A Study on Production of English Vowels by Taiwanese Adult Learners: An Acoustic Perspective

Ming-Chung Cheng*

Abstract
This study presents an acoustic study of English vowel production by 10 male and 10 female Taiwanese adult speakers (TASs) who are learning English as a foreign language and compares $F_1$ and $F_2$ values of ten English vowels pronounced by them and English native speakers (ENSs). Each subject’s vowel sounds are recorded and measured three times in order to acquire objective results. Results show that TASs and ENSs are different in vowel height and frontness. Pedagogical implications with the major finding are provided for teachers to help TASs improve their pronunciation.

Key words: vowel production, acoustics, phonetics, adult EFL learner

1. Introduction
As students learn a foreign language, they usually experience difficulties in the target language pronunciation. This situation is quite obvious in Taiwan. Learning in an English-as-a-foreign-language (EFL) environment in which English is not used outside the classroom, they usually find pronunciations of English difficult to master. Moreover, students usually learn English under the influence of their mother tongue (Flege, 1989; Odlin, 1989). Ing (1988) indicates that, when learning English consonants, learners with Taiwanese as their first language sometimes substitute /h/ for /l/ in ‘force’, /s/ for /θ/ in “thick”, and /l/ for /θ/ in ‘that’. In addition to substitution, other processes, like insertion (e.g. /laida/ for /latt/ in ‘light’), deletion (e.g. deletion of syllable-final stops as in ‘sit’), and transformation (e.g. /daŋ/ for /daun/ in ‘down’) occur, too. It is no doubt that their native language has a great influence upon their acquisition of the target language pronunciation. To illustrate, substitution occurs when students learn the sounds of the target language, but there are no corresponding counterparts in their mother tongue. In such a situation, interlingual interference occurs because “the native language is the only previous linguistic system upon which the learner can draw” (Brown, 2000, p. 224).

Similar to the production of English consonants, the productions of English vowels by Taiwanese learners also present a complicated condition. For example, native speakers of Taiwanese find it difficult to pronounce /æ/, which does not appear in sound inventory of Taiwanese. Furthermore, they are usually confused with the length of

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vowels, as /i/ versus /ɪ/ and /u/ versus /ʊ/.
Confusion of English vowel length is owing to
the lack of such vowel
length distinctions\(^1\) in Taiwanese. In Taiwanese
sound inventory exist only long vowels. In brief,
phonetic inaccuracies mentioned above show that
Taiwanese influences the acquisition of English
sounds whether vowels or consonants.

In this study, the researcher collected data
from a vocational high school in southern Taiwan.
Some students in this program are adult EFL
learners, who are experiencing difficulties in
correctly pronouncing English vowels. For
example, one of their English vowel production
errors results from the failure in vowel length
distinctions. To illustrate, when sound pairs,
such as /i,ɪ/ and /e,ɛ/, are used in pronunciation
practice, they do not feel hard to pronounce these
sounds. Nevertheless, when short vowels are
articulated alone, they have the sensation that
pronouncing English short vowels is quite
difficult, and, sometimes, short vowels sound like
their long counterparts. In addition, their errors
also include the confusion of /eɪ/ and /æ/ and the
misplacement of the tongue position for English
vowels. Auditorily speaking, in terms of
Sonority Hierarchy (Katamba, 1989; Roca &
Johnson, 1999), which states that low vowels are
the most sonorous, /æ/ should be ‘louder’ than /eɪ/.
However, students pronounce /æ/ as /eɪ/ in words,
like ‘apple’, ‘apt’ and ‘ask’. That is, they place
their tongue position higher than that of /æ/ and
similar to that of /eɪ/. Moreover, long vowels /ɪ/,
/eɪ/, /u/ and /o/ exist in both English and
Taiwanese, hence, compared with the short
vowels, adult EFL learners state that it is much
easier to pronounce long counterparts. However,
though these sounds are perceptually similar, are
they acoustically similar? Even though both
native and target languages have the same sounds,
they may be acoustically different. (Odlin, 1989)

Kenworthy (1997) indicates that many
factors (e.g. the mother tongue, the age, the
amount of exposure, attitude and identity, etc)
may also play significant roles in learners’
pronunciation acquisition. Cenoz and Lecumberri
(1999) confirm that training has a positive effect
upon the discrimination of English vowels.
Flege (1995), Munro (1996) and Flege, Bohn and
Jang (1997) also state that the incorrect
pronunciation has relations to the amount of
experiences of or exposures to the target language.
Hence, compared with young learners, adult
learners in Taiwan are more influenced by the
native language, get less exposure of English, and
more identify of the native cultures. It is this
kind of learners that teachers should pay more of
their attention to.

