Instrumental Analysis of English Vowels Produced by Male and Female Zilfaawi Arabic Speakers

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Received: May 23, 2023 Accepted: July 10, 2023 Online Published: July 25, 2023

doi:10.5430/wjel.v13n7p206 URL: https://doi.org/10.5430/wjel.v13n7p206

Abstract

Arab and non-Arab English as a foreign language (EFL) students continue to have difficulty pronouncing English vowels accurately. To examine this, our study analyzes how male and female Saudi EFL students pronounce English monophthongs when compared to native speakers assessed in previous research. Gender-related variations between male and female Arab English speakers are also explored. Formant frequencies (F1 and F2) are employed to evaluate vowel quality, with vowel duration measured to investigate vowel length. Learners' pronunciations of English words containing vowels of interest are used to collect data. Five male and five female EFL learners produced English monophthongs in the /hVd/ context. We then compare the results with previous data on native English speakers and conduct acoustic analysis. Regarding duration, male non-native English speakers' data are compared with previous results for male native speakers, revealing that the vowels of Saudi learners are shorter than those of native English speakers, and those of non-native men are longer than those of non-native women. Moreover, the low vowels produced by Saudi and native men are longer than their non-low vowels. Regarding vowel quality, men produce lower vowels than native speakers. Women, however, produce lower and more front vowels than native women. Statistically, this study reveals significant differences between male and female Saudi EFL learners in producing English vowels. Saudi men's vowel space is more centralized than Saudi women's space. Both men and women overlap low vowels. Saudi learners' mispronunciations of English vowels indicate that L1 interference is not the only cause of mispronunciations.

Keywords: monophthongs, mispronunciation, phonetics, Zilfaawi, EFL, interference, duration

1. Introduction

English as a foreign language (EFL) is difficult to learn. Students must be proficient in a variety of essential communication skills, such as listening and speaking. Correct pronunciation is a crucial element of linguistic proficiency. Roach (2009) characterized the British English vowel system as a complex system consisting of short and long simple vowels, in addition to diphthongs. This specific dialect of English has 12 vowels – namely /ɪ/, /ʊ/, /e/, /æ/, /ʌ/, /ɒ/, /ə/, /i:/, /u:/, /ɔ:/, /ɑ:/, and /ɜ:/ – which are represented orthographically as i, u, o, a, and e. However, Modern Standard Arabic (MSA), like many dialects of Arabic, has three short vowels, /a/, /i/, and /u/, and three long counterparts, /a:/, /i:/, and /u:/ (Al-Ani, 1970; Alghamdi, 1998). Some Arabic dialects use the long mid vowels /e:/ and /o:/ in place of the MSA diphthongs /ay/ and /aw/. Long vowels are represented by three letters. However, the Arabic writing system uses diacritical marks above or below consonants to indicate short vowels (Kaladeh, 2016; Al-Ani, 1970).

The Arabic and English vowel systems are distinct in numerous ways. Abboud and McCarus (1983) observed that many Arabic vowels are articulated differently from their corresponding English vowels. This can be seen in the following comparisons. The Arabic long /a/ is similar to the English /æ/, but not identical. The Arabic short /a/ falls between the English /ʌ/ and /ʌ/. The Arabic long /ɪ/ is very similar, but not identical, to the English vowel /i/. The Arabic short vowel /ɪ/ is also very similar to the English short vowel /ɪ/. The Arabic long-back vowel /u/ is similar to its English counterpart. The Arabic short vowel /u/ is similar to the English vowel /ʊ/.

Gender differences play a significant role in English vowel production. The differences between male and female voices are due to physiological and vocal tract differences (Pépiot, 2012). Vocal differences between males and females can primarily be explained by anatomical and physiological differences, such as the length and thickness of the vocal folds of female speakers (Fant, 1960). This explains why male speakers' vibrations tend to be slower than those of female speakers (Kahane, 1978). Fant (1960) noted that the vocal tract, from the vocal folds to the lips, is a major anatomical factor, the average length of which is 17–18 centimeters in men and approximately 14.5 centimeters in women (Simpson, 2009).

Numerous studies (Mitleb, 1981; Munro, 1993) have examined the impediments to attaining native-like pronunciation among foreign-language learners. Although L1 significantly affects the learning of a new language, pronunciation problems can occur for various reasons. Learning English vowels can be challenging because each vowel is pronounced in multiple ways (Gimson & Cruttenden, 1994). Additionally, some words have distinct spellings but the same pronunciation (e.g., bear and bare). The orthographic conventions of English are deceptive and complex, and learners who cannot enunciate each word fluently based on its spelling are likely to mispronounce that word (O'Connor, 1980). Lack of exposure to and experience with English pronunciation may be a factor in difficulty with producing vowels correctly.

Many researchers have investigated the acoustic properties of English vowels produced by Arab EFL learners. However, only a few studies have investigated the short and long vowels produced by Saudi male and female EFL learners. Therefore, the current study aims to fill this gap by measuring male and female EFL learners' formants and durations of vowels. In addition, it compares non-native and native speakers of British English, on the one hand, and male and female non-native speakers, on the other hand. Moreover, it studies the mispronunciations of certain sounds and finds possible reasons for such errors to help teachers and instructors inform their teaching practices regarding English vowels.

1.1 Arabic-Accented English

Arab students' challenges with English pronunciation are well represented in the second-language literature (Haji & Mohammed, 2019; Hubais & Pillai, 2010; Munro, 1993; Ramadan & Thai, 2021). These studies suggest that Arab EFL learners of English produce English sounds with comparable characteristics. Munro (1993) observed that, in terms of vowel quality, the back vowels generated by Arabic speakers tend to mirror their equivalent Arabic vowels. Many studies concerning English vowel production by Arabic speakers have indicated similarities between speakers from diverse locations. For example, it has been demonstrated that Jordanian and Saudi speakers convey the length differential between Arabic and English vowels (Flege & Port, 1981; Mitleb, 1981). In addition, it was revealed that /ɪ/, /ɛ/, and /æ/ exhibited substantial movement in F1, F2, or both (Andruski & Nearey, 1992).

Multiple studies have found that people encounter trouble with vowel length contrast and have a propensity to produce diphthongs as monophthongs in speech. Hubais and Pillai (2010) analyzed the duration of vowels to determine the length differences between common vowel pairs. The results demonstrated that the vowels of the Omani speakers occupied the same vowel space as those of the British English speakers, but various vowels had distinct qualities. Mitleb (1981) and Munro (1993) discovered that the Arabic speakers surveyed contrasted vowel length with a greater duration difference than did the American English speakers. Additionally, Munro (1993) observed that the lengths of all vowels generated by Arabic speakers were consistently shorter than those produced by American speakers. He put this disparity down to the transmission of shorter-length attributes of comparable Arabic vowels. Moreover, Cox and Palethorpe (2005) discovered that Lebanese Australians preferred to shorten long vowels and diphthongs.

1.2 Gender Effect on the Production of English Vowels

Gender is one of the determinants of accuracy in the acquisition of speaking abilities, particularly when it comes to the production of English vowels. Male and female speakers of English produce vowels in different ways. Simpson and Ericsdotter (2003) explored gender differences in durational disparities between 48 speakers of English and Swedish from the United States and Sweden. The females created a longer duration for vowels and a wider distinction between short and long vowels than did the males. Moreover, Koffi (2019) examined English vowels generated by male and female Nepali speakers. This investigation revealed physiological differences in the structure of the larynx between the genders. In a study of Iberian Spanish, Chládková, Escudero, and Boersma (2011) detected gender variances in the duration of vowels and found that women tended to produce larger duration disparities between short and long vowels. Further, Martland, Whiteside, Beet, and Baghai-Ravary (1996) examined 10 vowels from a variety of perspectives, including gender and accent. In the general British northern accent, the front vowels /æ/, /ih/, and /eh/ were pronounced significantly lower by females than by males. In addition, women created lower back vowels than did men. Nevertheless, Hariri's (2012) literature review of gender-based research and accurate pronunciation found no significant difference between male and female English learners in the production of vowels. Added to this, Kassaian (2011) researched how native Persian speakers perceive and produce English speech sounds, as well as the effects of age and gender, reporting that the perception and production of English sounds were unaffected by gender.

