The Movement of the Vowel in American English

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中文摘要

本文旨在探討英文母音之音域，及長、短母音更精確之語音特質。舌位之高低一直被視為引導母音發音之重要因素，然而本研究發現，同一音域中之長、短母音其實存在更具分辨性之語音特質：母音的走向。這個發現可以立即破解英語學習者一向認為長母音發長，短母音發短的迷思，也可讓英語學習者有更明確的資料，藉以判定學習者發出之英語母音之正確性，更可提高英語學習者對語音辨識的信心。

關鍵詞：英語母音、音域、母音走向

Abstract

This study examines the space of English vowels and how each pair of tense-lax vowels can be distinguished on the basis of precise phonetic qualities. The positions or heights of the tongue have been widely reported and believed to be factors that determine the production of a vowel. However, data in this study show that there is another feature that makes the tense-lax vowels more distinguishable—the tense vowel and lax vowel in the same phonetic space move in very different directions, mostly opposite to each other. This finding may help EFL learners in two aspects: (1) They no longer need to worry about whether the tense vowel should be pronounced longer in time than the lax vowel; and (2) they can have a set of precise data to use as a base when they have to check whether they have produced the English vowels satisfactorily. To conclude, awareness of this feature may be beneficial to Taiwanese EFL learners both in grasping the subtle differences of the tense-lax vowel pairs and in producing the speech product with confidence.

Key words: vowel space，vowel movement，tense vowel，lax vowel
The Movement of the Vowel in American English

Introduction

It would be a familiar topic among English teachers if they tried to recall how difficult it is for Mandarin-speaking EFL learners in Taiwan to pronounce /e/, /æ, ə, ɔ/, /u/ or /ʊ/ vowels satisfactorily. It is true that some EFL learners claim that English pronunciation does not really matter as long as communication is made, and thus, poor pronunciation is not a top priority in the process of language learning. However, my expectation here is for another group of learners who take pronunciation as an equally important element as any other (syntax, diction, etc.) in second or foreign language learning. At this point, fossilization (Selinker, 1983) may pop into our mind and act as an indispensable excuse for second language learners’ deviated performance. Fortunately, there also comes an alleviative comment indicating that second language learners often do show success in achieving pronunciation closer and closer to target language norms (Borden, Gerber, & Milsark, 1983; Odlin, 1989).

The aim of this paper is not to challenge the concept of “fossilization” in any sense, but to reconsider the assumption that only the individuals with especially high phonetic sensitivity will be able to open their ears to a new sound system and therefore able to overcome most of the inhibiting influence of phonological patterns in the native language (Odlin, 1989). The key phrase “open their ears” seems to refer too much to physical organs or functions related to perceptual processes implying that there are some people who “cannot open their ears” or “do not open their ears wide enough” to perceive the subtle features of a foreign language. This is certainly not true. Saying a person has high phonetic sensitivity means he/she knows what to listen for and is able to tell the subtle differences among different sound qualities. This ability is also believed to be trainable. MacCarthy (1976), for instance, believes that “…‘learning to listen’ has nothing to do with improving the physical properties of anyone’s actual hearing mechanism: phrases such as ‘to have a good ear for languages’, to ‘train’ or ‘improve the ear,’ refer to the ear in a metaphorical sense only. He continues, “…it can be assumed that the actual hearing of the language learner is adequate to his task. What is required, though, is that he should learn to direct his attention to the auditory phenomena of the new language, and that he should do so in a way quite different from the way he listens to and understands his own language.” Language learners, as Celce-Murcia et. al. made it more specific, may listen to and process speech by calling up their prior knowledge, or schemata (higher-order mental
frameworks that organize and store knowledge), to help them make sense of the bits and pieces of information they perceive and identify using certain strategies (Celce-Murcia, Brinton, & Goodwin, 1997).