In addition, it has been widely reported that
individuals with an Asian language as their
mother tongue will show phonetic inaccuracies
when they learn English as their second language
(Flege, 1989; Pittam & Ingram, 1992; Torone,
phonetic inaccuracies may result from the
segmental, prosodic or rhythmic differences
between the first and second languages (Anderson-

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\(^1\) In Taiwanese, the only short vowel is /o/, as contrasted with
its long counterpart /o/. However, /o/ occurs in quite limited
environment. For more details, please refer to Chung (1996)
and Ting (1979).
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hsieh & Venkatagiri, 1994; Cheng, 1987; Eady, 1982; Fan, Chen & Lin, 1998; Os, 1985). Languages in Taiwan and English differ from each other in segments, prosody (i.e. tone vs. intonation), and rhythmic patterns (i.e. syllable-timed vs. stress-timed); therefore, it is worthwhile to explore whether or not phonetic inaccuracies occur.

Nowadays, more and more Taiwanese learn English as a foreign language; thereby, it is essential to establish the acoustic data between English and Chinese languages, such as Mandarin, Taiwanese, Hakka, etc. However, studies in the literature (Flege, Bohn and Jang, 1997; Chen, et al, 2001) confined their attention to the influence of Mandarin on productions of English. To my knowledge, few studies focus themselves on the productions of English vowels by Taiwanese EFL adult learners. To establish such acoustic data is urgent and significant. Thereby, the aims of this study are to explore English vowel productions from an acoustic perspective, to compare the acoustic differences of English vowels pronounced by English native speakers (ENSs) and Taiwanese adult speakers (TASs), and to provide English teachers with pedagogical implications for the instruction of English vowel pronunciations for adult EFL learners.

The purpose of this study focuses on the investigation of the differences of English vowels in terms of the first formant ($F_1$) and the second formant ($F_2$), which will be further probed below. English vowels articulated by native speakers are compared with those pronounced by TASs. Both genders are taken into consideration. Based on the comparison of $F_1$ and $F_2$, pedagogical implications for improving adult English vowel productions can be reached. Thereby, the research question is stated below.

**Research Question**

What are the differences of English vowels pronounced by ENSs and TASs in terms of $F_1$ and $F_2$ on the one hand and in terms of different genders on the other hand?

### 2. A Brief Sketch of English and Taiwanese Vowels, Vowel Formants

In this section are the literature review of (1) vowels in American English and those in Taiwanese and (2) $F_1$ and $F_2$ of vowels and their relations to places of articulation of vowels, all of which are further narrated respectively below.

#### 2.1 Vowels in American English and Taiwanese

This study involves ten vowels of American English (i.e. /i/, /ɪ/, /e/, /ɛ/, /æ/, /ʌ/, /ʊ/, /o/, /ɔ/, and /ɑ/). Traditionally, vowels can be distinguished in terms of tongue height (i.e. high, mid, and low) and tongue advancement (i.e. front, central, and back) (Gimson, 1989; Katamba, 1989). Figure 1 contains vowel charts of American English and Taiwanese in which each vowel is placed in their appropriate positions (Mackay, 1987; Pollock & Berni, 2001; Prator & Robinett, 1998; Sun, 2002, to name just a few).