1.3 Literature Review

Vowel quality and quantity in English as a first language vary across dialects. An identical effect applies to EFL. For Arab EFL learners, English vowels appear problematic.

A study conducted by Munro (1993) aimed to investigate 10 English vowels in both /bVt/ and /bVd/ contexts. The study participants consisted of 23 American speakers and 23 Arabic EFL learners. The study comprised EFL learners from diverse Arab nations, including Kuwait (6), Jordan (5), Sudan (4), Saudi Arabia (3), Syria (2), Palestine (2), and Egypt (1). Following acoustic analysis of F1, F2, and duration, the study showed that non-native speakers significantly shifted toward their Arabic counterparts in the production of English vowels. It was observed that a mere 2 out of the total 23 EFL speakers were able to produce the five front vowels /i, ɪ, e, ɛ, ae/, with F1 and F2 values that were comparable to those of native English speakers. Furthermore, the findings also revealed that the native speakers of Arabic tended to amplify the temporal disparities between English vowels. However, it is noteworthy that all English vowels produced by the Arabic L1 speakers were consistently shorter than those produced by the native American speakers. One limitation is that the number of male and female participants was not the same across all study participants from the different Arab nations.

Hubais and Pillai (2010) focused their research on Omani English students to identify the difficulties they faced while attempting to master language vowels. They analyzed 10 male Omani speakers' pronunciations of English monophthongs. Based on the frequency of the first (F1) and second (F2) formants, vowel quality was evaluated and vowel duration was recorded to study length differences between common vowel pairs. American English vowels occupied less space than did British English vowels. Nonetheless, the majority of vowels displayed a dramatic difference from British English in terms of quality. In general, /iː/, /æ/, /ɑː/, /ʌ/ and especially /ɪ/, /ɜː/, /ʊ/ and /ɔː/,

appeared to be fronted more than in British English. The fronting of /ɜː/ may be attributed to the speakers' recognition of the following r in the target words, whereas /e/ appeared to have moved toward /ɪ/ – a behavior observed by Munro (1993). In the vowel pairs /ɪ/-/iː/, /ʌ/-/ɑː/, /ʊ/-/uː/, and /ɒ/-/ɔː/, the Omani subjects contrasted vowel length rather than quality. Vowels in adjacent pairs sometimes overlapped during generation, which was especially true for back-vowel pairs. This indicates that there was no apparent distinction in how they were created. In other words, the pairings do not always create vowels with unique qualities. Despite the presence of length contrast, the average duration of the difference in length between vowel pairs was not consistent, with the majority of the variation originating from long vowels. However, similar to the findings of previous investigations, the Omani speakers retained their length differentials, and created /iː/, /æ/, and /ɑː/ similar to the Arabic /i/ and /iː/, /a/, and /a/, respectively. This phenomenon did not occur with the sounds /ʊ/ and /u/. Although in Arabic these vowels are generated in a more retracted manner in the acoustic vowel space, the Omani subjects' pronunciation of /uː/ was very close to that of British English, where it is pronounced farther toward the front. When compared with the Arabic /u/ and /uː/, the /ʊ/ was much more fronted. Hubais and Pilai's (2010) study was constrained by the fact that it exclusively focused on male speakers of the dialect, which represents a limitation. Furthermore, the researchers involved in the study failed to provide a specific location within Oman from which the participants were recruited.

Al-Badawi (2012) investigated many linguistic errors, including phonetic errors, made by Saudi participants aged 19–20. Each participant had learned English in Saudi Arabia. To discover typical errors, he employed a qualitative interview method using audio-recorded field interviews with participants. According to the aforementioned author, the Saudi EFL learners tended to swap /ə/ for /ɔ/, /ə/ for /ʊ/, and /ɛ/ for /ɪ/. He noted that a lack of sufficient English vowel knowledge was the primary source of these phonetic errors. He also found that Saudi EFL learners created English vowels depending on their imperfect knowledge and not by substituting Arabic vowels for English vowels, as no similar vowels exist in their L1. One limitation of Al-Badawi's study (2012) was the single use of the qualitative interview, with no acoustic analysis to support the results.

Ali (2013) compared the English vowel production of EFL-learning Sudanese Arabic speakers with that of British native speakers. The Sudanese Arabic speakers had difficulty when it came to English vowels in both isolated and linked speech, with the author attributing this to the influence of the participants' L1 and a lack of exposure to vowels in L2. Ali (2013) revealed that the generation of English center and back vowels by Sudanese speakers differed from that of British speakers. He noted that the English vowel /ɛ/, in words written with the "e" letter, was pronounced /ɪ/, because in Arabic sounds correlate with letters; this may affect the pronunciation of vowels produced by Sudanese speakers.

Khalil (2014) analyzed the generation of English vowels by speakers of Egyptian Arabic and compared the results with those of general American English (GAE) vowels using acoustic analysis. She analyzed 11 GAE vowels generated in the context of /hVd/ by five male and five female Egyptian speakers. The findings of her investigation demonstrated that the Egyptians' L1 influenced their English vowel production. According to her line of reasoning, the vowels /æ/, /ɛ/, /ɑ/, /ɔ/, and /o/, which are the most challenging for Egyptians to pronounce in English, are not part of the Egyptian vowel inventory. She explained that the Egyptian Arabic vowel system may influence the formation of the front vowels /ɛ/, /æ/, and /e/, as well as the back vowels /ɑ/, /o/, /ʊ/, and /ɔ/. The back vowels /ɑ/, /o/, and /ɔ/ were problematic for the speakers of Egyptian Arabic and conflicted with American English vowels /u/ and /ʊ/.

In addition, Hassan (2014) performed his research in order to analyze the challenges that Sudanese students encountered when attempting to pronounce English sounds, as well as to determine the factors which contributed to these issues. A total of 50 students from the Sudanese University of Science and Technology participated. As many as 30 professors from the same university were also engaged. The information was gathered via careful observation, audio recordings of student pronunciation, and the administration of a pre-made questionnaire. After amassing the data, the researcher used statistical and descriptive methods to organize and examine the information. The survey revealed that most of the Sudanese learners who were assessed struggled with properly pronouncing English consonants. Furthermore, they had trouble pronouncing several English consonants, in addition to difficulties with both short and long vowel pronunciation in English. Some of the factors contributing to these problems were also discussed.

Taqi, Algharabali, and Akbar (2018) conducted a study to investigate the realizations of five vowel sounds (/iː/, /eɪ/, /ʌ/, /ʊ/, and /oʊ/) in the English language. The sample comprised 55 male and female students from Kuwait who were learning English as part of this study. Interviews were utilized as part of a mixed methodology approach. The results of the investigation showed that the students of English in Kuwait had trouble articulating all vowel sounds. According to Taqi et al. (2018), three primary factors contribute to vowel pronunciation errors in the second language. One of the key contributors to this phenomenon is L1 transfer, whereby the learner has acquired the rule regulating vowel production but incorrectly resorts to L1 vowel production due to time constraints. Another factor is the tendency for L2 vowel sound-orthography patterns to be overgeneralized. Lastly, the above-mentioned authors found the L2 strategy to be a factor. Here, the lack of certain vowels in the learner's native language led to the development of L1 speech patterns that were different in how they were perceived, such as using speech organs and suprasegmental features (Carter & Nunan, 2001). Taqi et al.'s (2018) study was restricted because their analysis was confined to the reported five vowels. An additional constraint pertained to the absence of an analysis of vowel duration.

Kharma and Hajjaj (1989) stated that one of the biggest problems which Arabic speakers may face is the difference between vowels such as /e/-/ɪ/ and /ɒ/-/ʌ/ and /ɔː/. According to Bauman-Wängler (2009), Arabic speakers have specific difficulties in English vowel sound articulation and perception, particularly vowel sounds that are very close to Arabic ones, such as /ʌ/, /e/, and /ɔ/.

