

# **Acoustic Analysis of Taiwanese Learners' Pronunciation in English Vowels**

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## **Abstract**

"Acoustic phonetics" is the method of dealing with the speech measurement and providing a record of speakers' pronunciation in terms of intensity, frequency, and the articulatory properties. This study focuses on utilizing native speaker's vowel patterns for comparing the measurement obtained from Mandarin Chinese speakers, in order to employ the quantitative evidence for the absence or presence of certain features. The analysis of acoustic phonetics enhances our understanding and perception of the fundamental components of speech sounds. The comparison between the Chinese subjects' productions of English vowels and Chinese vowels indicates that the problem of inaccurate pronunciation results from L1 interference. Based on the findings of this acoustic study, some pedagogical implications are suggested.

## **1. Introduction**

### **1.1 Developing Phonological Perception**

In recent years, phonics approach, involving both decoding and encoding perspectives, has been viewed as one of effective ways for promoting learner's reading skills and speech performance. A great deal of studies are concerned with applying phonics to teach English pronunciation of EFL adults or young children. (Kuo, 2000; Lin, 2001) However, the study regarding the effects of auditory perception, through computer assistance and web learning, on improving learners' phonological awareness, word recognition, and reading skills is still on

the call. "Acoustic phonetics" is the method of recording, recognizing, and distinguishing different sounds. So, it deals with the measurement of speech in terms of intensity and frequency as well as its dynamic articulatory properties. In this view, this project attempts to employ the quantitative evidence for the absence or presence of certain features. Another purpose is to explain how acoustic phonetics enhances our understanding and perception of the fundamental components of speech sounds.

## 1. 2 Acoustic-Phonetic Perspective

Recent work in speech research demonstrated that certain articulatory properties of speech sounds could be recorded, analyzed, and evaluated in the computer laboratories. The linguists access these convenient paths to sound analysis through web assistance and computer software. The three acoustic properties of speech sounds- duration, frequency and pitch, amplitude and loudness- are examined with the help of electronic equipment known as sound spectrograph. The *frequency* of a speech sound refers to the vibration rate of the vocal folds during the sound production. Then, *intensity*, as the result of the energy of air displacement, mainly refers to the articulatory quality. Moore (In Hardcastle & Laver (eds.), 1999) states that for speech sound, the variations in voiced pitch convey intonation which can identify stressed words. Furthermore, the voiced pitch also can convey information about the gender, age, and the affective state of the speakers. As a result, the acoustic features, correlating with the other articulatory features, can be collected from the normal speech patterns of individuals of variant age or gender. In this project, I will focus on utilizing native speaker's vowel patterns for comparing the measurement obtained from Mandarin Chinese speakers.

## 2. Background of the Study and Relevant Literature Review

### 2.1 Distinctive Features of Vowels

According to the vowel analysis of Singh and Singh (1982), the differences between the vowels of English can be examined in terms of articulatory location and the formant frequencies. The sound spectrogram of the vowels can be observed based on the distance of F1, F2, and F3. Ball & Rahilly (1999) suggested vowel height is reflected in F1, tongue advancement is reflected in F2, and lip rounding affect the overall energy throughout the formants. The value of vowels will change according to speaker and accent. This acoustic experiment will focus on the comparison of eight vowels, /i/, /I/, /E/, /Θ/, /A/, /□/, /Y/, /υ/, in the words "*heed, hid, head, had, hood, hawed, who'd.*"

Moreover, American English vowels, /A/, /ι/, /υ/, /ε/ and /o/, have the counterparts of /Υ/, /—/, /×/, /世/, and /又/ in Mandarin Chinese language. Different from American language, the Mandarin language owns the medial vowels, such as /—/, /×/ can be linked with other vowels to form vowel combinations. Besides, /又/ is a diphthong rather than a back, front vowel like /o/. Similarly, /Υ/ and /世/ are the simple vowels. In this project, these five vowels will be compared to explore the possible transfer or interference which may influence EFL speakers' pronunciation.