Taiwanese\(^2\) is one of the eight major dialects

\(^2\) Other names for Taiwanese include South Min, Southern Min, Xiamen, etc.
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in China, which is spoken mainly in Southern Taiwan (Li, 1992). Similar to Mandarin, Cantonese and Hakka, Taiwanese is a tone language in which seven lexical tones are used to distinguish different word meanings (Chung, 1996; Ting, 1979; Zhang, 1989; among others). In Taiwanese exist ten vowels, four are nasalized vowels, one is a short vowel and five are oral long vowels; the latter of which is the major concern in this study. Note that, though Taiwanese vowels are given in Figure 1, this study does not place many emphases upon the language interference from Taiwanese vowels to English ones.

Ten Vowels in American English

![American English Vowel Chart](image1)

Six Oral Vowels in Taiwanese

![ Taiwanese Vowel Chart](image2)

Figure 1 American English and Taiwanese Vowel Charts

On the basis of Figure 1, Taiwanese, similar to English, have long vowels; however, it does not have short vowels. Moreover, the quality of /e/ and /o/ in Taiwanese are not the same as those in English.\(^3\) /e/ and /o/ in English are pronounced as /ey/ and /ow/, a process known as “gliding” (Ladefoged, 2001a). However, the focus of this study is on how Taiwanese adult EFL learners can be directed to correctly pronounce the English vowels. Though /e/ and /o/ in English are different from those in Taiwanese, it does not seem to have a great influence upon the research results.

2.2 Formant 1 (F\(_1\)), Formant 2 (F\(_2\)) and Place of Articulation of Vowels

From an acoustic viewpoint, the quality of different vowels depends on their overtone structures (Fry, 2001; Lass, 1996; Singh & Singh, 1982, among others). When a sound is articulated, the vocal folds vibrate to produce pitch (F\(_0\)), which is perceived either as intonation in English or as tone in Taiwanese (Wang, 1988). However, at the same time, the articulated sound contains a number of overtones, the lowest two are called F\(_1\) and F\(_2\). F\(_1\) and F\(_2\) are different from F\(_0\), because they are decided by the shape of the oral cavity (i.e. resonance chamber). Different sounds result from different shapes of oral cavity.

Traditionally, based on articulatory-based approach, the productions of vowels are described in terms of the height and the backness of the tongue (Ladefoged, 2001b). However, “the traditional articulatory descriptions of vowels are

\(^3\) Thanks to one of the reviewers for reminding me of the differences between English and Taiwanese.
related to the formant frequencies” (Ladefoged, 2001b, p. 176). In other words, $F_1$ and $F_2$ can be used to characterize the productions of vowels. $F_1$ is related to vowel height inversely. The higher $F_1$ is, the lower the tongue height is. Hence, high vowels have low $F_1$, whereas low vowels have high $F_1$. As far as $F_2$ is concerned, it is related to the degree of backness of vowels. Namely, the higher $F_2$ is, the more advanced the vowel is. Hence, front vowels have high $F_2$, whereas back vowels have low $F_2$. To depict vowel space, Ladefoged (1993) suggests:

There is a better correlation between the degree of backness and the distance between the first two formants, which are far apart in front vowels and close together in back vowels. Furthermore, the distance between the two formants decreases in the front vowels, a fact that fits the traditional articulatory descriptions. (p. 196)

3. Methodology

This section presents the design of this research, which includes subjects, speech materials, instruments, procedures and acoustic analysis, each of which are further explicated respectively.

3.1 Subjects

Two groups of individuals get involved in this study. The first group contains twenty native speakers of American English, ten males and ten females. They speak American English as their first language. They are now teaching in institutes of technology or public high schools in Taiwan. Another group consists of twenty TASs (ten males and ten females) in the Department of Continuing Education in National Kangshan Vocational High School, and they are now learning English as a foreign language. They are selected based on the following criteria. First of all, Taiwanese is the most commonly used language in their daily life and after class. Though they are able to speak Mandarin, it is rarely used in their daily lives, except in very formal situation. Second, they have received formal instruction of English for at least three years in the Department of Continuing Education in public junior high schools. Third, they have the ability to pronounce English vowel sounds without great difficulties. Fourth, their learning achievements of English are much better than those of other students in the class. The average ages of Taiwanese adult male and female speakers are 35.5 (range= 31 - 45 years) and 34.5 (range= 28 – 40 years) respectively.

