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Comparative Study of the Acoustic Vowel Space of Egyptian English Vowels and General American English Vowels

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COMPARATIVE STUDY OF THE ACOUSTIC VOWEL SPACE OF EGYPTIAN ENGLISH VOWELS AND GENERAL AMERICAN ENGLISH VOWELS

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ABSTRACT

This study provides cross-language comparisons of Egyptian English and General American English (GAE) vowels. The main purpose of this study is to determine the intelligibility of Egyptian speakers in comparison with GAE speakers. In order to implement this comparison, eleven GAE vowels in /hVd/ contexts produced by five male and five female Egyptian speakers were analyzed acoustically using Praat software. The results reveal that Egyptian speakers' production of GAE vowels is affected by the Egyptian vowel system. While some GAE vowels are easy for Egyptians to pronounce intelligibly, others such as /æ, ɛ, o, ɔ, a/, are difficult to produce close to the standard American English pronunciation.

1.0 Introduction

Intelligible pronunciation is a fundamental part of speaking any language. Adult language learners cannot achieve native-like phonology in their L2 (Strange, Yamada, Kubo, Trent, Nishi, and Jenkins, 1998; Munro, 1993). Ladefoged (2006) stated that there are many factors that may cause accent; however, differences in vowel pronunciation are the main cause. As Fromkin et al. (2011) elucidate, vowels are produced "without [any] articulators touching or even coming close" (p. 252).Thus, we can give a better description of vowels by describing their acoustic structure (Yavas, 2006).

2.0 Background

In any language, vowels play an important role as they are the most noticeable and central sound of syllables (Al-Eisa, 2003). Vowels are produced without any articulators making contact (Fromkin, Rodman, & Hyams, 2011), and thus are best described by their acoustic structure rather the articulatory movement involved.

The GAE vowel system is described as a large system containing simple vowels as well as diphthongs. It has 12 vowel phones /i, ɪ, e, ɛ, æ, u, ʊ, ɔ, o, ʌ, ɑ, ə/ which are represented orthographically by <a, e, i, o, u>. The International Phonetic Association (2010) plots the formant values of GAE Vowels in a vowel chart such as this one.

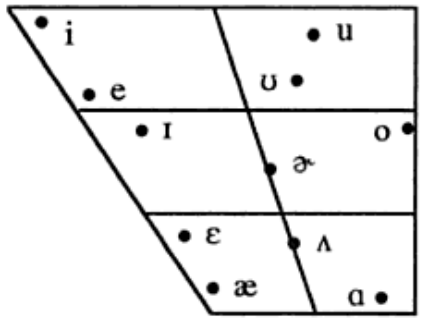

Figure 1: GAE Vowels Plotted in the Vowel Space

On the other hand, Modern Standard Arabic (MSA): the written norm for all Arab countries has three short vowels, /a, i, u/, and three long counterparts, /a:, i:, u:/ (Alghamdi, 1998; Alotaibi & Hussain, 2010). There are three letters that indicate the long variant. However, the Arabic writing system does not allow the short vowels to appear as separate letters. Instead, there are three different diacritic marks placed above or below the consonants to indicate the vowel following this consonant (Alotaibi & Hussain, 2010; Kotby, Saleh, Hegazi, Gamal, Salam, and Fahmi, 2011; Al-Eisa, 2003). To summarize, Arabic vowels tend to be described with the famous vowel triangle below, taken from the International Phonetic Association (2010, p.11):

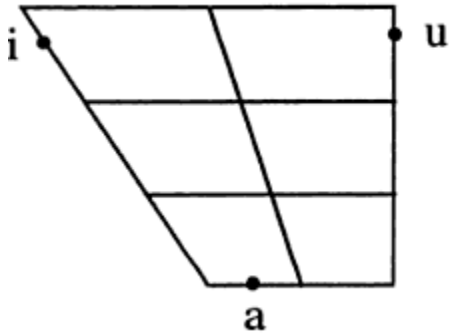

Figure 2: Egyptian Vowels Plotted in the Vowel Space

Munro (1993) conducted an acoustic analysis to compare the production of 10 English vowels in /bVt/ and /bVd/ contexts of two groups of speakers: a group of American English native speakers and another group of Arabic native speakers who started learning English in adulthood. The study revealed significant differences between the two groups in the production of the tested English vowels. Additionally, his findings showed the effect of the Arabic vowel system in the production of English vowels by Arabic speakers. Hubais and Pillai (2010) investigated the production of English vowels by ten male Omani speakers. Their results were in agreement with Munro's results.

3.0 The Present Study

This study qualifies as an acoustic study of vowels with one main objective, namely, to understand the challenges that Arabic speakers in general, but Egyptians in

particular, face when learning to speak English. It replicates the most widely cited study on vowel acoustic conducted by Peterson and Barney (1952) in which they analyzed the sound of GAE vowels.

Answers to the following research questions will, I hope, shed some light on these challenges.

3.1 Research Questions

1) To what extent are Egyptian English vowels similar to or differ from GAE vowels?

2) To what extent does the Arabic vowel system affect Egyptian Arabic speakers' production of American English vowels?

To answer these questions, first, the values of the first and second formants (F1 and F2) of Egyptian English vowels were documented. Second, a comparison between these measurements and the standard measurements of GAE vowels was conducted. Finally, the production of GAE vowels by Egyptian males and females were investigated to observe the effects of the Egyptian vowel system on their language usage.