According to Barros (2003), the realization of central vowels can vary somewhat. Because sequences with or without /r/ coloring do not exist in the Arabic sound system, a variant of /u/-/æ /or /a/ is used in lieu of /ʌ/, altering the quality of the Arabic r sound in that context. Variations in the English vowels, particularly short open vowel sounds such as /ʊ/, /ɜ/, and /ɪ/, can provide a significant challenge for speakers of Arabic. The vowel sound /ɪ/ can be articulated to sound like /e/ by lowering and lengthening it, whereas the sound /ɜ/ can be made to sound like /æ/or /i/ (Power, 2003).

Numerous researchers have looked into the acoustic characteristics of English vowels produced by Arab EFL learners. Nevertheless, there is a need for more research on how Saudi EFL learners of both genders produce short and long vowels. The present study aims to address this research gap by quantifying the formants and durations of Saudi English speakers of both genders to answer the following research questions:

1. What are the acoustic properties and durations of English vowels produced by Zilfaawi Arabic learners of English compared with native English speakers?
2. Is there a gender-related effect on the production of vowels by native speakers of Zilfaawi Arabic?
3. What is the nature of vowel production errors observed among Zilfaawi Arabic English learners?

2. Methods

2.1 Materials

The stimuli consisted of 11 English words. Each word contained one of the 11 English vowels tested, namely /i/, /ɪ/, /æ/, /ɛ/, /e/, /ɑ:/, /ɒ/, /ɔ:/, /ʊ/, /ʌ/, and /ɜ:/. All stimuli were monosyllabic words with the initial glottal consonant /h/ and final voiced stop consonant /d/. To obtain a more naturalistic production, the target words were placed in a carrier sentence, “Say the word hVd again.” The selection of these hVd words ensured a consistent phonetic environment and made it easier to determine the vowels in the spectrogram. The dataset comprised 5 repetitions $\times$ 11 vowels $\times$ 10 speakers = 550 items.

To compare the English vowel values produced by the Saudi EFL learners, we used Deterding’s (1990) F1 and F2 measurements for British English vowels as reference values, as presented in the Results section. Regarding duration, the results of the current study were compared with the average British male duration values of the 11 British vowels reported by Wells (1963).

2.2 Participants

Ten native speakers of Zilfaawi Arabic (five males and five females) participated in this study. They majored in English at our institution. The speakers were randomly selected from third- and fourth-year students, and their age range was 21–24. All participants were born, grew up, and educated in the city of Zulfi. Speakers who did not speak this particular dialect or had been extensively exposed to other foreign languages were eliminated from the study to avoid possible interference from another dialect or language. Most participants had taken phonetics and phonology courses in the previous two semesters. None of the participants reported any visual impairments. All individuals were unpaid volunteers, and consent was obtained in accordance with established protocols.

2.3 Procedures

The recordings were made in our institution’s quiet labs using a microphone (BadAax CM40 Studio Mic) connected directly to a Windows portable computer. The data were saved as files at a sampling rate of 44 kHz and quantization of 16 bits. Individual recordings were made with the participants. The words were presented to the participants via PowerPoint, with one word per slide, to avoid list effects. No verbal models were offered, but, if required, words that rhymed with the right output were presented. Each participant read the randomized list of the 11 vowels of BBC English in the hVd environment five times in the carrier phrase “Say the word …… again.” Table 1 provides a list of vowels and words used to elicit the pronunciations.

Table 1. Stimuli presented to the participants in the study

Vowel	**Target word**	**The word in a sentence**
i:	heed	*Say the word heed again*
ɪ	hid	*Say the word hid again*
æ	had	*Say the word had again*
e	head	*Say the word head again*
ɑ:	hard	*Say the word hard again*
ɒ	hod	*Say the word hod again*
ɔ:	hoard	*Say the word hoard again*
u:	who’d	*Say the word who’d again*
ʊ	hood	*Say the word hood again*
ʌ	hud	*Say the word hud again*
ɜ:	heard	*Say the word heard again*

2.4 Analysis

The audio files were also acoustically analyzed using the Praat acoustic software (Boersma & Weenink, 2009). Measurements of the first and second formants of the vowels were recorded and annotated. As in many studies on vowels, the first two formants were chosen because they are significant to the perception of vowel quality (e.g., Flemming & Johnson, 2007; Hawkins & Midgley, 2005). A wideband spectrogram was used to segment the target vowels based on the corresponding waveforms and auditory examinations. The vowel onset was established as the first waveform's minimum that coincided with the distinct appearance of vowel formants on the wideband spectrogram. The vowel offset, however, was delineated as the final waveform minimum that coincided with the vanishing or attenuation of the second formant (F2) (Wright & Nicholas, 2014). A TextGrid file was created with the identified boundaries for the sound of the vowels after they were analyzed. Following this, a script was used to carry out automatic measurements of the duration and the vowel formants at the midpoint of the vowel durations. Measurements of formants were taken from the middle of the vowels, because that is where they were in their most stable state. Subsequently, the findings were compiled into a text file to be analyzed with the help of the R statistical software.

To determine whether vowel formants created by Zilfaawi speakers approached those produced by the native English speakers presented in Deterding (1990), a unified chart mapping the total formant means was compared with the vowel charts provided in Deterding's (1990) study, in which male and female speakers were recorded, contrary to most of the literature focusing on male speakers.

3. Results

3.1 Formant Comparisons of English Vowels

This section compares the formants and durations of the English vowels of Saudi and British speakers. Pairwise comparisons of all 11 vowels tested for differences in F1, F2, and duration. A total of 101 pairwise comparisons were conducted. The Bonferroni correction method was used to overcome the multiple comparison problem.

3.1.1 Formant Comparison of English Vowels between Male Saudi Speakers and British Speakers

The differences in F1 and F2 for English vowels of Saudi and British men are shown in Figure 1 and Table 2 below.

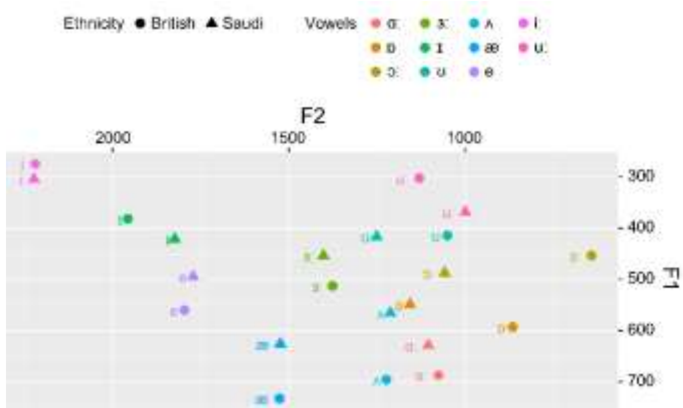

Figure 1. Vowel space of Saudi men and British men for English vowels

Table 2. The differences in F1 & F2 of English vowels of Saudi and British men

First Formant (F1)

Vowels	*Saudi male*	*British male*	*Mean Difference*	*t*	*p*	Significance after Bonferroni Correction
/iː/	301.19	275	26.19	5.73	$.06*10^{-4}$	***
/ɪ/	429.71	382	47.71	5.42	$.01*10^{-3}$	**
/e/	509.19	560	-50.80	-4.33	$.02*10^{-2}$	*
/æ/	636.91	732	-95.08	-3.41	$.02*10^{-1}$	
/ɜː/	456.52	513	-56.47	-6.07	$.02*10^{-4}$	***
/ʌ/	588.60	695	-106.39	-4.73	$.08*10^{-3}$	**
/ʊ/	424.24	414	10.24	1.25	0.22	
/uː/	368.37	302	66.37	8.69	$.07*10^{-7}$	***
/ɒ/	564.55	593	-28.44	-1.10	.28	
/ɑː/	638.64	687	-48.35	-3.05	$.05*10^{-1}$	
/ɔː/	491.18	453	38.18	2.47	.02	

Second Formant (F2)