3.2 Speech Materials

All the subjects in this study pronounce a list of English words, as shown in Table 1. Eight English vowels (i.e. /i/, /I/, /e/, /æ/, /u/, /u/, /O/, and /a/) are placed into the context of $hVd$, forming words ‘heed’, ‘hid’, ‘head’, ‘had’, ‘who’d’, ‘hood’, ‘hawed’, and ‘hod’. /e/ and /o/ are put in words ‘hay’ and ‘home’ respectively.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Speech materials of English vowels and Taiwanese vowels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>English Vowels</td>
</tr>
<tr>
<td>heed</td>
<td>/hid/</td>
</tr>
<tr>
<td>hid</td>
<td>/hid/</td>
</tr>
<tr>
<td>hay</td>
<td>/he/</td>
</tr>
<tr>
<td>head</td>
<td>/hed/</td>
</tr>
<tr>
<td>had</td>
<td>/hed/</td>
</tr>
<tr>
<td>who’d</td>
<td>/hud/</td>
</tr>
<tr>
<td>hood</td>
<td>/hud/</td>
</tr>
<tr>
<td>home</td>
<td>/hom/</td>
</tr>
<tr>
<td>hawed</td>
<td>/hOd/</td>
</tr>
<tr>
<td>hod</td>
<td>/hod/</td>
</tr>
</tbody>
</table>
3.3 Instruments

The instruments in the present study consist of a notebook computer and a desktop computer. The notebook computer is used when data are collected – that is, the sounds are recorded directly into the computer and saved as WAV files, which ensures that the collected speech data will not be converted during transmission from the notebook computer to the desktop computer. The desktop computer is used to analyze the collected speech data. Both of them have P4 1.8G Hz CPUs. Besides, Praat, a spectrographic program composed by Dr. Paul Boersma and Dr. David Weenink and designed to analyze speech, is utilized in the study. The functions of Praat include formant analyses, pitch and intensity analyses and spectrographic analyses. It is a shareware, which can be downloaded from the website [http://www.praat.org](http://www.praat.org). This program has been setup in both computers. In addition, a microphone is also utilized in this study. The microphone is linked to the notebook computer in order to record the speech sounds.

3.4 Procedures

The procedures can be divided into two stages, data collection and data analysis, which will be explained in subsequent sections.

In data collection stage, ENSs pronounced English words. Their speeches, with rate and intensity maintained, were recorded in a quiet room.

As for TASs, they were also encouraged to articulate English words. To make them familiarize with the English words, the list of words had been given to them one week before the experiment was done. They could practice the words and ask questions about them. The speech data were recorded in a language lab. Students entered the lab one by one for fear that their talking might reduce the recording quality. They were encouraged to pronounce the words with the same pace and intensity. No corrections or clues, even if they made mistakes, were given to them during the recording session so that their pronunciations could be as natural and spontaneous as possible. Each TASs needs to pronounce the words three times and each time is at regular intervals of a week from other times. In the stage of data analysis, Praat is utilized to measure the frequencies of $F_1$ and $F_2$ for English vowels.

4. Results and Discussions

In this section are the analyzing results and discussions of the collected speech data. The emphases are placed on two aspects. In terms of $F_1$ and $F_2$, the first discussion focuses on the comparison of English vowels produced by male native speakers of English (MNSs) and Taiwanese male adult speakers (TMASs). The next focus is on the comparison of English vowels produced by English female native speakers (FNSs) and Taiwanese female adult speakers (TFASs).4

4 Comparisons in section 4 are based on the means of $F_1$ and $F_2$ values. However, the results are slightly different from teaching implications given in Table 6, which is based on the results of Independent-Sample $t$-test of all collected $F_1$ and $F_2-F_1$ values. The slight differences result partly from the different types of comparisons and partly from the compared data.
4.1 Comparison of English vowels produced by MNSs and TMASs

This section presents the comparison of English vowels produced by MNSs and TMASs in terms of $F_1$ and $F_2$. Table 2 and 3 below show the mean values of $F_1$, $F_2$ and $F_2 - F_1$ of ten English vowels by MNSs and TMASs respectively.