4.0 Participants

The participants for this study were 10 Egyptian adults: five males and five females. Their proficiency in English was estimated to be at the intermediate level.

4.1 Methodology

This study uses the acoustic analysis method to answer the research questions. Li (2004) defined acoustic analysis as the method of providing a record of speakers' pronunciation in term of intensity, frequency, and the articulation properties.

4.2 Materials

The list created by Peterson and Barney (1952) which includes /hVd/ utterances: <heed>, <hid>, <head>, <had>, <hawed>, <hod>, <hood>, <who'd>, and <hud>, in addition to two more vowels: <hayed>, and <hoed> from the Hillenbrand, Getty, Clark, and Wheeler study (1995) were used. Reading a list of words ensures that all the vowels are stressed. This makes it easy to measure their acoustic characteristics (Koffi, 2013).

4.3 Data collection

Audio recordings were made of all participants reading the list of words provided to them. Each word was repeated three times. The recordings were made with a digital audio recorder (Olympus WS-700M). After the recordings were completed, I downloaded them to my laptop. I then used the switch sound file convert software to convert them from WMA formant to WAV formant to be able to conduct the acoustic analysis using the Praat software. F1 and F2 were measured for the target vowels by measuring the whole vowel from the onset to the offset. Finally, the data obtained from the acoustic analysis were normalized using a free online website called NORM (Thomas & Kendall, 2013).

5.0 The Acoustic Analysis of GAE Vowels Produced by Egyptian Speakers

Each participant provided 33 tokens (11 * 3). Collectively, all participants provided 660 tokens (330 tokens for males and 330 tokens for females). For each vowel, the average F1 and F2 values of the three repetitions by each participant were calculated. Then, the averages for each vowel were calculated for the entire group. Finally, data was analyzed and then compared to average formant frequency data found in Peterson and Barney (1952) to determine the extent to which GAE vowels produced by Egyptian speakers were different from or similar to GAE production. The focus was on the F1 values because height is the most important feature in the assessment of intelligibility (Koffi, 2011). Ladefoged (2006) reported that F1 carries about 80% of the acoustic energy of the vowel when pronounced. According to Yang (1996), there are gender differences in the vocal tract ratio. Therefore, the males' and females' data were analyzed separately. The following spectrogram represents the production of the word hayed by one of the male speakers.

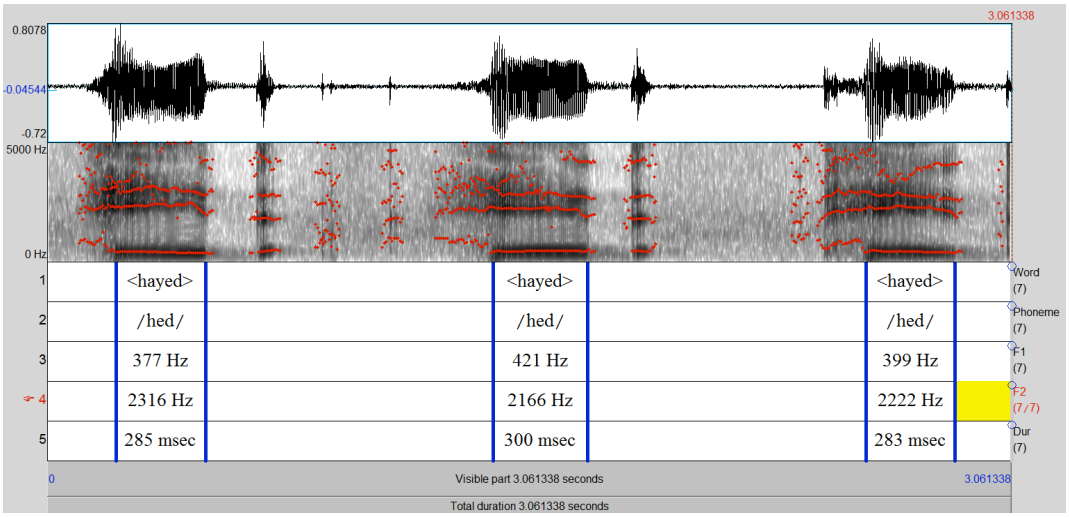

Figure 3: A Spectrogram of the GAE Word /hed/, Egyptian Male Speaker

5.1 The Measurements of GAE Vowels by Egyptian Females vs. GAE

The entire body of data for this section is summarized in the following table. Table 1 shows the averages of F1 and F2 values in Hz of GAE vowels produced by Egyptian females as well as the standard measurements of American native females for all the 11 target vowels. The difference in F1 and F2 values of both pronunciations is bolded. The standard deviations and the ranges of the five measurements of the Egyptian participants are provided as well. Providing the range and the standard deviation is important because they show whether the data collected from the entire group is representative of the data for individuals.

Words		heed	hid	hayed	head	had	hod	hawed	hoed	hood	who'd	hud
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
GAE	F1	310	430	536	610	860	850	590	555	470	370	760
Egy.	F1	337	460	438	436	625	453	450	441	453	399	672
	Diff.	**27**	**30**	**98**	**174**	**235**	**397**	**140**	**114**	**17**	**29**	**88**
	SD	10	23	17	22	36	15	19	12	7	7	11
	Range	29	53	51	60	99	65	51	32	22	17	32
GAE	F2	2790	2480	2530	2330	2050	1220	920	1035	1160	950	1400
Egyp	F2	2650	2129	2428	2087	2255	1306	1134	1133	1264	1044	1403
	Diff.	**140**	**351**	**102**	**209**	**168**	**86**	**214**	**98**	**104**	**94**	**3**
	SD.	52	15	48	35	78	25	19	17	12	28	30
	Range	130	32	136	99	217	73	54	54	113	78	95

Table 1: GAE Vowels and Egyptian English Vowels Produced by Females

The following graphs show a comparison of F1 and F2 in Hz for each vowel.