## 2.2 Acoustic cues

Acoustic information plays an important role in speaker's pronunciation access. Evidence from the comparison of target language speakers and first language speakers suggests that the close relationship between the acoustic output and the phonological awareness. It is probable to draw inferences to judge whether the smaller linguistic units is related to the manners and places of articulation. The acoustic cues depend on the variant factors: speech rate (Miller, 1981), coarticulation (referring to the preceding and following phonological context; Fowler, 1984.), and the effects of speaker variations due to differences in dialect, age, and gender. Somehow the variation to segments also results from the extraction of linguistic data.

Based on the above rationale, the purpose of this study is to compare the vowel features with the acoustic-phonetic analysis via the PRAAT. The main research questions are addressed:

- 1) In Mandarin Chinese, are there similar linguistic features that hinder or facilitate English vowels?
- 2.) Does gender have any effect on vowel perception?

## 3. Experimental Investigation

### 3.1 Implementation Tool

Ball & Rahilly (1999) mention that acoustic phonetic approach provides a quantifiable record of speech event using instrumental techniques. The software, PRAAT, is implemented to produce visual image, so the measurement of vowels can be presented. The three levels of formants of vowels will be specified and analyzed. In additional, two types of the formant

chart depicted the statistical representation. The first type is the formant chart showing the vowels of two speakers of different languages, and the second, the formant chart shows relationship between the American English Vowels (in the blue line) with Chinese vowels (in the red line). 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 English vowels in the words "heed, hid, head, had, hood, hawed, who'd."

### **Subjects**

To elicit the acoustic output of the different sex groups: one group has two female speakers, and the other has two male speakers participated in this project. For the purpose of the present study, I attempt to hold the linguistic, age, and educational variables. The two native speakers, Lisa and Mike, are selected based on the following criteria: a) American English native speakers b.) the duration of staying in the southern part of Taiwan not less than one year c.) age range around 30-35. d.) cram school English teacher. As for the Chinese language groups, Yi-Min and Kai, since the interference of the mother tongue may influence on a speaker's production, female and male subjects were selected from the group whose mother tongue is Mandarin Chinese. Two subjects learn English more than ten years and university graduates, aged between 30 to 35.

### **Procedure**

The first step is two American speakers and two Chinese speakers are asked to read the word list selected from Chapter eight, in Ladefoged's *A course in Phonetics* (2001). The second step is two Chinese speakers read the word lists, which show the similar pronunciation in Mandarin Chinese and English. The word list includes the characters of "哈、必、互、背、

厚" corresponding to "hod, bee, who, bay, hoe." The difficulty comes from the recording of American subjects. Since their speech production are tape-recorded in the setting of the cram school, the background noise may play a variable. On the other hand, Chinese speaker are invited to read the word lists in the quiet room without noise interfering. Then, the final step is to analyze the statistic linguistic data with the representation of the formant chart after vowel extraction.

## 4. Data Analysis

### 4.1 Spectrographic analysis

#### Female Subjects

(1) Analysis of eight American vowels in female native speaker's pronunciation in the words "h\_d"

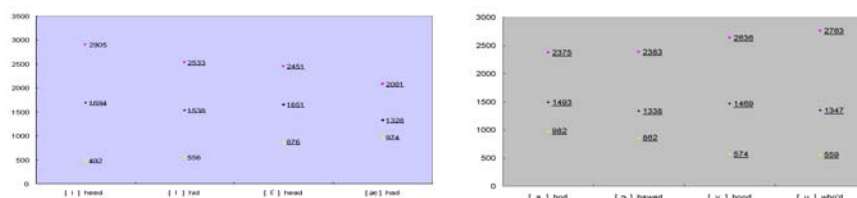


Figure 1 The frequencies of the words "heed, hid, head, had, hod, hawed, hood, who' d."

Vowel	ɪ	i	e	ə	ɒ	ɑ	ɔ	ʊ
F2	1694	1538	1651	1328	1493	1338	1469	1347
F1	492	556	876	974	982	862	574	559
F2-F1	1202	982	775	354	511	476	895	788

The results from Figure 1 to Table 1 illustrate the formants structure of female native speaker's pronunciation for the eight vowels. The F1 formant poses an inverse proportion to the tongue

height.