**Table 2** $F_1$, $F_2$ and $F_2 - F_1$ of ten American vowels by MNSs

<table>
<thead>
<tr>
<th>Vowel</th>
<th>$F_2$</th>
<th>$F_1$</th>
<th>$F_2 - F_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>2335</td>
<td>410</td>
<td>1925</td>
</tr>
<tr>
<td>e</td>
<td>2120</td>
<td>514</td>
<td>1606</td>
</tr>
<tr>
<td>æ</td>
<td>2233</td>
<td>421</td>
<td>1812</td>
</tr>
<tr>
<td>ə</td>
<td>1922</td>
<td>538</td>
<td>1384</td>
</tr>
<tr>
<td>O</td>
<td>1801</td>
<td>798</td>
<td>1003</td>
</tr>
<tr>
<td>o</td>
<td>1437</td>
<td>798</td>
<td>639</td>
</tr>
<tr>
<td>u</td>
<td>1659</td>
<td>790</td>
<td>869</td>
</tr>
<tr>
<td>ɔ</td>
<td>1586</td>
<td>642</td>
<td>944</td>
</tr>
<tr>
<td>ɔ̅</td>
<td>1777</td>
<td>632</td>
<td>1145</td>
</tr>
<tr>
<td>u̅</td>
<td>1504</td>
<td>443</td>
<td>1061</td>
</tr>
</tbody>
</table>

**Table 3** $F_1$, $F_2$ and $F_2 - F_1$ of ten American vowels by TMASs

<table>
<thead>
<tr>
<th>Vowel</th>
<th>$F_2$</th>
<th>$F_1$</th>
<th>$F_2 - F_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>2207</td>
<td>625</td>
<td>1582</td>
</tr>
<tr>
<td>e</td>
<td>1852</td>
<td>512</td>
<td>1340</td>
</tr>
<tr>
<td>æ</td>
<td>1994</td>
<td>559</td>
<td>1435</td>
</tr>
<tr>
<td>ə</td>
<td>1977</td>
<td>544</td>
<td>1433</td>
</tr>
<tr>
<td>O</td>
<td>1879</td>
<td>627</td>
<td>1252</td>
</tr>
<tr>
<td>o</td>
<td>1422</td>
<td>902</td>
<td>520</td>
</tr>
<tr>
<td>ɔ̅</td>
<td>1558</td>
<td>683</td>
<td>875</td>
</tr>
<tr>
<td>o̅</td>
<td>1637</td>
<td>667</td>
<td>970</td>
</tr>
<tr>
<td>u̅</td>
<td>1459</td>
<td>587</td>
<td>872</td>
</tr>
<tr>
<td>u</td>
<td>1451</td>
<td>551</td>
<td>900</td>
</tr>
</tbody>
</table>

4.1.1 Comparison of $F_1$ of English Vowels by MNSs and TMASs

In this part, $F_1$ of English vowels by MNSs and TMASs will be exhibited and analyzed. Figure 2 presents $F_1$ values of ten English vowels by MNSs and TMASs.

![Figure 2](image)

From Figure 2, TMASs are similar to MNSs in the production of /i/, /e/, /o/ and /u/. As stated in section 2, $F_1$ is inversely related to the tongue height. The higher $F_1$ value is, the lower the tongue position is. Hence, in productions of /i/, /e/, /o/ and /u/, TMASs’ tongue position is lower than MNSs’. By contrast, TMASs’ tongue position is higher than that of MNSs in the production of /æ/ and /O/.

4.1.2 Comparison of $F_2$ of English Vowels by MNSs and TMASs

In this part are $F_2$ values of ten English vowels by MNSs and TMASs. Figure 3 presents $F_2$ values of ten English vowels by MNSs and TMASs.

![Figure 3](image)
From Figure 3, the contours of TMASs and MNSs are similar in the production of vowels /i/, /e/, /æ/, /ɑ/, /ɑ/, /ɔ/, and /u/. \(F_2\) is in relation to the tongue advancement. The higher \(F_2\) value is, the more advanced the tongue position is. Hence, in productions of /i/, /e/ and /u/, TMASs’ tongue position is not so advanced as MNSs’. Figure 4 shows the format chart of English vowel productions of both MNSs and TMASs.