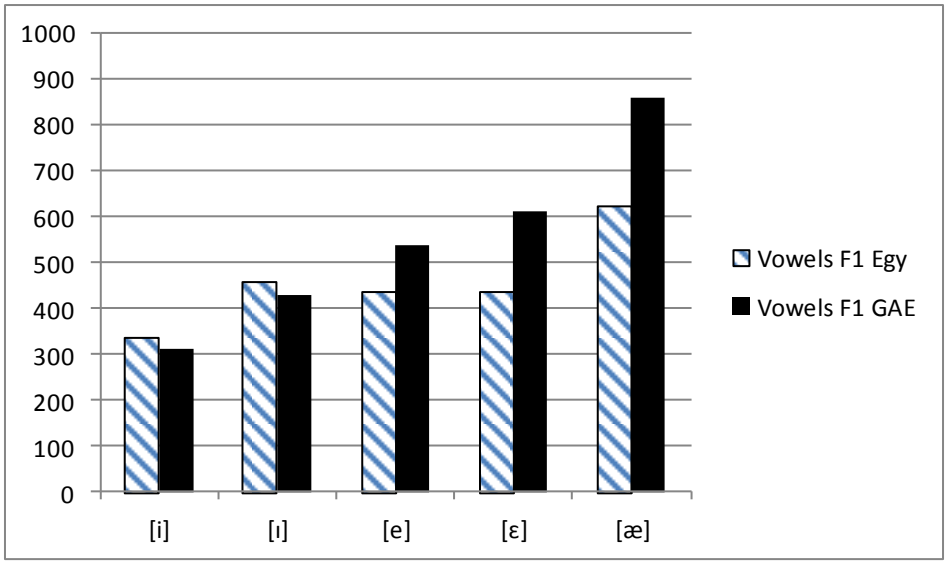

Figure 4: Comparison of F1 Values in GAE and Egyptian English front Vowels of Females

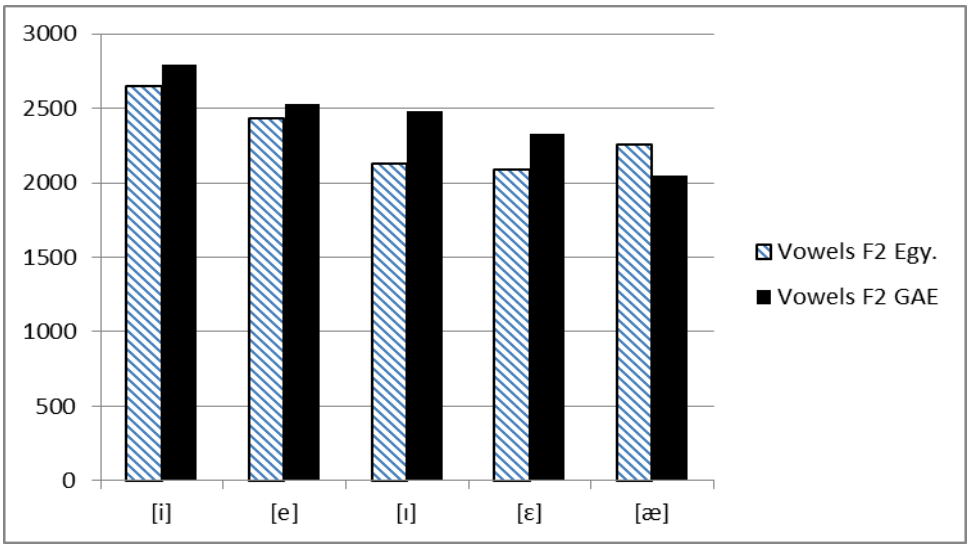

Figure 5: Comparison of F2 Values in GAE and Egyptian English Front Vowels

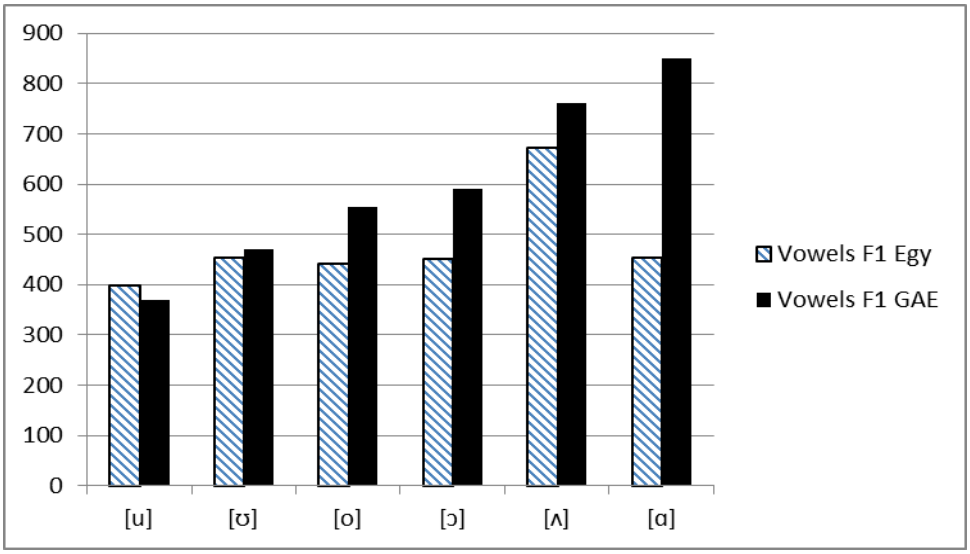

Figure 6: Comparison of F1 Values in GAE and Egyptian English Back Vowels of Females