(2) Analysis of eight American vowels in Mandarin Chinese speaker's pronunciation in the words "h\_\_d"

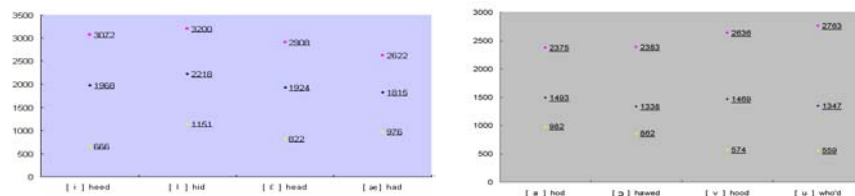


Figure 2 The frequencies of the words "heed, hid, head, had, hod, hawed, hood, who'd."

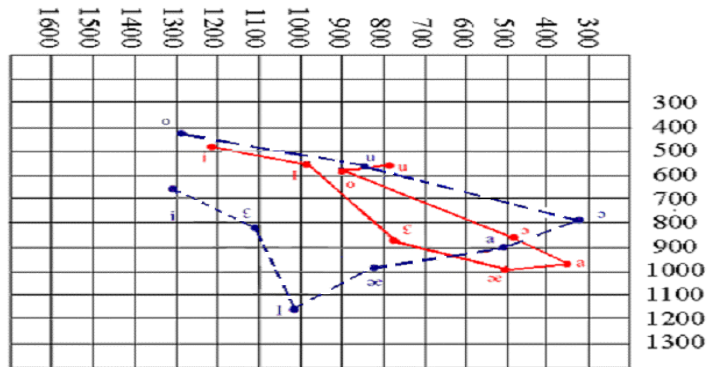
Vowel	ɪ	I	E	⊕	A	□	Y	ʊ
F2	1968	2218	1924	1815	1419	1132	1724	1447
F1	666	1151	822	976	913	797	437	579
F2-F1	1302	1067	1102	839	506	335	1287	868

The results from Figure 2 to Table 2 illustrate the formants structure of female native speaker's pronunciation for American vowels. The F1 formant poses an inverse proportion to the tongue height.

(3) Comparison of American English vowels: female English native speaker vs. female Mandarin speaker

Comparing with American female speaker (the solid line), female Chinese speaker (the dashed line), have phonic problems in distinguishing /I/ and /E/, /Y/ and /ʊ/, and /Y/ and /I/. The formant chart show Yi-min is conscious of her production, so she attempted to read the words in the list in the way of words-pair contrasting, such as "heed, hid", "head, had", "hod, hawed", "hood, heard." Figure 3 describes the difference between Lisa's pronunciation and Yi-Min's.

Evidently, the F1 formants of [ɪ] [I] are much higher than Lisa's. And, the chart also shows the physiological difference: the vocal tract of American subject is longer and her oral cavity is larger than Yi-Min.



**Figure 3** A formant chart showing the vowels of two speakers of different languages. 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 English vowels in the words "heed, hid, head, had, hood, hawed, who'd."

(4) Comparison of Chinese vowels with American vowels

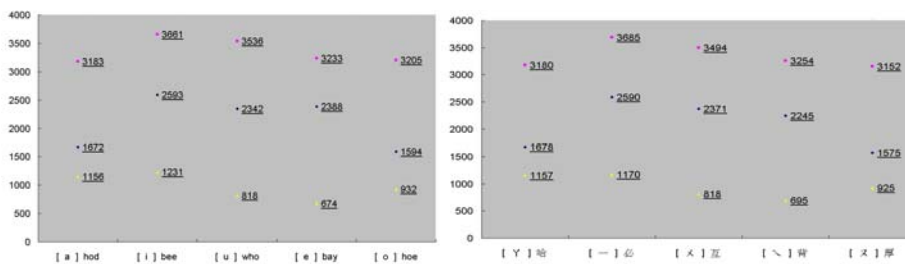
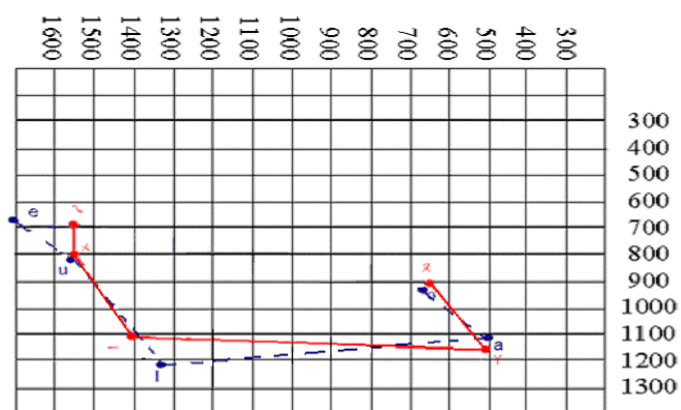