Vowels	*Saudi male*	*British male*	*Mean Difference*	*t*	*p*	Significance after Bonferroni Correction
/iː/	2254.58	2221	33.58	0.93	.36	
/ɪ/	1852.91	1958	-105.08	-2.86	$.08*10^{-1}$	
/e/	1744.82	1797	-52.17	-1.10	.27	
/æ/	1504.02	1377	-22.97	-0.49	.62	

/ɜː/	1332.47	1593	-44.52	-0.62	.53
/ʌ/	1227.18	1224	3.18	0.04	.96
/ʊ/	1255.11	1051	204.11	2.49	.01
/uː/	1005.22	1131	-125.78	-1.38	.17
/ɒ/	1121.57	866	255.57	3.61	.01*10^{-1}
/ɑː/	1101.36	1077	24.36	0.34	.73
/ɔː/	1055.81	642	413.81	3.90	.06*10^{-2}

Regarding the F1 results in Table 2, it must first be noted that no significant differences were found in F1 for /æ/, /ʊ/, /ɒ/, /ɑː/, and /ɔː/ between Saudi and British men. Second, the results show that the Saudi and British men differed significantly in the first formant for /iː/, /ɪ/, /e/, /ɜː/, /ʌ/, and /uː/. The Saudi men had a higher average F1 (lower in vowel space) than the British men for /iː/, /ɪ/, and /uː/, while the Saudi men had a lower average F1 (higher in vowel space) than the British men for /e/, /ɜː/, and /ʌ/. With regard to F2, shown in the second part of Table 2, no significant differences were found between the Saudi and British men for any of the 11 English vowels.

3.1.2 Formant Comparison of English Vowels between Female Saudi Speakers and British Speakers

The differences in F1 and F2 for the English vowels of the Saudi and British women are presented in Figure 2 and Table 3 below.

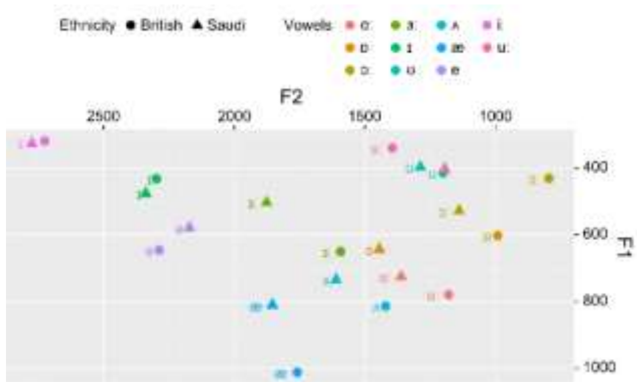

Figure 2. Vowel space of Saudi and British women for English vowels

Table 3. The differences in F1 and F2 of English vowels of the Saudi and British women

First Formant (F1)						
Vowels	*Saudi female*	*British female*	*Mean Difference*	*t*	*p*	Significance after Bonferroni Correction
/iː/	321.86	319	2.86	0.27	.78	
/ɪ/	487.84	432	55.84	2.01	.06	
/e/	591.02	645	-53.97	-1.31	.20	
/æ/	832.86	1011	-178.13	-5.13	.02*10^{-3}	**
/ɜː/	518.98	650	-131.01	-6.07	.02*10^{-4}	***
/ʌ/	751.78	813	-61.21	-1.87	.07	
/ʊ/	400.51	414	-13.48	-0.88	0.38	
/uː/	406.95	339	67.95	2.86	.08*10^{-1}	
/ɒ/	658.70	602	56.70	1.42	.16	
/ɑː/	736.78	779	-42.21	-1.75	.09	
/ɔː/	538.24	431	107.24	6.52	.09*10^{-5}	***
Second Formant (F2)						
Vowels	*Saudi female*	*British female*	*Mean Difference*	*t*	*p*	Significance after Bonferroni Correction
/iː/	2831.04	2723	108.04	2.43	.02	
/ɪ/	2353.56	2296	57.56	0.79	.43	
/e/	2168.03	2287	-118.97	-1.71	.10	
/æ/	1853.67	1759	94.67	2.23	.03	
/ɜː/	1880.32	1593	287.32	3.93	.06*10^{-2}	
/ʌ/	1587.92	1422	165.92	3.11	.04*10^{-1}	
/ʊ/	1174.13	1203	-28.86	-0.37	.71	
/uː/	1158.25	1396	-237.74	-4.54	.01*10^{-2}	*
/ɒ/	1399.42	994	405.42	7.90	.03*10^{-6}	***
/ɑː/	1262.84	1181	81.84	2.28	.03	
/ɔː/	1073.3	799	274.29	6.07	.02*10^{-4}	***

Looking at the F1 mean values, it is clear that there were no significant differences between the Saudi and British women for /iː/, /ɪ/, /e/, /ʌ/,

/ʊ/, /uː/, /ɒ/, and /ɑː/. Only three of the vowels exhibited a significant difference: /æ/, /ɜː/, and /ɔː/. The Saudi women had a lower average (higher in vowel space) F1 for /æ/ and /ɜː/ than the British women, as well as a higher average (lower in vowel space) F1 for /ɔː/ than the British women.

The F2 values of the Saudi and British women presented in Table 3 above show no significant differences between the Saudi and the British women for /iː/, /ɪ/, /e/, /æ/, /ʌ/, /ʊ/, and /ɑː/. Only three of the vowels exhibited a significant difference: /uː/, /ɒ/, and /ɔː/. The Saudi women had a higher average (more fronted) F2 for /ɒ/ and /ɔː/, and a lower average F2 (more retracted) for /uː/ than the British women.

3.1.3 Formant Comparison of English Vowels between Saudi Men and Saudi Women

To observe whether there are differences in the pronunciation of English vowels between Saudi men and women, we ran pairwise t-tests for each of the 11 English vowels. The differences in F1 and F2 between the Saudi men and women are shown in Table 4 and Figure 3.

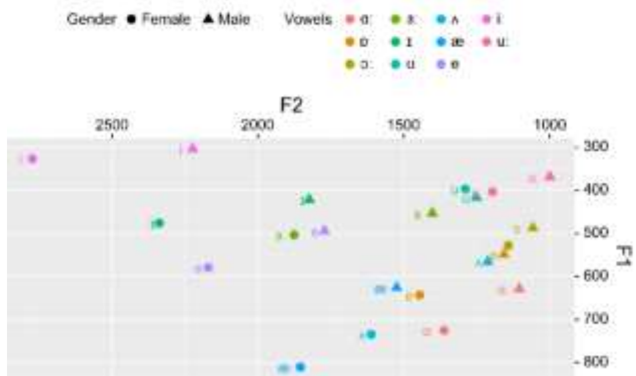

Figure 3. Vowel spaces of Saudi men and women for English vowels

Table 4. The differences in F1 and F2 of English vowels of the Saudi men and women

First Formant (F1)

Vowels	*Saudi male*	*Saudi female*	*Mean Difference*	*t*	*p*	Significance after Bonferroni Correction
/iː/	301.19	321.86	-20.67	-1.81	.07	
/ɪ/	429.71	487.84	-58.12	-1.99	.05	
/e/	509.19	591.02	-81.83	-1.92	.06	
/æ/	636.91	832.86	-195.95	-5.28	.08*10^{-4}	***
/ɜː/	456.52	518.98	-62.45	-2.29	.02	
/ʌ/	588.60	751.78	-163.18	-4.11	.01*10^{-2}	*
/ʊ/	424.24	400.51	23.73	1.37	.17	
/uː/	368.37	406.95	-38.58	-1.54	.13	
/ɒ/	564.55	658.70	-94.14	-1.98	.05	
/ɑː/	638.64	736.78	-98.14	-3.41	.01*10^{-1}	
/ɔː/	491.18	538.24	-47.06	-2.08	.04	

Second Formant (F2)

Vowels	*Saudi male*	*Saudi female*	*Mean Difference*	*t*	*p*	Significance after Bonferroni Correction
/iː/	2254.58	2831.04	-576.46	-10.08	.03*10^{-11}	***
/ɪ/	1852.91	2353.56	-500.64	-6.18	.04*10^{-5}	***
/e/	1744.82	2168.03	-423.20	-5.04	.09*10^{-4}	***
/æ/	1504.02	1853.67	-349.65	-5.54	.01*10^{-4}	***
/ɜː/	1332.47	1880.32	-547.84	-5.38	.02*10^{-4}	***
/ʌ/	1227.18	1587.92	-360.74	-4.09	.01*10^{-4}	***
/ʊ/	1255.11	1174.13	80.98	0.71	.47	
/uː/	1005.22	1158.25	-153.03	-1.45	.15	
/ɒ/	1121.57	1399.42	-277.85	-3.18	.02*10^{-1}	
/ɑː/	1101.36	1262.84	-161.47	-2.04	.04	
/ɔː/	1055.81	1073.3	-17.48	-0.15	.88	

Overall, there were no significant differences in F1 between the Saudi men and Saudi women for /iː/, /ɪ/, /e/, /ɜː/, /ʊ/, /uː/, /ɒ/, /ɑː/, and /ɔː/. Only two of the vowels showed a significant difference: /æ/, and /ʌ/. The Saudi women had a higher average (lower in vowel space) F1 for both /æ/ and /ʌ/ than the Saudi men.