At this point, we may question exactly what elements second language learners have to “pay their direct attention to” as they try to listen to a target language. If we narrow the topic to only the quality of the English vowel, we can modify the question into the following: What are the exact qualities of the English vowel second language learners need to perceive if they try to acquire the English vowel satisfactorily? For this question, we seem to have answers ranging from the vowel space of the whole phonemic system—it is quite well accepted that vowel space varies according to Englishes spoken in different communities (Ladefoged & Maddieson, 1996)—to the space of each vowel (Wolfram & Schilling-Estes, 1998). Celce-Murcia et al. (1997) made a very impressive and probably the most complete summary of the characteristics of North American English vowels and diphthongs:

1. Vowels are classified as high, mid, or low, referring to the level of the tongue within the oral cavity and the accompanying raised or lowered position of the jaw.

2. Vowels are also classified as front, central, or back, depending on how far forward or back the tongue is positioned within the oral cavity during articulation and which part of the tongue is involved.

3. Vowels can be either tense or lax. These terms refer to the amount of muscle tension used to produce the vowel, the tendency of the vowel to glide, its distribution in closed or open syllables and its relative place of articulation (i.e., its position in the center or on the periphery of the vowel quadrant).

4. Vowels are simple or glided. The latter term refers to vowels with tongue movement occasioned by an accompanying /y/ or /w/ glide. Of these glided

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1 According to Celce-Murcia et al., The listeners process incoming speech by employing the following four strategies:
1. Listeners attend to stress and intonation and construct a metrical template—a distinctive pattern strategy and weakly stressed syllables—to fit the utterance.
2. They attend to stressed vowels.
3. They segment the incoming stream of speech and find words that correspond to the stressed vowels and their adjacent consonants.
4. They seek a phrase—with grammar and meaning—compatible with the metrical template identified in the first strategy and the words identified in the third strategy. (Celce-Murcia et al., 1997, p. 223)
The Movement of the Vowel in American English

vowels, those with an adjacent glide are distinguished from the three phonemic diphthongs, which involve a nonadjacent glide.

5. Vowels are characterized by the degree of lip rounding or spreading that occurs during their articulation (p. 102). In addition, it is also added that only the constellation of these factors can adequately characterize a vowel’s articulatory features. However, the long list does not seem to provide the “subtle” elements that will help EFL learners to solve their problems in pronunciation. There are still a number of issues to be faced when the second language learners try to “perceive” the characteristics of each English vowel.

1. Even if the EFL learners are informed with the information that English vowels can be classified as high, mid, or low, there is still difficulty for the EFL learners to locate the exact “high” or “low” even if they have plenty of chances to listen to authentic sound data.

2. EFL learners also have similar difficulties in locating the “front” or “back” positions of the vowel.

3. Tense or lax vowels used more metaphorically than practically while EFL learners have to perceive the different qualities between /i/ and /ɪ/; /ʌ/ and /ɑ/; or /ɔ/ and /ɑ/. To tell the difference of the amount of muscle tension used to produce these vowels does not seem to be of great use in helping EFL learners clarify the doubts in their mind.

4. If we look at the spectrogram of any English vowel (except for the reduced vowels), not a single stressed vowel is “simple,” if it is referred to as a “monophthong” without a gliding effect (see the analyses section). In other words, every English stressed vowel seems to move from one location to another. And where can the EFL students find the relevant information?

5. Lip rounding and spreading have been regarded as two of essential factors that determine whether a vowel should be pronounced correctly. However, EFL learners may notice that North American English speakers do not “spread” or “round-up” their lips overtly while speaking English. If these two factors are overemphasized, deviated performance may result if the processes are not
The relatively best solutions to these issues have been found in Ladefoged’s *Vowels and Consonants* (2001), which provides detailed descriptions of how /i,ɪ,ɛ,æ,u,u,ʌ/ as in *heed, hid, head, had, who’d, hood,* and *hood* are pronounced. Graphs are used to illustrate how these vowels are made inside the oral tract and how the tongue moves when producing each vowel. Clear as they are, these graphs are still not enough for EFL learners to conceive the unique features of each English vowel. To compensate for this, Ladefoged also provides continuous images as videos (in the CD that comes with the book) demonstrating how the vowels /i, e, a, o, u/ are pronounced (see Figure 1). These images seem to depict the complex coordinated movements of the vocal organs more precisely compared with the drawn or animated graphs. However, EFL learners still need further information concerning how these vocal organs operate in a chronological order.