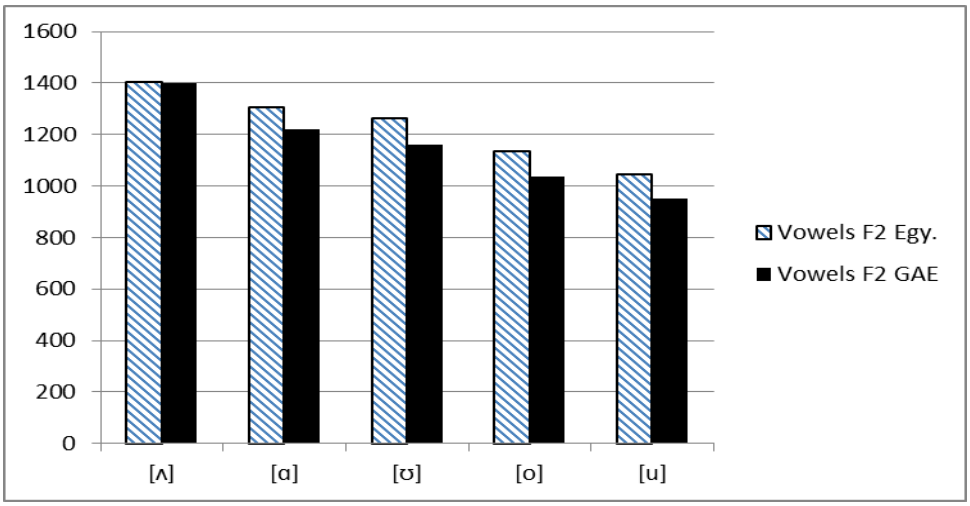

Figure 7: Comparison of F2 Values in GAE and Egyptian English Back Vowels of Females

In order to have a clearer picture, all measurements were put together in the following acoustic vowel space.

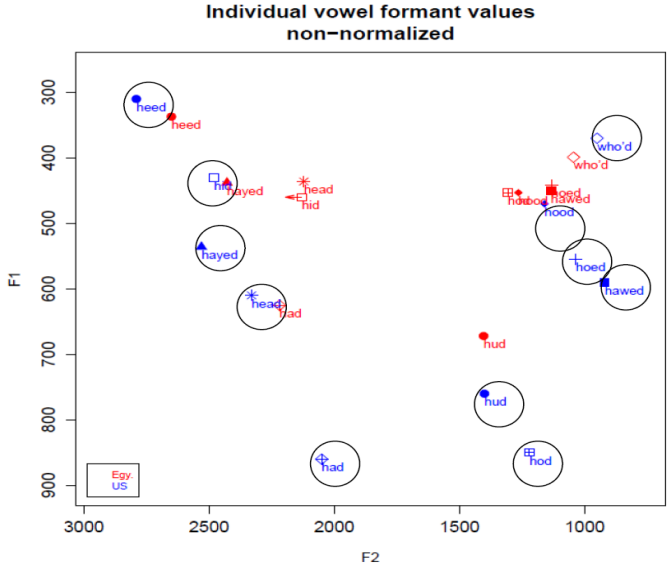

Figure 8: Comparative Vowel Quadrant for Egyptian and GAE Female Speakers:
Circled Words Refer to GAE Vowels

By analyzing the data in Table 1 with the support of the above charts and acoustic vowel space, a few observations can be made. First, the Egyptian females' English vowels occupy a smaller space than GAE vowels. Also, there are some significant differences in F1 formant values between Egyptian females' pronunciation and GAE that may cause serious intelligibility issues. For instance, the Egyptian English vowels /ɪ/ (460 Hz, 2194 Hz) in the word <hid>, /e/ (438 Hz, 2428 Hz) in the word <hayed>, and /ɛ/ (436 Hz, 2121 Hz) in the word <head> are very close to each other in terms of height. Their acoustic

spaces overlap with each other. Furthermore, the words <hid> and <head> are close in terms of backness/frontness as well. This overlapping may lead to some intelligibility problems. It is worth noting that the Egyptian females' /æ/ (625 Hz, 2255 Hz) in the word <had> is raised almost to the level of the GAE /ɛ/ (610 Hz, 2330 Hz) in the word <head>. This indicates that the vowel /æ/ is problematic for Egyptian females. However, the acoustic space of Egyptian /i/ (337 Hz, 2650 Hz) and GAE /i/ (310 Hz, 2790 Hz) are similar. Likewise, the acoustic spaces of Egyptian /u/ (399 Hz, 1044 Hz) and GAE /u/ (370 Hz, 950 Hz) are near each other. This means that these two vowels are not problematic for Egyptian females. On the other hand, the Egyptian females' back vowels /ʊ/ (453 Hz, 1264 Hz), /ɔ/ (450 Hz, 1134 Hz), /o/ (441 Hz, 1133 Hz), and /ɑ/ (453 Hz, 1306 Hz) are produced in exactly the same area. They also interfere with /ʊ/ (470 Hz, 1160 Hz) in GAE. This leads to serious intelligibility issues. Finally, Egyptian females pronounce the vowel /ʌ/ (672 Hz, 1403 Hz) in the word <hud> higher than in the standard GAE pronunciation (760 Hz, 1640 Hz).