With regard to average F2, there were no significant differences between the Saudi men and women for /ʊ/, /uː/, /ɒ/, /ɑː/, and /ɔː/, as can be seen in Table 3 above. However, there were significant F2 differences between the Saudi men and women in several front vowels: /iː/, /ɪ/, /e/, /æ/, /ɜː/, and /ʌ/. For all of these vowels, the Saudi women had a higher average (more fronted) F2 than the Saudi men.

3.2 Formant Comparisons of Adjacent English Vowels

3.2.1 F1 and F2 Comparisons of Male Saudi Speakers

The F1 and F2 comparisons of the adjacent front vowels of the Saudi men are combined and shown in Table 5. To compare /ɪ/, /ɜː/, and /e/, a one-way ANOVA was conducted. The results were statistically significant ($F(2,72) = 10.04$, $p < .001$). The front vowels part shows the results of the post-hoc Tukey's HSD test for determining significance in pairwise comparisons. The results show that the Saudi men's /e/ had a higher (lower in vowel space) F1 than both their /ɜː/ and /ɪ/. However, there was no significant difference between /ɪ/ and /ɜː/ in terms of F1.

Following this, a one-way ANOVA was applied to the F1 values of the adjacent low vowels in the Saudi men. The results were significant ($F(3,96) = 3.38$, $p < .05$). The post-hoc comparisons yielded only one statistically significant result: for /ɒ/ and /ɑː/. On average, the Saudi men had a lower F1 (lower in vowel space) for /ɒ/ than they had for /ɑː/. No other significant differences were observed between the other low-vowel pairs.

Table 5. F1 and F2 comparisons of adjacent vowels of Saudi men

			Tukey's HSD post-hoc comparisons of F1 and F2 between adjacent vowels by Saudi men		
First Formant (F1)					
Front vowels					
Vowels	$Mean_1$	$Mean_2$	*Mean Difference*	*p*	Significance after adjustment
/ɪ/-/ɜː/	429.71	456.52	-26.81	.30	
/e/-/ɜː/	509.19	456.52	52.66	.01	**
/e/-/ɪ/	509.19	429.71	79.47	$.01*10^{-2}$	***
Low vowels					
/ɒ/-/ɑː/	564.55	638.64	-74.08	.04	*
/ʌ/-/ɑː/	588.60	638.64	-50.03	.29	
/æ/-/ɑː/	636.91	638.64	-1.72	.99	
/ʌ/-/ɒ/	588.60	564.55	24.04	.82	
/æ/-/ɒ/	636.91	564.55	72.35	.06	
/æ/-/ʌ/	636.91	588.60	48.30	.32	
Back vowels					
/ʊ/-/ɔː/	424.24	491.18	-66.93	$.01*10^{-2}$	***
/uː/-/ɔː/	368.37	491.18	-122.81	$.01*10^{-7}$	***
/uː/-/ʊ/	368.37	424.24	-55.87	$.01*10^{-1}$	**
Second Formant (F2)					
Front vowels					
vowels	$Mean_1$	$Mean_2$	*Mean Difference*	*p*	Significance after adjustment
/ɪ/-/ɜː/	1852.91	1332.47	520.43	$.01*10^{-7}$	***
/e/-/ɜː/	1744.82	1332.47	412.34	$.01*10^{-7}$	***
/e/-/ɪ/	1744.82	1852.91	-108.09	.33	
Low vowels					
/ɒ/-/ɑː/	1121.57	1101.36	20.20	.99	
/ʌ/-/ɑː/	1227.18	1101.36	125.82	.52	
/æ/-/ɑː/	1504.02	1101.36	402.66	$.01*10^{-2}$	***
/ʌ/-/ɒ/	1227.18	1121.57	105.61	.66	
/æ/-/ɒ/	1504.02	1121.57	382.45	$.04*10^{-2}$	***
/æ/-/ʌ/	1504.02	1227.18	276.84	.01	**
Back vowels					
/ʊ/-/ɔː/	1255.11	1055.81	199.30	.29	
/uː/-/ɔː/	1005.22	1055.81	-50.59	.92	
/uː/-/ʊ/	1005.22	1255.11	-249.89	.14	

We also analyzed the differences and overlaps between the speakers' back vowels. The one-way ANOVA of F1 values yielded significant results ($F(2,72) = 31.29$, $p < .001$). The post-hoc test shows that all three vowels were significantly different. Specifically, the Saudi men had higher average (lower in vowel space) F1 for /ɔː/ than they had for /ʊ/, and in turn had a higher F1 for /uː/.

The F2 comparisons of the adjacent front vowels of the Saudi men are also shown in Table 5. The results for /ɪ/, /ɜː/, and /e/ were statistically significant ($F(2,72) = 26.36$, $p < .001$), showing that the Saudi men's /e/ had a higher F2 (more fronted) than /ɜː/, but not /ɪ/. Additionally, /ɪ/ had a higher average F2 (more fronted) than /ɜː/.

As for low vowels, the results were significant (F(3,96) = 8.06, p < .001). Table 5 shows the results of the post-hoc Tukey's HSD test for determining significance in pairwise comparisons; the test yielded only three statistically significant and three insignificant results. Overall, there was no difference in F2 between the pairs /ɒ/-/ɑː/, /ʌ/-/ɑː/, and /ʌ/-/ɒ/. However, the Saudi men's F2 for /æ/ was higher (more fronted) than their F2 for /ɑː/, /ɒ/, or /ʌ/. We also analyzed the differences and overlaps between the speakers' back vowels. The one-way ANOVA of the F2 values yielded insignificant results (F(2,72) = 1.99, p > .05).

Because the results shown in Figure 4 display a close distance between the two vowels, a single t-test was conducted to test the difference between /ʊ/ and /ɜː/ The results (presented in Table 6) showed no significant difference in F1 and F2 for /ʊ/ and /ɜː/.

Table 6. F1 and F2 comparisons of /ʊ/ and /ɜː/ of Saudi men

First Formant (F1)						
Vowels	$Mean_1$	$Mean_2$	*Mean Difference*	t	p	Significance after Bonferroni Correction
/ʊ/ -/ɜː/	424.24	456.52	-32.27	-1.75	.08	
Second Formant (F2)						
vowels	*Saudi male*	*Saudi female*	*Mean Difference*	t	p	Significance after Bonferroni Correction
/ʊ/ -/ɜː/	1255.11	1332.47	-77.36	0.71	.47	

Overall, the Saudi men exhibited no statistically significant differentiation between the pairs /ɪ/-/ɜː/, /ʌ/-/ɑː/, /æ/-/ɑː/, /ʌ/-/ɒ/, /æ/-/ɒ/, /æ/-/ʌ/, and /ʊ/-/ɜː/ in terms of F1. With regard to F2, they exhibited no statistically significant differentiation between the pairs /e/-/ɪ/, /ɒ/-/ɑː/, /ʌ/-/ɑː/, /ʌ/-/ɒ/, /ʊ/-/ɔː/, /uː/-/ɔː/, /uː/-/ʊ/, and /ʊ/-/ɜː/.