No satisfactory answers can be found in the literature or instruction books related to pronunciation, the only possible approach is to continue exploring more into the quality of each vowel in English. By so doing, I have noticed two important features that have been left out in most of the discussions in the teaching of English pronunciation. First, interpreting the vowel space of English in a specific way that EFL learners might have a chance to tell how English vowels should be pronounced differently from their native language through different mechanisms. Second, provide data to show that every English vowel, tense or lax, glides from one location to another, and the glide of the English vowel differs from that of EFL learners’ native language. To focus on these issues that Taiwanese EFL learners might be faced with, I contrasted these two qualities between English and Mandarin vowels. Below are the two questions to which I have tried to find

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2 Mandarin is considered here, rather than other dialects, because all of the subjects we had for this project speak Mandarin as a dominant language. Some do speak other dialects, but the use of these dialects is limited to family greetings or everyday conversations.
solutions from the data I have collected in the past few years. 

Question 1: Is there evidence that different vowel spaces of English and Mandarin make it difficult for Mandarin-speaking EFL learners to locate the vowel space of English?

Question 2: Is there evidence that the tense vowel should move along the course that is distinctively different from that of the lax vowel, so that the speaker of the language in question may not get confused?

The possible solutions to the second question will hopefully provide information of the chronological movement for each vowel and thus may serve as a pedagogical aid in instruction of English pronunciation.

Subjects and Sound Materials

The data were extracted from the set of recorded data I collected in my pronunciation class and the data I collected during a visit to UC Santa Barbara in January 2001 and my one-year stay at UC Los Angeles in 2002. In this paper, only three subjects from both native-speaking and non-native speaking groups of English were selected to provide the major contribution of sound data. The native speakers were all college students or graduate students who were born and grew up in California. Non-native speakers were all English majors at a National University in Taipei. The expressions they read consisted of different vowels (see appendix A). All the voices were recorded as digital sound files by an IBM Thinkpad T23 (in wave files with the rate of 44100 Hz).

Analyses

The data were treated in two different ways. First we located and visualized the vowel space of English based on the native speakers’ data and non-native speakers’ data respectively by employing a computer speech analyzer PRAAT. The locations of vowel space were illustrated by means of formant charts with the first formant (F1) on the ordinate (the vertical axis: 0 Hz-1500 Hz) and the second formant (F2) on the abscissa (the horizontal axis: 0 Hz -3500 Hz), showing the space and the relation between different vowels. The values of formant 1 and formant 2 were used to plot the basic position of each vowel in the oral tract. The formant chart was arranged in a way that matches most of the graphs in the pronunciation instruction books with the lip position on the left side and the pharynx on the right.

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3 PRAAT is a sound analyzer developed by Dr. Paul. P. G. Boersma and Drs. David J. M. Weenink at Institute of Phonetic Sciences, University of Amsterdam. It is free software downloadable at www.praat.org.
Comparing the two formant charts (See Figure 2), we were highly impressed with the overlapping spaces of the English vowels. In the central area of the left formant chart (representing the vowel space of English), the vowels /ei/, /ou/ and /u/ are concentrated—either overlapped (i.e., /ei/ and /ou/) or closely jammed (i.e., /u/ and /ou/), whereas the space of each of the Mandarin vowels has a very clear-cut area spreading on both sides of the formant chart (see the chart on the right). The frequency values of the six vowels show that most of Mandarin vowels are located in the area with F1 from 300 Hz to 700 Hz and F2 from 700 Hz to 2,600 Hz. On the other hand, most of English vowels are located in the area with F1 from 300 Hz to 1,000 Hz and with F2 from 700 Hz to 2,200 Hz.

Examining each vowel of the chart separately, we see the /i/ sound as in “pea” in English is in the middle area (with the first formant of around 1400 Hz in frequency) while the Mandarin /i/ sound as in “瞥” is in the front space (with higher first formant of 2,500 Hz in frequency). And the /u/ sound as in “too” is lower and much more in the middle than the /u/ sound as in “吐,” which is relatively higher (with lower first formant by 200 Hz frequency) and occurs relatively far in the back (with lower second formant by 700 Hz in frequency). The /ei/ sound as in “bay” is spreading from the front to the back in English while its counterpart in Mandarin stays in the front.