![Figure 4](image)

**Figure 4** A formant chart showing the frequency of the first formant on the ordinate (the vertical axis) plotted against the distance between the frequencies of the first and the second on the abscissa (the horizontal axis) for eight American vowels. Thin line stands for MNS’s vowels and thick line represents TMAS’s vowels.

Based on Figure 4, the distance between the same sounds articulated by MNSs and TMASs can be used to express the degree of deviance. In other words, the longer the distance is, the more deviant the sound pronounced by MNSs and TMASs is. Hence, in terms of front vowels, TMASs have more difficulties in pronouncing /i/ and /e/ than /i/ and /E/, for the distance between /i/ by MNSs and /i/ by TMASs, and the distance between /e/ by MNSs and /e/ by TMASs are longer than those of /i/ and /E/. Hence, unlike their perception that long vowels are easier to articulate than short vowels, in actual pronunciation, they perform better in front short vowels than front long ones. As far as back vowels are concerned, the distance of /o/ by MNSs and TMASs are shorter than that of /O/. That is, they are experiencing less difficulties in pronouncing /o/ than /O/. Hard to differentiate, the distance of /u/ and /O/ are similar. This phenomenon shows that TMASs may be experiencing nearly the same difficulties in articulating /u/ and /O/.

### 4.2 Comparison of English vowels produced by FNSs and TFASs

This section presents the comparison of English vowels produced by FNSs and TFASs in terms of \(F_1\) and \(F_2\). Table 4 and 5 below show the mean values of \(F_1\), \(F_2\) and \(F_2-F_1\) of ten English vowels by FNSs and TFASs respectively.

**Table 4** \(F_1\), \(F_2\) and \(F_2-F_1\) of ten American vowels by FNSs

<table>
<thead>
<tr>
<th>Vowel</th>
<th>(F_1)</th>
<th>(F_2)</th>
<th>(F_2-F_1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>2407</td>
<td>430</td>
<td>1977</td>
</tr>
<tr>
<td>i</td>
<td>2106</td>
<td>540</td>
<td>1566</td>
</tr>
<tr>
<td>e</td>
<td>2361</td>
<td>448</td>
<td>1913</td>
</tr>
<tr>
<td>e</td>
<td>2008</td>
<td>644</td>
<td>1364</td>
</tr>
<tr>
<td>æ</td>
<td>1920</td>
<td>942</td>
<td>978</td>
</tr>
<tr>
<td>a</td>
<td>1597</td>
<td>886</td>
<td>711</td>
</tr>
<tr>
<td>O</td>
<td>1518</td>
<td>808</td>
<td>710</td>
</tr>
<tr>
<td>o</td>
<td>1461</td>
<td>613</td>
<td>848</td>
</tr>
<tr>
<td>u</td>
<td>1562</td>
<td>590</td>
<td>972</td>
</tr>
<tr>
<td>u</td>
<td>1486</td>
<td>494</td>
<td>992</td>
</tr>
</tbody>
</table>
Table 5  \(F_1, F_2 \) and \( F_2 - F_1 \) of ten American vowels by TFASs

<table>
<thead>
<tr>
<th></th>
<th>(F_2)</th>
<th>(F_1)</th>
<th>(F_2 - F_1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>1921</td>
<td>442</td>
<td>1479</td>
</tr>
<tr>
<td>t</td>
<td>2042</td>
<td>478</td>
<td>1564</td>
</tr>
<tr>
<td>e</td>
<td>1976</td>
<td>567</td>
<td>1409</td>
</tr>
<tr>
<td>e</td>
<td>2018</td>
<td>581</td>
<td>1437</td>
</tr>
<tr>
<td>æ</td>
<td>1869</td>
<td>680</td>
<td>1189</td>
</tr>
<tr>
<td>o</td>
<td>1632</td>
<td>934</td>
<td>698</td>
</tr>
<tr>
<td>O</td>
<td>1447</td>
<td>742</td>
<td>705</td>
</tr>
<tr>
<td>o</td>
<td>1322</td>
<td>739</td>
<td>583</td>
</tr>
<tr>
<td>u</td>
<td>1518</td>
<td>506</td>
<td>1012</td>
</tr>
<tr>
<td>o</td>
<td>1464</td>
<td>532</td>
<td>932</td>
</tr>
</tbody>
</table>