A quick look at Figures 5 and 7 and Table 1, and we see that the differences in F2 values between Egyptian females' measurements and the standard GAE measurements are minimal. These differences have minor effect in terms of frontness/backness. The next part of this section deals with Egyptian males' data.

5.2 The Measurements of GAE Vowels by Egyptian Males vs. GAE Males

The values of F1 and F2 for Egyptian males' productions and GAE males' productions were compared and contrasted separately. However, all data for this section is summarized in Table 2.

Words		heed	hid	hayed	head	had	hod	hawed	hoed	hood	who'd	hud
Vowels		[i]	[ɪ]	[e]	[ɛ]	[æ]	[ɑ]	[ɔ]	[o]	[ʊ]	[u]	[ʌ]
GAE	F1	270	390	476	530	660	730	570	497	440	300	640
Egyp.	F1	286	410	394	394	522	481	438	456	481	346	614
	Diff.	**16**	**20**	**82**	**136**	**138**	**249**	**132**	**41**	**41**	**36**	**26**
	SD.	3	17	14	12	9	10	20	21	11	18	19
	Range	9	50	37	35	20	25	47	53	33	44	56
GAE	F2	2290	1990	2089	1840	1720	1090	840	910	1020	870	1190
Egyp	F2	2283	1822	2059	1862	1705	1322	1091	1028	1145	1055	1280
	Diff.	**7**	**168**	**30**	**22**	**15**	**231**	**251**	**118**	**125**	**185**	**90**
	SD.	49	81	140	70	86	43	60	59	52	24	51
	Range	144	251	376	206	241	110	157	162	154	99	142

Table 2: GAE Vowels and Egyptian English Vowels Produced by Males

The following four charts display a comparison of F1 and F2 values in Hz for each vowel.

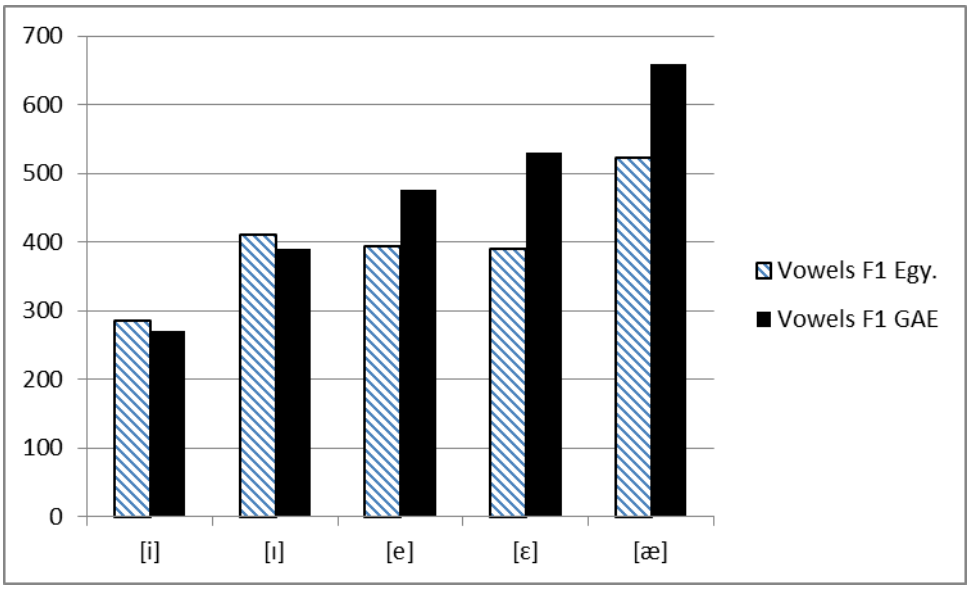

Figure 9: Comparison of F1 Values in GAE and Egyptian English Front Vowels of Males

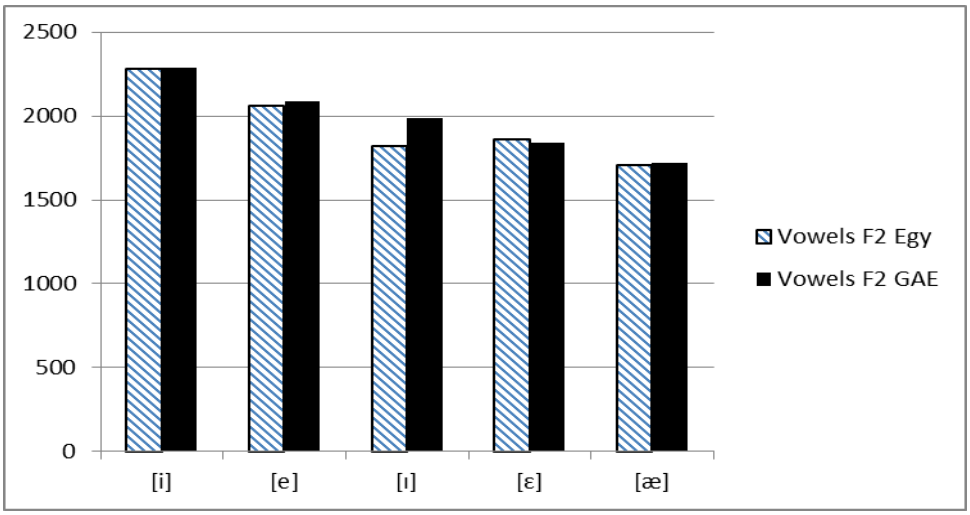

Figure 10: Comparison of F2 Values in GAE and Egyptian English Front Vowels of Males