**Figure 2** The formant charts with the frequencies of the first formant (the vertical axis) against the frequencies of the second formant (the horizontal axis) represent the plots of the vowels /i, ei, a, o, ou, u/ as in “pea, bay, odd, owe, moss, too” pronounced by a native speaker of Californian English and as in “瞥，背，阿，恆，摩，吐” pronounced by a Mandarin-speaking student.
The /a/ sound in “odd” is not as low as in Mandarin; however it pushes more back to the pharynx while the /a/ sound as in “阿” in Mandarin stays in the middle though lower in its tongue position. Another noticeable contrast is that the English /ɔ/ sound as in “moss” is much lower, overlapping the /a/ sound\textsuperscript{1} in “odd”, while the Mandarin /ɔ/ sound in “摩” pushes more to the pharynx wall. And the /ou/ sound as in “owe” is also in the middle area while the Mandarin /ou/ as in “慪” is pronounced in the position much closer to the pharynx.

Is there evidence that this will affect the Mandarin-speaking subjects so that they acquire the English vowel with difficulties? Data collected from the three Mandarin-speaking subjects show that, after a two-week intensive training, they still had problems with the /ɔ/ and /ou/ vowel when producing English. Figure 3 shows that these two vowels look closer to the space of the /ɔ/ and /ou/ vowels when they pronounced Mandarin utterances. However, they were quite successful in picking up the other vowels /i/, /ei/, /u/ and /a/. The data show two things: First, EFL students do tend to apply what they are familiar with to the target language if they fail to grasp the subtle differences. Second, given effective instructions, EFL learners may have great chances to acquire pronunciation of a target language successfully.

The second set of data was examined to see whether the movement of each vowel differs in different languages. Since the regular formant charts did not show chronological order of movement for each vowel, I tried to employ a new approach by cutting each vowel into five segments and each segment was numbered accordingly. The formant chart for each vowel was marked with numbers instead of IPA symbols. And the numbers therefore reflected the direction of the movement of the vowel. The findings through this approach, as expected, have provided information regarding how tense vowels and lax vowels have different vowel qualities by traveling through different courses while being pronounced.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{formant_chart.png}
\caption{The formant chart represents the plots of the vowels /i, ei, a, ɔ, ou, w/ extracted from “pea, bay, odd, owe, moss, too” pronounced by a Mandarin speaker.}
\end{figure}

\textsuperscript{1} Ladefoged reported the same finding in his \textit{A Course in Phonetics} (2001, p. 207).
Figure 4  The arrows in the formant charts reflect the movement of the /i/ and /I/ vowel produced by a native speaker of Californian English.

Figure 4 indicates the contrastive movements of the English vowels /i/ (left) and /I/ (right). The /i/ vowel moves from the middle area to the upper-front direction while the /I/ vowel moves from the higher-front area to the lower-middle position. The speakers of many languages, such as Mandarin, Japanese, Greek or Spanish, do not distinguish the tense vowel /i/ and the lax vowel /I/. The speakers of these languages may not have the phonetic sensitivity in distinguishing these two vowels. The Mandarin-speaking subjects, for example, produced /i/ sound as in “譬” with more freedom in having the vowel pronounced. Figure 5 shows three types of how the Mandarin /i/ was pronounced by three subjects. It is very obvious that the second and third charts (to the right) are very different from the general way the English /i/ vowel is pronounced. The same pattern occurs in the following pairs: /ei/ and /e/ as in “bay” and “yes”; /ou/ and /o/ as in “owe” and “moss”; /u/ and /u/ as in “too” and “looks”; and /a/ and /a/ as in “odd” and “judges.”
The Movement of the Vowel in American English

Figure 6  The arrows in the formant charts reflect the movement of the /ei/ and /e/ vowel produced by a native speaker of Californian English.