Table 3 The formants of the five Mandarin vowels						Table 4 The formants of the five American vowels					
Vowel	A	ɪ	ʊ	ɛ	o	Vowel	Y	—	ɤ	ɨ	ɤ
F2	1672	2593	2342	2388	1594	F2	1678	2590	2371	2245	1575
F1	1156	1231	818	674	932	F1	1157	1170	818	695	925
F2-F1	516	1362	1524	1714	662	F2-F1	521	1420	1553	1550	650

Figure 4 depicts the comparison chart of English vowels, /A/, /ʌ/, /ʊ/, /ɛ/ and /o / and the Chinese counterparts of /ʏ/, /-/, /ɤ/, /ɛ/, and /ɤ/ in Mandarin Chinese language. Since Chinese is a tone language, F1 formants of /ʏ/, /-/ in "哈""必"are ranked higher. It also shows that /ɤ/and /ʊ/ are affected by the preceding consonant "厂" and "h". Generally speaking, "ɤ"Chinese language is a diphthong /oʊ / rather than a back, front vowel like /o /, which interfere the pronunciation of /o /.



**Figure 4** This formant chart shows relationship between the American English Vowels (the dashed line) with Chinese vowels (the solid line). The frequency of the first formant is plotted on the ordinate, and the difference between the frequencies of the second and the first is plotted on the abscissa.

### Male Subjects

#### Spectrographic analysis

(1) Analysis of eight American vowels in male native speaker's pronunciation in the words "h\_d"

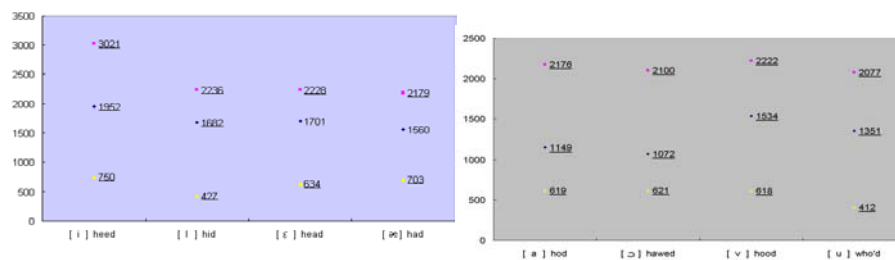


Figure 5 The frequencies of the words "heed, hid, head, had, hod, hawed, hood, who'd."

Vowel	ɪ	I	E	⊖	A	□	Y	ʊ
F2	1952	1682	1701	1560	1149	1072	1534	1351
F1	750	427	634	703	619	621	618	412
F2-F1	1202	1255	1067	857	530	451	916	939

The results from Figure 5 to Table 5 illustrate the formants structure of female native speaker's pronunciation for eight nine vowels. The F1 formant poses an inverse proportion to the tongue height.

(2) Analysis of eight American vowels in Mandarin Chinese speaker's pronunciation in the words "h\_d"