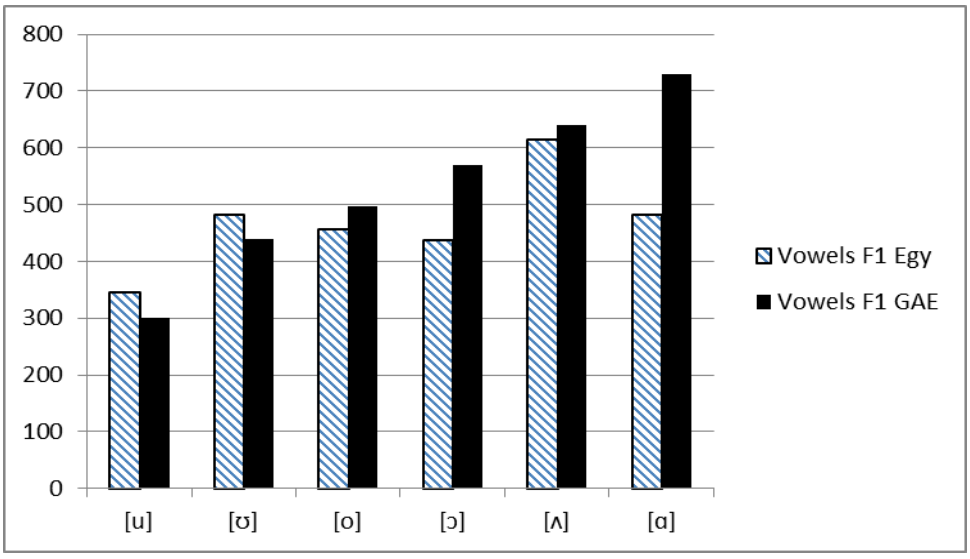

Figure 11: Comparison of F1 Values in GAE and Egyptian English
Back Vowels of Males

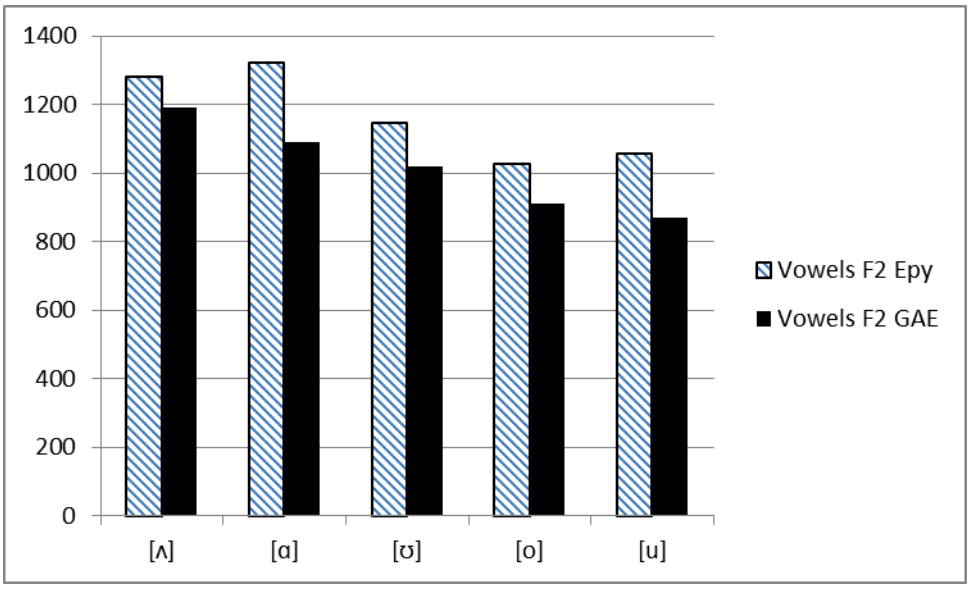

Figure 12: Comparison of F2 Values in GAE and Egyptian English
Back Vowels of Males

In order to create a clearer picture, all measurements were put together in the following acoustic vowels space.