3.2.2 F1 and F2 Comparisons of Female Saudi Speakers

The F1 and F2 comparisons of the adjacent front vowels of the Saudi women are shown in Table 7. To compare /ɪ/, /ɜː/, and /e/, a one-way ANOVA was conducted. The results were not significant (F(2,71) = 2.97, p >.05).

Table 7. F1 and F2 comparisons of adjacent vowels of Saudi women

			Tukey's HSD post-hoc comparisons of F1 and F2 between adjacent vowels by Saudi women		
			First Formant (F1)		
Front vowels					
Vowels	$Mean_1$	$Mean_2$	*Mean Difference*	p	Significance after adjustment
/ɪ/-/ɜː/	487.84	518.98	-31.14	.75	
/e/-/ɜː/	591.02	518.98	72.03	.23	
/e/-/ɪ/	591.02	487.84	103.18	.06	
Low vowels					
/ɒ/-/ɑː/	658.70	736.78	-78.07	.35	
/ʌ/-/ɑː/	751.78	736.78	15.00	.98	
/æ/-/ɑː/	832.86	736.78	96.08	.17	
/ʌ/-/ɒ/	751.78	658.70	93.08	.20	
/æ/-/ɒ/	832.86	658.70	174.15	.01*10^{-1}	**
/æ/-/ʌ/	832.86	751.78	81.07	.31	
Back vowels					
/ʊ/-/ɔː/	400.51	538.24	-137.72	.06*10^{-4}	***
/uː/-/ɔː/	406.95	538.24	-131.28	.01*10^{-3}	***
/uː/-/ʊ/	406.95	400.51	6.44	.96	
			Second Formant (F2)		
Front vowels					
vowels	$Mean_1$	$Mean_2$	*Mean Difference*	p	Significance after adjustment
/ɪ/-/ɜː/	2353.56	1880.32	473.24	.03*10^{-3}	***
/e/-/ɜː/	2168.03	1880.32	287.70	.01	*
/e/-/ɪ/	2168.03	2353.56	-185.53	.16	
Low vowels					
/ɒ/-/ɑː/	1399.42	1262.84	136.58	.16	
/ʌ/-/ɑː/	1587.92	1262.84	325.08	.01*10^{-3}	***
/æ/-/ɑː/	1853.67	1262.84	590.83	.01*10^{-7}	***
/ʌ/-/ɒ/	1587.92	1399.42	188.50	.02	
/æ/-/ɒ/	1853.67	1399.42	454.25	.01*10^{-7}	***
/æ/-/ʌ/	1853.67	1587.92	265.75	.05*10^{-2}	***
Back vowels					
/ʊ/-/ɔː/	1174.13	1073.3	100.83	.46	

/uː/-/ɔː/	1158.25	1073.3	84.95	.57
/uː/-/ʊ/	1158.25	1174.13	-15.88	.98

Next, we conducted a one-way ANOVA to assess the F2 values of the adjacent low vowels in the Saudi women. The results were significant ($F(3,97) = 4.63$, $p < .01$). The post-hoc comparisons shown in Table 7 yielded only one statistically significant result: for /æ/ and /ɒ/. On average, the Saudi women had a lower F1 (lower in vowel space) for /ɒ/ than they had for /æ/. No other significant differences were observed between the other low-vowel pairs.

We also analyzed the differences and overlaps between the speakers' back vowels. One-way ANOVA of F1 values yielded significant results ($F(2,72) = 16.97$, $p < .001$). The post-hoc test showed that the Saudi women had a higher average F1 (lower in vowel space) for /ɔː/ than they had for both /ʊ/ and /uː/. There were no significant differences in F1 between /uː/ and /ʊ/.

The F2 comparisons of the adjacent front vowels of the Saudi women are also shown in the second part of Table 7. To compare /ɪ/, /ɜː/, and /e/, a one-way ANOVA was conducted. These results were significant ($F(2,71) = 11.23$, $p < .001$). The results show that the Saudi women's /ɜː/ had a lower F2 (more at the back) than /e/ and /ɪ/. No difference in F2 was found between /e/ and /ɪ/.

Subsequently, we conducted a one-way ANOVA to assess the F2 values of the adjacent low vowels in the Saudi women. The results were significant ($F(3,96) = 31.11$, $p < .001$). Table 7 shows the results of the post-hoc Tukey's HSD test for determining significance in pairwise comparisons; the test yielded only four statistically significant results and two insignificant results. Overall, there was no difference in F2 between the pairs /ɒ/-/ɑː/ and /ʌ/-/ɒ/. However, the Saudi women's F2 for /æ/ was higher (more fronted) than their F2 for /ɑː/, /ɒ/, and /ʌ/. Additionally, for /ʌ/ the Saudi women had a higher average F2 (more fronted) than they had for /ɑː/.

We also analyzed the differences and overlaps between the speakers' back vowels. One-way ANOVA of F2 values yielded insignificant results ($F(2,72) = 0.89$, $p > .05$). Table 7 shows the pairwise comparisons, all of which were non-significant.

Overall, the Saudi women exhibited no statistically significant differentiation between the pairs /ɪ/-/ɜː/, /e/-/ɜː/, /e/-/ɪ/, /ɒ/-/ɑː/, /ʌ/-/ɑː/, /æ/-/ɑː/, /ʌ/-/ɒ/, /æ/-/ʌ/, and /uː/-/ʊ/ in terms of F1, and they exhibited no statistically significant differentiation between the pairs /e/-/ɪ/, /ɒ/-/ɑː/, /ʌ/-/ɒ/, /ʊ/-/ɔː/, /uː/-/ɔː/, and /uː/-/ʊ/ in terms of F2.

3.3 Duration Comparisons of English Vowels

3.3.1 Duration Comparison of English Vowels between Saudi and British Men

Differences in the duration of Saudi and British men's English vowel production are shown in Figure 4 and Table 8.

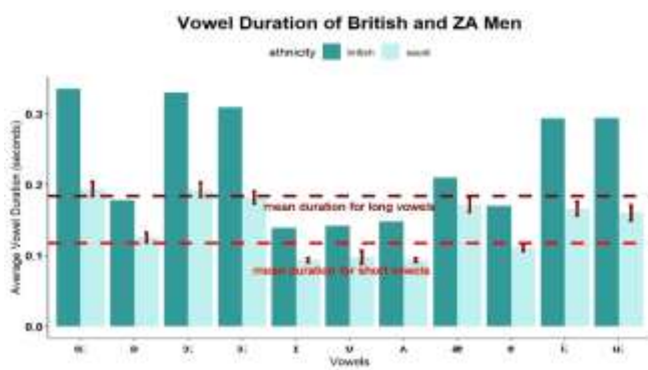

Figure 4. Vowel durations of Saudi and British men for English vowels

Table 8. The differences in duration of English vowels of the Saudi and British men

Vowels	Saudi	British	Mean difference	t	p	Significance after Bonferroni correction
/iː/	.16	.29	-0.12	-13.31	$.01*10^{-10}$	***
/ɪ/	.09	.13	-0.04	-13.25	$.01*10^{-10}$	***
/e/	.11	.17	-0.05	-14.21	$.03*10^{-11}$	***
/æ/	.17	.21	-0.03	-3.97	$.05*10^{-2}$	
/ɜː/	.18	.30	-0.12	-14.59	$.01*10^{-11}$	***
/ʌ/	.09	.14	-0.05	-17.642	$.03*10^{-13}$	***
/ʊ/	.09	.14	-0.04	-4.66	$.09*10^{-3}$	**
/uː/	.16	.29	-0.13	-12.26	$.07*10^{-10}$	***
/ɒ/	.12	.17	-0.05	-7.35	$.01*10^{-5}$	***
/ɑː/	.19	.33	-0.14	-13.73	$.07*10^{-11}$	***
/ɔː/	.19	.33	-0.13	-13.74	$.07*10^{-11}$	***

In terms of duration, all vowels showed significant differences except for /æ/. The British men had a longer duration than the Saudi men for /iː/, /ɪ/, /e/, /ɜː/, /ʌ/, /ʊ/, /uː/, /ɒ/, /ɑː/, and /ɔː/.