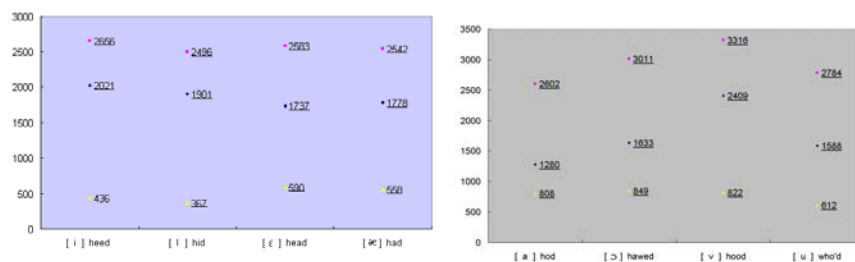


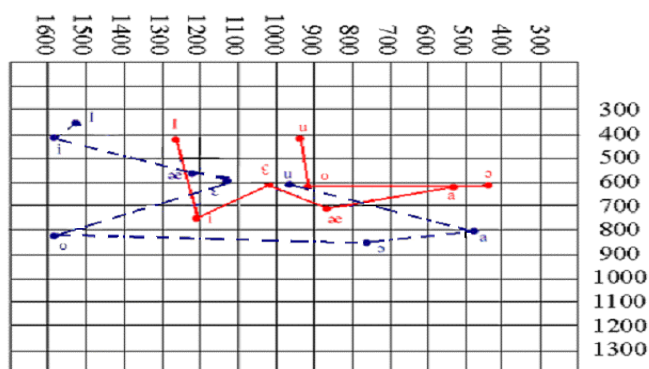
Figure 6 The frequencies of the words "heed, hid, head, had, hod, hawed, hood, who'd."

Vowel	ɪ	I	E	⊖	A	□	Y	ʊ
F2	2021	1901	1737	1778	1280	1633	2409	1588
F1	436	367	590	558	808	849	822	612
F2-F1	1585	1534	1147	1220	472	784	1587	976

The results from *Figure 6* to *Table 6* illustrate the formants structure of female native speaker's pronunciation for eight American vowels. The F1 formant poses an inverse proportion to the tongue height.

(3) Comparison of the eight American vowels: male American native speaker vs. male Mandarin speaker

Comparing with American male speaker (the solid line), male Chinese speaker (the dashed line), have phonic problems in front-low /ə/ and back –high vowel /Y/ and /ʊ/. He also cannot distinguish front-high tense [ɪ] and front-high lax [I] and front-mid lax /E/, and front-low /ə/. These evidences mean Kai's unstable vowels are front vowels. *Figure 7* describes the difference between Mike's pronunciation and that of Kai. Besides, F1 formants of back vowels /A/,/ɑ/, /Y/, /ʊ/ are much higher than American speaker. Similar to female-female subject comparison, the chart also shows the physiological difference: the vocal tract of American speaker is longer and her oral cavity is larger than male Chinese speaker. However, the F1 formants of the front vowels of female Chinese speaker are higher than Kai's partly because woman's pitch is higher than man's.



**Figure 7** A formant chart showing the vowels of two speakers of different languages. 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 English vowels in the words "heed, hid, head, had, hood, hawed, who'd."

(4) Comparison of Chinese vowels with American vowels: Yi-Ming vs. Kai

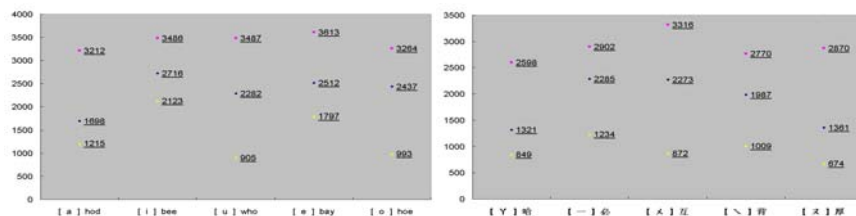
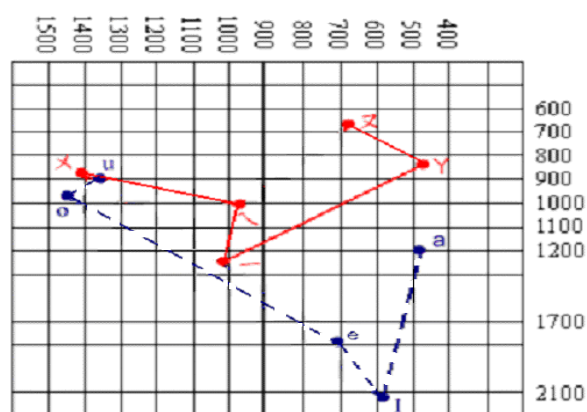


Table 7 The formants of the five Mandarin vowels						Table 8 The formants of the five American vowels					
Vowel	A	ɪ	ʊ	ɛ	ɔ	Vowel	Y	ɨ	ɤ	ɘ	ɚ
F2	1698	2716	2282	2512	2437	F2	1321	2285	2273	1987	1361
F1	1215	2123	905	1797	993	F1	849	1234	872	1009	674
F2-F1	483	593	1377	715	1444	F2-F1	472	1051	1401	978	687