4.2.1 Comparison of \(F_1\) of English Vowels by FNSs and TFASs

In this part, \(F_1\) values of English vowels by FNSs and TFASs are discussed. Figure 5 below presents \(F_1\) values of ten English vowels by FNSs and TFASs.

Figure 5  \(F_1\) values of ten English vowels by FNSs and TFASs

From Figure 6, the contour of \(F_2\) is not as deviant as that of \(F_1\). TFASs and FNSs are similar in the production of vowels /ɪ/, /ɛ/, /æ/, /ɑ/, /ɒ/, /u/ and /ʊ/. When producing /ɪ, /ɛ/ and /ɑ/, TFASs’ tongue position is not as advanced as FNSs’. Figure 7 shows the format chart of English vowel productions of both FNSs and TFASs.

Figure 6  \(F_2\) values of ten English vowels by FNSs and TFASs

Based on Figure 7, in terms of front vowels, similar to TMAss, TFASs have more difficulties in pronouncing /i/ and /ɛ/ than /ɪ/ and /ɛ/, for the distance between /i/ by MNSs and /ɪ/ by TMAss, and the distance between /ɛ/ by MFSs and /ɛ/ by TFASs are longer than those of /i/ and /ɛ/. As far as back vowels are concerned, the distance of /ʊ/ by FNSs and TFASs are longer than that of /ɒ/. That is, TFASs are experiencing less difficulties in pronouncing /ɒ/ than /ɒ/. Moreover, the distance of /u/ is shorter than that of /ʊ/. In other words, /ʊ/ than /u/, is more difficult to articulate.

Figure 7  A formant chart showing the frequency of the first formant on the ordinate (the vertical axis) plotted against the distance between the frequencies of the first and the second on the abscissa (the horizontal axis) for eight American vowels. Thin line stands for FNS’s vowels and thick line represents TFAS’s vowels.
5. Conclusion

This section presents the summary of the main findings in this study and pedagogical implications of language instruction are also provided. What is more, some limitations as well as suggestions for future studies are proposed for researchers who intend to conduct further studies.

5.1 Summary of the Main Findings

This study investigates the productions of English vowels by 20 adult EFL learners (10 males and 10 females) whose mother tongue is Taiwanese. The main findings are stated as follows.

First of all, in terms of F<sub>1</sub>, TMASs are similar to MNSs in the production of /I/, /E/, /o/ and /U/. In productions of /i/, /e/, /a/, and /u/, TMASs’ tongue position is lower than that of MNSs. By contrast, TMASs’ tongue position is higher than that of MNSs in the production of /Q/ and /O/. Concerning TFAS, TFASs is similar to FNSs in the productions of /I/ and /u/. However, in productions of /e/, /æ/ and /o/, TFASs’ tongue position is slightly lower than that of FNSs. By contrast, TFASs’ tongue position is higher than that of FNSs in the production of /I/, /E/, /Q/, /A/, /O/, /u/ and /ʊ/.

Next, as far as F<sub>2</sub> is concerned, TMASs and MNSs are similar in the production of vowels /i/, /e/, /æ/, /ø/, /o/ and /ʊ/. However, in productions of /i/, /e/ and /æ/, TMASs’ tongue position is not so advanced as MNSs. As for TFASs, TFASs and FNSs are similar in the production of vowels /i/, /e/, /æ/, /ø/, /o/ and /ʊ/. When producing /i/, /e/ and /æ/, TFASs’ tongue position is not as advanced as FNSs’.

Third, unlike their perception that long vowels are much easier to pronounce than short ones, both genders exhibit some difficulties to pronounce long vowels. For TMASs, /i:/ and /æ:/ are more difficult than their short counterparts. For TFASs, /I/, /e/ and /O/ are easier than their long counterparts.