The formant chart in Figure 6 indicates that the /ei/ and /e/ vowels move to the right (to the pharynx); however, the /ei/ vowel moves upwards while the /e/ vowel moves downwards. The opposite directions of the sound movement also help native speakers of this language avoid getting confused because the vowel qualities are distinguishable. This finding is quite different from most of the data reported before. It is often described that the /ei/ vowel is supposed to glide from the /e/ position and then approach the /i/ vowel space (e.g., Celce-Murcia et al., 1997, p. 94). When we examined the formant charts of the /ei/ vowel as in “背” produced by three Mandarin speakers (see Figure 7), the chart looks uniform in movement and the direction leads

Figure 7  The arrows in the formant charts show that the /ei/ vowel as in “背” produced by three different Mandarin speakers are uniform in movement.

Figure 8  The arrows in the formant charts show the /ei/ vowel as in “bay” produced by three different Californian English speakers.
to the space of the vowel /i/. However, the formant charts in Figure 8 show that Californian English speakers tend to pronounce the /ei/ vowel as in “bay” from the front area to the central area and then it moves up approaching the high area of the vocal tract. This is quite different from what we are aware of from the books of pronunciation or phonetics. It is also interesting to find that the phonetics description for the English /ei/ vowel actually fits the Mandarin /ei/ better.

The formant charts in Figures 9 to 11 will not be interpreted in great detail because they all show the same pattern as explained in the previous paragraphs. However, here is the key point I want to emphasize again—the findings confirm that each minimal tense-lax pair of vowels does have unique qualities distinctive enough for speakers, native or non-native, to avoid getting confused while producing them.

In this section, the data we analyzed have provided two positive answers to the research questions I made in the previous section. First, the vowel space of California English is different from that of Mandarin. We will discuss later to see if the
difference has any correlation with Taiwanese EFL students' performance in English pronunciation. Second, the data also show we can positively say that the phonetic qualities of each set of minimal pair of tense-lax vowels, such as /ɪ/ and /ɨ/, /ei/ and /eɪ/, etc., can be illustrated clearly both in vowel space and in the movement of the vowel.

![Formant charts](image)

**Figure 11** The arrows in the formant charts reflect the movement of the /ɑ/ and /ʌ/ vowel produced by a native speaker of Californian English.

Although we still need a larger sample size to determine whether the data reported in this section can represent the whole population of the Californian English community, the uniform patterns produced by three Californian subjects still speak powerfully as to how they speak their native tongue.

**Discussion**

It is known that “non-native speakers are likely to categorize foreign language sounds largely in terms of the phonemic inventory of the native language (Scholes, 1968, Liberman et al, 1957), and the purpose of this paper is to provide data or information that may help language learners not to categorize foreign language sounds in terms of the phonemic inventory of the native language because the learners are aware of the distinctive features of the target language. Lehn & Slager (1983) reported that for languages like Arabic and English, the phonemically simple nuclei in both languages are similar in that both sets are phonetically short and lax. But since Arabic has fewer contrasts, the range of allophonic variation of each vowel phoneme is much greater than in English; e.g., Arabic /a/ has allophones within the area bounded by [ɛ], [æ], [ɑ], and [ʌ]. And hence English contrasts as in *bet-bat, cat-cot, cot-cut, cot-caught* are all difficult (pp. 37-38). The findings of this study show that Mandarin, compared with English, also has fewer contrasts in terms of the contrasts between tense and lax vowels. Since Mandarin has fewer contrasts, the range of allophonic variation of each vowel phoneme is also expected to be much greater than in English;
for instance, the Mandarin /i/ may have allophones within the area bounded by [i], [iy], and [ɨ] (see Figure 5). This interprets well why Mandarin-speaking EFL learners have problems distinguishing *bet-bat* (Liu, 2001) and *bit-beat, cat-cot, cot-cut, cot-caught*.