3.3.2 Duration Comparison of English Vowels between the Saudi Men and Women

The differences in the duration of the Saudi men's and women's English vowel production are shown in Figure 5 and Table 9.

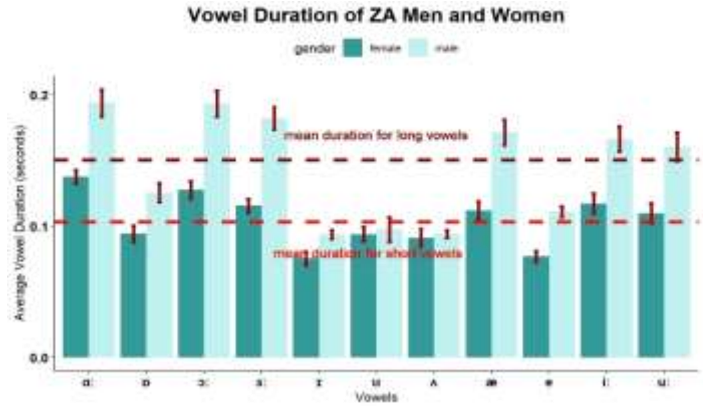

Figure 5. Vowel durations of Saudi men and women for English vowels

Table 9. The differences in duration of English vowels of the Saudi men and women

Vowels	Men	Women	Mean difference	t	p	Significance after Bonferroni correction
/iː/	.16	.11	.04	4.00	$.02*10^{-2}$	*
/ɪ/	.09	.07	.01	2.92	$.05*10^{-1}$	
/e/	.11	.07	.03	5.74	$.06*10^{-5}$	***
/æ/	.17	.11	.06	5.03	$.08*10^{-4}$	***
/ɜː/	.18	.11	.06	6.56	$.08*10^{-6}$	***
/ʌ/	.09	.09	0	.35	.72	
/ʊ/	.09	.09	0	0.32	.74	
/uː/	.16	.11	.05	3.83	$.04*10^{-2}$	*
/ɒ/	.12	.09	.03	3.28	$.01*10^{-1}$	
/ɑː/	.19	.13	.06	4.88	$.02*10^{-3}$	***
/ɔː/	.19	.12	.06	5.44	$.02*10^{-4}$	***

As can be seen in Table 9, no significant differences in duration were found for /ɪ/, /ʌ/, /ʊ/, and /ɒ/ between the Saudi men and women. However, the Saudi men showed consistently longer pronunciations of /iː/, /e/, /æ/, /ɜː/, /uː/, /ɑː/, and /ɔː/ than the Saudi women.

4. Discussion

This study investigates the particular difficulties that Zilfaawi EFL learners experience while producing English vowels and finds that they generally maintain distinctions between most vowel pairs throughout production.

The study was conducted independent of each participant's gender. Therefore, it makes distinct observations. Figures 1 and 2 show that the Saudi male and female speakers had a more centralized vowel space than the British speakers. The men manipulated the height dimension significantly, but no significant changes were observed in the frontness dimension. However, women underwent changes in both dimensions. The vowel /ɪ/ was the only one with significant F1 and F2 differences for men. The vowel /ɔː/ was the only one with significant F1 and F2 differences for women (fronter and lower).

Regarding high vowels, the men and women in the current study agreed to locate the high vowel /iː/ as the vowel with the lowest F1 and highest F2 (higher and more fronted) in their vowel space. These results are consistent with data obtained by many researchers, such as Munro (1993) and Hubais and Pillai (2010). Among the front and back high vowels, the lax vowel /ɪ/ was the lowest high vowel on the height dimension. Compared with female native speakers, there seemed to be no significant differences discovered for high vowels (front and back) among the women, except for a slight, significant production difference for the high back vowel /u:/. The Saudi women produced this vowel farther back in the vowel space. This result aligns with what has been reported in the literature on producing the back vowel /u:/ farther back to resemble the Arabic vowel /u:/, which is produced farther back in the vowel space compared with English (Hubais & Pillai, 2010). However, the women's non-significant differences in the other high vowels contrast with many studies which have reported problems in producing such vowels (e.g., Ali, 2013; Hubais & Pillai, 2010; Khalil, 2014). The statistical analysis used to compare the adjacent high vowels revealed that the women had difficulty differentiating between the vowel pairs /e/-/ɪ and /uː/-/ʊ/.

However, the men seemed to have some differences in the height dimension when producing high vowels. In contrast with some authors who mentioned that high vowels did not cause any production challenges (Ali, 2013; Khalil, 2014; Munro, 1993), the Saudi men in this study tended to produce the vowels with a higher average F1 (lower in vowel space) than the British men for the vowels /iː/, /ɪ/, and /uː/. Moreover, the Saudi men had a lower average F1 (higher in vowel space) than the British men for the vowel /e/, making the vowels /ɪ/ and /e/ closer. The vowels /e/ and /ɪ/ are frequently cited as causing difficulties among Arab EFL learners. These outcomes have been detailed by

Munro (1993), Khalil (2014), and Hubais and Pillai (2010). Emran and Anggani (2017) also discovered that learners of Libyan changed /e/ with /iː/ or /ɪ/. Ababneh (2018) further noted that Saudi EFL students frequently confused the vowel /e/ with /i/. Additionally, Ali (2013), Kalaldeh (2016), and Al-Rubaat and Alshammari (2020) reported similar results. However, an overlap test indicated that men can differentiate between the high vowels /iː/, /ɪ/, /uː/, and /ʊ/ and the mid vowels /e/ and /ɔː/ by maintaining contrast in the height dimension.

Mid-front and back vowels cause problems for Arabic speakers of English (Haubai & Pillai, 2010; Kharma & Hajjaj, 1989; Power, 2003**)**. The women in our study produced /ɔː/ lower and more fronted in the vowel space. This is consistent with results reported in the literature. Previous research with other Arab EFL learners indicated that /ɔː/ merged with /ɒ/, which may lead to confusion between such words as "cot" and "caught," as well as "shot" and "short" (Haji & Mohammed, 2019; Hubais & Pillai, 2010). Hubais and Pillai (2010) stated that this confusion may be due to the speaker's difficulty in creating back vowels. The testing, in our study, of the female productions indicates an overlap between the two vowel pairs /ʊ/-/ɔː/ and /uː/-/ɔː/ in the advancement dimension (F2). As for the non-existent vowel in the Arabic inventory, the vowel /ɜː/ was produced differently on the height dimension. The men and women produced this vowel significantly more frequently in the vowel space. By contrast, it was produced toward the front by the women, although not significantly, making it more similar to the vowel /eː/ in Arabic. Testing the overlap between the front vowel pairs /ɪ/-/ɜː/ and /e/-/ɜː/ indicated no overlap between these pairs for men. However, the women showed an overlap between the two pairs. This means that raising the vowel and fronting it makes it closer to the front vowel, with no significant difference between them, which might affect the intelligibility of the vowels produced by Saudi learners. Hubais and Pillai (2010) reported /ɜː/ fronting and mentioned that the fronting of the vowel might be attributed to the speaker's recognition of the following r in the target words. Moreover, the vowels not present in Arabic, such as the vowel /ɜː/, exhibit different quirky characteristics. Power (2003) also reported that the vowel /ɜː/ was produced similarly to /i/. This raising could be caused by the inconsistency of pronounced English sounds and orthography, because the infinitive form "hear" (/hɪə/) is with the high front vowel /ɪ/ (O'Connor, 1980). Therefore, learners must practice pronouncing English words to ensure correct pronunciation.