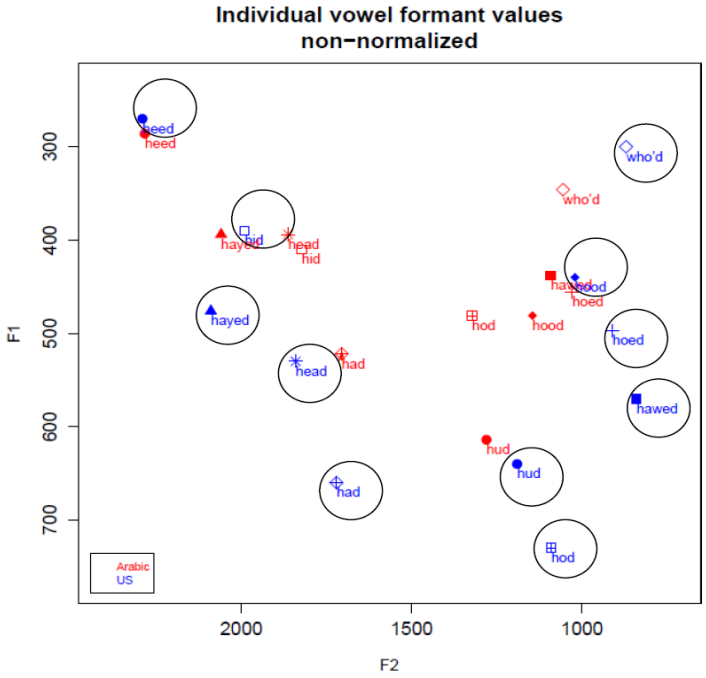

Figure 13: Comparative Vowel Quadrant for Egyptian and GAE Male Speakers
(circled words refer to GAE vowels)

The acoustic vowel space of Egyptian males shows that the Egyptian males' English vowels occupy a smaller acoustic space than GAE vowels. Also, the acousic distances among the Egyptian females' English vowels /ɪ/ (410 Hz, 1822 Hz) in the word <hid> , /e/ (394 Hz, 2059 Hz) in the word <hayed>, and /ɛ/ (394 Hz, 1862 Hz) in the word <head>, are very small. The difference is (16 Hz) in F1 values and 237 Hz in F2 values. Their acoustic spaces overlap with each other. Furthermore, the words <hid> and <head> are close in terms of backness/frontness as well. This may result in some inteligibility problems. Furthermore, the Egyptian males raise the vowel /æ/ (522 Hz, 1705 Hz) in the word <had> a little bit higher than the vowel /ɛ/ (530 Hz, 1840 Hz) in the word <head> in GAE. They are produced in almost the same area. However, the acoustic space of the Egyptian /i/ in the word <heed> (286 Hz, 2283 Hz) is almost identical to /i/ (270 Hz, 2290 Hz) in GAE. This indicates that this vowel is not problematic for Egyptian males. Regarding the back vowels, the acoustic space of the vowel /u/ in the word <who'd> for Egyptian males (346 Hz, 1055 Hz) is lower than its position in GAE (370 Hz, 950 Hz). Similarly, Egyptian males produce the vowel /ʊ/ (481 Hz, 1145 Hz) in the word <hood> lower than in GAE. Its acoustic space is close to the vowel /o/ (497 Hz, 910 Hz) in the word <hoed> in GAE. Moreover, in the Egyptian males' pronunciation, the acoustic spaces of the vowels /ɔ/ (438 Hz, 1091 Hz) in the word <hawed> and /o/ (456 Hz, 1028 Hz) in the word <hoed> are raised close to the vowel /ʊ/ in the word <hood> (440 Hz, 1020 Hz) in GAE. Also, Egyptian males raise the vowel /ɑ/ in the word <hod> (481 Hz, 1322 Hz) close to the vowel /o/ (497 Hz, 910 Hz) in the word <hoed> in GAE; however, their production is more fronted than /o/ in GAE. Finally, Egyptian males also raise the vowel /ʌ/ (614 Hz, 1280 Hz) in the word <hud> higher than the standard pronunciation (640 Hz, 1190 Hz).

5.3 The Effect of Arabic Vowel System

The following two charts are acousitc vowel spaces for Egyptian vowels and GAE vowels by Egyptian speakers. They illustrate how Egyptian speakers transfer the properties of Egyptian vowels to their production of GAE vowels. The circled words present the Egyptian vowels; the uncircled words refer to GAE vowels produced by Egyptian speakers. Figure 11 shows the data for females, and Figure 12 displays pronunciations by males.

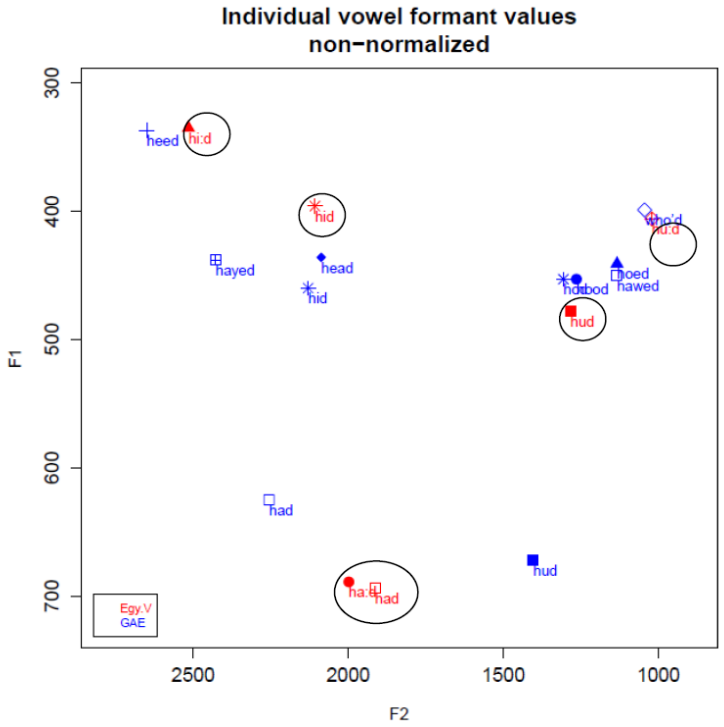

Figure 14: Comparative Vowel Quadrant for Egyptian English Vowels and Egyptian Arabic Vowels of Female Speakers