5.2 Pedagogical Implications for Teachers and TASs

According to the discussion and comparison of English vowel productions between ENSs and TASs, here are pedagogical implications for teachers who are now teaching adult EFL learners whose first language is Taiwanese and for Taiwanese adult learners of English. Table 6 presents the pedagogical implications in terms of tongue positions of vowels when TASs try to produce English vowels. Note that the criterion for determining +, = or – is based on the results of Independent-Sample t-test. P-value less than .05 indicates that differences between ENSs and TASs are statistically significant, indicated by an asterisk (*). Take /i/ and /æ:/ for TMAs in Table 6 for example. When pronouncing /i/, TMAs should place their tongue more advanced and higher than they actually do. On the contrary, TMAs’ tongue position should be placed less advanced and lower than they actually do when they pronounce /æ:/.

Therefore, Table 6 will be helpful for English teachers to improve their adult students’ productions of English vowels.
Table 6  Pedagogical Implications for TASs' English Vowel Productions

<table>
<thead>
<tr>
<th></th>
<th>For TMASs</th>
<th>For TFASs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tongue</strong></td>
<td><strong>(p-value)</strong></td>
<td><strong>(p-value)</strong></td>
</tr>
<tr>
<td><strong>i</strong></td>
<td>Height: +.001* = .763</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advancement: +.000* = .000*</td>
<td></td>
</tr>
<tr>
<td><strong>I</strong></td>
<td>Height: + .935 = .104</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advancement: + .011* = .965</td>
<td></td>
</tr>
<tr>
<td><strong>e</strong></td>
<td>Height: +.000* = +.000*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advancement: +.000* = +.000*</td>
<td></td>
</tr>
<tr>
<td><strong>e</strong></td>
<td>Height: +.012* = .088</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advancement: - .046* = .378</td>
<td></td>
</tr>
<tr>
<td><strong>æ</strong></td>
<td>Height: - .000* = - .000*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advancement: - .003* = - .018*</td>
<td></td>
</tr>
<tr>
<td><strong>a</strong></td>
<td>Height: + .023* = .444</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advancement: = .152 = .856</td>
<td></td>
</tr>
<tr>
<td><strong>O</strong></td>
<td>Height: -.009* = .117</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advancement: = .960 = .962</td>
<td></td>
</tr>
<tr>
<td><strong>o</strong></td>
<td>Height: = .410 = -.001*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advancement: = .783 + .006*</td>
<td></td>
</tr>
<tr>
<td><strong>o</strong></td>
<td>Height: = .212 = -.011*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advancement: + .002* = .507</td>
<td></td>
</tr>
<tr>
<td><strong>u</strong></td>
<td>Height: + .000* = .404</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advancement: = .123 = .406</td>
<td></td>
</tr>
</tbody>
</table>

(‘+’ means that the tongue place of TASs should be ‘more advanced or higher’ than they actually do. ‘-’ represents ‘less advanced or lower’ and ‘=’ means that the tongue is placed “equally” the same position.)

5.3 Limitations and Suggestions for Further Study

Though this study yields several findings in terms of acoustic analysis, several limitations consist in this study. First, for any study to be convincing and objective, more subjects, including ENSs and TASs, need to be recruited. Hence, further studies should include more subjects so as to obtain much more objective data. Second, the speech material of this study only focuses on the context of hVd, left other linguistic contexts untouched. Especially, as indicated by Ladefoged (2001b, p. 232) that “vowels are always longer before voiced consonants than before voiceless,” both ENSs and TASs produced ‘lengthened’ short vowels, which may explain why TASs did not show much difference from ENSs in short vowel productions, and came to a biased conclusion that TASs have less difficulties with short vowels than with long vowels. Hence, other linguistic contexts, such as hVt, also need to be taken into full consideration. Third, it is common in the Departments of Continuing Education that adult students sit side by side with young students. Hence, further research can compare English vowel productions between ENSs, TASs, and young learners in order to establish a multi-faceted perspective about the productions of English vowels.

References

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