To help EFL learners solve the above problems, the traditional understanding of the vowel space does not seem to provide substantial assistance. Since the traditional concept regards the vowel contrasts as more of a perception issue. Lado (1966) said that “the contrast between /i/ and /ɨ/ need not be considered a perception problem. It is a speaking problem.” He illustrated this with the German speaker who may “produce a difference in length rather than a difference in quality, and the lack of a quality difference will confuse the English-speaking listener.” (Lado, 1966. P. 22) Here I will assume that the vowel issues are two-fold. First, it is undoubtedly a perception problem. If a language acquirer or learner cannot perceive the subtle quality of vowel, how can he/she imitate and then acquire the vowel? In other words, one can copy or imitate a sound well only if one can distinguish the sound quality by listening, which I will regard as perception. Second, there is also a production or speaking problem. Since the quality of the two vowels matters significantly, there might be plenty of evidence or data that might help English learners to follow. For instance, if the learners are aware of the contrastive movement of the sound while producing the /i/ and /ɨ/ sound in English, which is completely different from producing the /i/ sound in Mandarin, the learners will know better when they go through the processes of picking up the accent. The findings also provide plenty of evidence that Californian English speakers produce their vowels on the basis of clear contrast of each pair of tense-lax vowel sets. This interprets why English native speakers have no problem with confusion in their own language.

The most widely-used procedure in helping EFL learners enhance their English pronunciation is to present minimal pairs of words, with or without context; it has been “taken for granted that the learner is capable of profiting from this. In reality, this type of thing is still quite beyond him: he is just not ready for doing it effectively, and he needs preparing so as to be ready.” (MacCarthy, 1976) “The deconditioning process should take the form of presenting to the ear as a preliminary, each of the basic phenomena of speech in its simplest form, far simpler than the form in which such phenomena would normally appear, when one thinks of the combination and superimposition of auditory features as they occur in any actual spoken language.” MacCarthy continued suggesting that the learner be first given a demonstration of some specific thing, and be told precisely what it is that is being demonstrated and then his attention needs to be drawn, carefully and systematically, to the difference between the separate auditory effects that he is being asked to
notice, by giving him the chance to hear the two stimuli juxtaposed.

This is exactly what this paper aims to provide here—a precise description of the pairs with specific contrastive vowel qualities like bit-beat and the contiguous pairs like bet-bat that most widely confuse second language learners without similar phonemic systems. In the processes of instruction or learning, PRAAT can serve as a useful instrument to help English learners check on themselves and see whether they personally are able to distinguish correctly between the two, or more, sound qualities involved. The simple repeat-after-me procedure may not be precise enough although it is still the most convenient one. Once in a while, the learners might want to use sound analyzers to make sure that their auditory judgments are as precise as the analytical data provided by the technological instruments.

There will be empirical studies following this project. The coming studies will focus on three things: (1) to analyze a larger set of data, including employing a linguistic corpus available now (such as *Santa Barbara Corpus of Spoken American English*) to explore more patterns concerning the subject matter discussed in this paper; (2) to analyze every vowel in English and in Mandarin to see if there is more contrastive information; and (3) to apply the findings in workshops or EFL classes to see if the findings of this study are beneficial to Taiwanese EFL learners if they have the motivation to polish their pronunciation. My conjecture is that these findings will both help EFL students focus their attention on specific phonetic qualities while they listen to the authentic sounds and help them with more detailed instructions while they need to produce the sound they hear. The pedagogical values of these findings are highly expected.

**Works Cited**


**Appendix A**

The utterances used as recording materials related to this study:

Mandarin vowels:

譬如說：這件裙子太窄了 (For the vowel /i/)
他的背很直 (For the vowel /ei/)
一吐就吐出來 (For the vowel /u/)
別再摳氣了 (For the vowel /ou/)
妹妹喜歡吃摩斯漢堡 (For the vowel /ɔ/)
阿德詐財成性 (For the vowel /a/)
English vowels:

The pea is a kind of plant. (For the vowels /i/ and /ɪ/)

The bay has fresh air. (For the vowel /ei/)
Yes, you are right. (For the vowel /ɛ/)

Odd jobs are here and there. (For the vowel /a/)
Two judges will be enough. (For the vowel /ʌ/)

Me too. (For the vowel /u/)
Your tie looks cute. (For the vowel /u/)

Do you believe that a rolling stone gathers no moss? (For the vowel /ɔ/)
I owe the landlord one hundred dollars. (For the vowel /ou/)