustrating the active interaction in the cognitive processing of L2 vowel perception. It should be noted that further testing with this model must be carried out in non-Mandarin languages to substantiate its feasibility and accountability in future L2 perceptual studies. It is also suggested that the research scope of English vowel pairing be enlarged in future studies. The research scope in the current paper is limited in that it only includes seven pairs (i.e., Pair 1 [hit]-[hɪt], Pair 2 [hejt]-[hɛt], Pair 3 [hæt]-[hɛt], Pair 4 [hæt]-[hejt], Pair 5 [howt]-[hɔt], Pair 6 [hut]-[hʊt], and Pair 7 [hat]-[hʌt]). Pairing of [hat]-[hæt], [hæt]-[hʌt], [hʌt]-[hʊt], or [hʌt]-[hɔt], for example, should be examined in future studies to further elaborate Chinese speakers' discrimination and assimilation of the English vowel system.

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台籍英語學習者英語母音感知區辨與同化之研究

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英文母音系統中有鬆母音、緊母音之別，但華語母音系統中缺乏此對比。中介音韻學實證研究多著墨於華語母語者學習英語母音時之發音困難，少有分析英語母音感知區辨與同化之模式。本研究實驗一探討：華語母語者感知英語母音之區辨模式；實驗二檢視：華語母語者如何將英語母音分類，並與華語母音同化。感知實驗結果支持「語音學習模式」（Flege 1995），但與「感知同化模式」（Best 1995）預測略異，本文指出「感知同化模式」之限制，即：單從第一語音與第二語音間之同化模式無法準確解釋實驗結果；引述標誌現象，本文建議一個三角互動模組，以闡述第二語音感知之運作。

關鍵詞：英語母音、華語母語者、語音學習模式、感知同化模式