Figure 8 depicts the comparison chart of English vowels, /A/, /ɪ/, /ʊ/, /ɛ/ and /o/ and the Chinese counterparts of /Y/, /ɨ/, /ɤ/, /ɘ/, and /ɚ/ in Mandarin Chinese language. Kai's F1 formants of /Y/, /ɨ/, /ɤ/ in "哈", "必" and "背" are ranked higher. It also shows that /ɤ/ and /ʊ/ are affected by the preceding consonant "尸" and "h". Different from Yi-Min, Kai's formant chart show that he could pronounce the Chinese diphthong "又" /ou/ in the right manner but fail to bring a positive transfer in pronouncing a back-mid vowel /o/. When articulating English, Kai' vocal oral cavity is larger than Yi-Min. Both of Yin-Min and Kai demonstrated the problem in the front vowel "i" and the back "u" correlating to their native language.



**Figure 8** This formant chart show relationship between the American English Vowels (in the blue line ) with Chinese vowels (in the red line). The frequency of the first formant is plotted on the ordinate, and the difference between the frequencies of the second and the first is plotted on the abscissa.

## 5. Pedagogical Implications

### 5.1 Reflection on EFL teaching and learning

This study examined the acoustic properties of Taiwanese adult learners' vowel pronunciation. Some significant differences in vowels have been identified between Taiwanese learners and native speakers. First of all, for the common errors with long or short vowel pattern, it is found that Mandarin Chinese speakers do have difficulties toward American English long vowel, /i/, /e/, /o/, and /u/ partly because of native language transfer. Second, some similar articulation patterns have been shown in Taiwanese learners' spoken Chinese and spoken English. We can infer that the influence of native language in the sounds /u/ and /o/ in English performance. And, Taiwanese learners may lack enough lip rounding and vowel heights. Third, female Taiwanese speaker outperformed in English vowels. The curve of female participant was more similar to that of native speaker. That is, it is evident that the pronunciation in vowels of male Taiwanese subject is greatly interfered by the first language.

Therefore, as language researchers and teachers, not only should we teach learners how to articulate certain sound patterns, we also have to guide them to understand and monitor the ways they produce. Acoustic-phonetic analysis provides the record of speakers' pronunciation across language boundaries and can be viewed as a description of a speaking accent, a gender comparison, or normal versus distorted speech. In addition, auditory transcription can help to "highlight patterns of pronunciation which would be difficult to pinpoint just by listening alone" (Ball and Rahilly, 1999). In Taiwan context, EFL teachers should pay more attention to speaker's production, make a balanced guidance between controlled practice and communicative practice, and recognize the potential socio-affective factors and the transfer factors in EFL learners' pronunciation. Because the segmental and suprasegmental features of the interlanguage has the tendency of "fossilization", learners' should be trained to know how to monitor their own speech by means of acoustic analysis and metacognitive awareness.

## 5.2 Recommendation for Future Study

In acoustic-phonetic approach, we assume learners can find a proper way to analyze their learning processes. The result of the study suggest that a computerized phonics learning environment may help teachers and learner realize the phonetic problems of vowel characteristics due to gender difference and native language. Pennington (1992) proposes that reflective practice would promote more motivated and confident speakers. With the development of computer technology, CALL and Web-based language instruction, which have been considered effective modern technology for English teaching and learning (Liou, 2001).

Additionally, the implementation of PRAAT helps us build up the understanding of vowel sounds and production. Also, it provides the salient evidences for error analysis. Through the visual and auditory cues, the phonological awareness of EFL learners can be aroused through

self-monitoring. Some recommendations are provided for future study related to acoustic phonetics and phonic instructions. First of all, both the research period and the speech length can be prolonged in order to find out more details of the pronunciation patterns of EFL learners. Analyzing and categorizing the subjects speech errors is so worthwhile that EFL teachers could know which pronunciation pattern are more difficult for their learners. Consequently, the follow-up study can entail more phonic patterns to detect speech errors. Since gender is an important factor in acoustic studies, a further study can be done to compare the differences in connected speech between male and female speakers. Moreover, a greater number of subjects can be included, to increase the reliability of the results and to make further generalization possible. Last, we can also evaluate students' attitude and belief toward computer assisted phonetics learning by collecting qualitative data via interviews or participant observation.

## About the Author

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