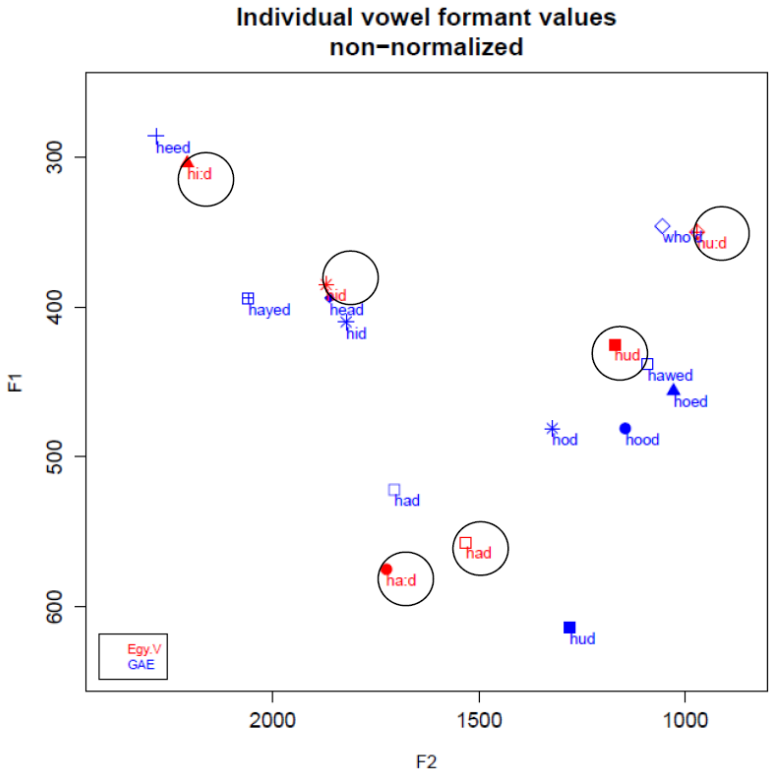

Figure 15: Compararive Vowel Quadrant for Egyptian English Vowels and Egyptian ArabicVowels of Male Speakers

A quick look at the two acoustic vowel spaces above shows that both genders of Egyptian speakers produce most GAE vowels almost in the same areas as Egyptian vowels. For instance, the two high Egyptian English vowels /i, u/ occupy the same vowel spaces as the Egyptian high long vowels /i:, u:/. For Egyptian females, the acoustic distances between all other Egyptian English back vowels / ʊ, o, ɔ, ɑ/ and the Egyptian short vowel /u/ are very small, which means that Egyptian females produce all these GAE back vowels in a fairly similar way as the Egyptian vowel /u/. On the other hand, Egyptian males produce most GAE front vowels /e, ɪ, ɛ/ in the same acoustic space as the Arabic short vowel /i/.

6.0 Conclusion

In summary, Egyptian speakers have problems with GAE vowels that are not existent in the Egyptian vowel system. Furthermore, Egyptian speakers may transfer the properties of Arabic vowels to their production of some GAE vowels. We can infer the influence of the Egyptian vowel system in the front vowels /e, ɛ, æ / as well as the back vowels /ɑ, ɔ, ʊ, o/ in GAE. In conclusion, based on the previous analyses, the production of GAE vowels by Egyptian speakers can be classified into three categories: non-problematic vowel pronunciation, semi-problematic, and problematic vowel sounds production.

Non-problematic:

/i, u, ʌ/: these vowels do not seem to present any challenge for Egyptian speakers. Their productions of these vowels are very close to GAE and their speech is intelligible while using words containing these vowels.

Semi-problematic:

/ɪ, ʊ/: according to the acoustic vowel spaces, these vowels might be troublesome for Egyptian speakers. Egyptian speakers do not have serious problems in producing /ɪ/ and /ʊ/ themselves; however, they tend to pronounce some other vowels in a way that interferes with /ɪ/ and /ʊ/. This may create some confusion for GAE hearers.

Problematic:

/e, æ, ɛ, o, ɔ, ɑ/: these are the most troublesome sounds when produced by Egyptian speakers. The acoustic vowel spaces clearly show how far Egyptian speakers' vowels are distanced from GAE. Finally, the back vowels /o, ɔ, ɑ/ are the most problematic vowels for Egyptian speakers. They overlap acoustically with each other and also interfere with GAE vowels /u/ and /ʊ/.

7.0 Limitation

As with any study, there are some limitations. The first limitation is that all participants were from one area in Egypt (Cairo and its suburbs), whereas there are many different dialects in Egypt such as in the coastal and southern areas. Second, the recordings were made without the advantages that would be found in a phonetics lab. Third, the context /hVd/ has minimal effects on the realization of the target vowels. However, using different contexts may give different results. Also, saying the words in connected speech instead of individual words may change the results.

8.0 Future Studies

The results of this study depended on using the word list style technique for collecting the data. The target vowels were placed on /hVd/ context. In future research, the data collection should be expanded to include different contexts and speech styles.

ABOUT THE AUTHOR

Samar Khalil received her MA in TESL/Applied Linguistic at Saint Cloud State University in May 2013. She hopes to pursue a PhD in Applied Linguistics. Her area of interest is computational linguistics.

Recommendation: This MA Thesis summary was recommended for publication by Professor Ettien Koffi, Ph.D., Linguistics Department, St. Cloud State University, St. Cloud, MN. Email: enkoffi@stcloudstate.edu

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