As reported in the literature on low vowels, there seems to be no agreement in the current study on the ordering of the low vowels in the vowel space compared with native speakers (/ɒ/, /ʌ/, /æ/, /ɑː/). The Saudi women had more production problems than the native women. The former produced the low vowel /æ/ higher in the vowel space (with lower F1 values) and the vowel /ɒ/ toward the front (with higher F2 values). The overlap test indicates that the women encountered problems differentiating between the vowel pairs /ɒ/-/ɑː/ and /ʌ/-/ɒ/. However, the Saudi men had more problems than the native men in producing the vowel /ʌ/. The former produced a lower vowel that was higher and farther back in the vowel space. The conducting of an overlap test revealed that the men encountered problems differentiating between the vowel pairs /ʌ/-/ɒ/ and /ʌ/-/ɑː/. This result is in line with what has been reported in the literature by many researchers as a common problem in vowel production for Arab learners of English. Kharma and Hajjaj (1989) stated that one of the biggest problems Arabic speakers have is the difference between vowels such as /ɒ/ and /ʌ/ in words like "lock" and "luck," and /ɔː/ in "caught" and "coat." Chouchane (2016) revealed that the Omani EFL learners surveyed frequently mixed the vowels /æ/ and /ʌ/, resulting in the pronunciation of the word "catch"/kætʃ/ as [kʌtʃ]. In their analysis of Omani Arabic, Hubais and Pillai (2010) reported that, in the vowel pairs /ʌ/-/ɑː/, /ʊ/-/uː/, and /ɒ/-/ɔː/, the Omani speakers contrasted vowel length rather than vowel quality. They also mentioned that vowels in adjacent pairs sometimes overlapped during generation, especially back-vowel pairs. According to Barros (2003), **t**he realization of the vowels /ʌ/, /e/, and /ɔ/, which are in the middle of the vowel space, can be somewhat variable.

Many studies have reported that male and female English speakers produce vowels in different ways (Abbasi, Channa, John, Memon, & Anwar, 2018; Haji & Mohammed, 2019; Hubais & Pillai, 2010; Hunter & Yarkiner, 2014; Ramadan & Thai, 2021; Sulong, 2016). To verify this hypothesis, the pronunciations of male and female Saudi EFL learners were compared. Overall, the Saudi men had a more centralized vowel space than the women. All vowels, except for the vowel /ʊ/, of the Saudi female learners in the current study were produced more front and lower than those of male learners. Many studies have reported similar conclusions when investigating the pronunciation of both male and female speakers (e.g., Martland et al., 1996). Martland et al. (1996) examined 10 vowels across gender and accent in their study. It was found that, in the British English accent, the females pronounced the front vowels /æ/, /ɪ /, and /e/ at much lower levels than did the males. Moreover, the females generated lower back vowels than the males in the acoustic vowel space.

In the current study, statistically, there were no significant differences in F1 between the Saudi men and women for all vowels except the low vowels /æ/ and /ʌ/. The Saudi women had a higher average F1 (lower in vowel space) for both /æ/ and /ʌ/ than the Saudi men.

Regarding average F2, there were no significant differences between the Saudi men and the women for the back vowels /ʊ/, /uː/, /ɒ/, /ɔː/ and the low vowel /ɑː/. However, there were significant F2 differences found between the Saudi men and women in several front vowels: /iː/, /ɪ/, /e/, /æ/, /ɜː/, and /ʌ/. For all these vowels, the Saudi women had a higher average F2 (farther fronted) than the Saudi men. The only exception was the lax back vowel /ʊ/, with a minor difference between the men and women.

These' results contradict those of certain studies that reported no gender differences in English vowel production. For example, Kassaian (2011) reported that Persian speakers perceive and produce English speech sounds with no significant gender differences. Moreover, Hariri (2012) argued that there are no substantial difference between female and male English learners when it comes to vowel production. Different productions between male and female speakers of Zilfaawi Arabic are expected because males and females in Saudi Arabia are segregated in social gatherings and in most places, such as schools and workplaces. In addition, Fant (1966) argued that the formant frequencies of vowels could be attributed to women's physiological differences in having a shorter pharyngeal cavity and a smaller laryngeal cavity than men.

Regarding duration, all the British and Saudi men and Saudi women agreed on ordering the short vowels as follows: /ɪ/, /ʌ/, /ʊ/, /e/, and /ɒ/, and the vowel /ɜː/, followed by /æ/, /iː/, /uː/,/ɑː/ and /ɔː/ as the longest ones exhibited by native speakers. However, interestingly, the Saudi men made the vowel /æ/ longer than /i:/ and /u:/. According to Hubais and Pillai (2010), the transfer of L1 could cause lengthening of low vowels. This transfer of L1 could also explain the equal length difference observed between the vowel pairs produced by Saudi speakers, /i:/-/ɪ/ and /u:/-/ʊ/ (.16-.9). The results of our study on Saudi male EFL learners align with what Munro (1993) observed: on average, the length of all vowels that were generated by Arabic speakers was consistently shorter than the length of the vowels produced by American speakers. He put this disparity down to the transmission of shorter attributes of comparable Arabic vowels. Cox and Palethorpe (2005) discovered that the Lebanese Australian people surveyed in their study preferred to shorten long vowels and diphthongs. Overall, the low vowels produced by the Saudi and native men were longer than those produced by the non-low vowels. These findings are in line with Lindblom's (1967) report that open vowels frequently last longer than closed vowels because low vowels require more biomechanical effort to form.

Simpson and Ericsdotter (2003) investigated gender differences in durational disparities. Their study included 48 participants from the United States and Sweden. They reported that the females created a longer vowel duration and a wider distinction between short and long vowels than did the males. However, the women in our study had shorter vowels than the men, and the difference in length between short and long vowels was smaller than that of the native Saudi male speakers. Compared with Saudi men, the short length of women's long vowels in this study supports what has been reported in the literature on Arabic speakers of English (Khalaf & Mohammed, 2022; Munro, 1993). Indeed, it has been stated that English vowels pronounced by Arab learners of English are shorter than those pronounced by native English speakers. However, this contrasts with Hariri's (2012) report that there is no substantial difference in vowels between female and male English learners. Compared with the Saudi men, the Saudi women ordered the vowels as follows: /ɪ/, /e/, /ʌ/, /ʊ/, /ɒ/, /iː/, /æ/, /ɜː/, /uː/, /ɔː/ and /ɑː/. They also consistently produced the three vowels /ʌ/, /ʊ/, and /ɒ/ with almost the same length. After rounding the numbers up, it was found that the variations between the two vowels /ʌ/ and /ʊ/ were so minor that they were not reflected in the final results. In addition, the vowels /iː/, /æ/, /ɜː/, and /uː/ were also produced with the same duration.

The results indicate that Zilfaawi EFL students mispronounce vowels to varying degrees. Learners' mispronunciations of English vowels, regardless of whether they have equivalent vowels in their L1, indicate that L1 interference is not the only cause of mispronunciations (Ali, 2013; Al-Badawi, 2012). Three possible factors could cause such problems with English vowels. The first of these is interference from the learner's native language (Haji & Mohammed, 2019; Hubais & Pillai, 2010; Munro, 1993). An example of this kind of error is the lengthening of the low vowel /æ/, making it longer than the high vowels /i:/ and /u:/. Second, the inconsistency of English sounds and orthography is another factor in mispronunciations (O'Connor, 1980). For instance, while the letter o in the word "some" and oo in "flood" should both sound like /ʌ/, the words "home" and "food" do not employ the same vowel. In this study, the word "heard" is pronounced /hid/, as mentioned above. Additionally, some participants pronounced the word "hood" as /huːd/ instead of /hʊd/. Mother-tongue interference might not be a possible reason for such mispronunciation, because the vowel /ʊ/ is available in the Arabic phonetic system, as reported by many Arabic studies (e.g., Al-Ani, 1970; Alotaibi & Husain, 2010; Haji & Mohammed, 2019). Third, inadequate exposure to English sounds and insufficient practice in pronouncing English words may be contributing factors (Al-Badawi, 2012; Haji & Mohammed, 2019). Some participants pronounced the vowels correctly during their first reading. However, in a different interpretation, the vowel was mispronounced, resulting in a vowel that differed from that of native speakers. For example, some speakers pronounced "hid" as /hiːd/ and /hɪd/.

5. Conclusion

The present investigation has substantially contributed to second-language (L2) speech production by examining vowel production among a cohort of Saudi EFL learners – a group which has received limited scholarly attention. The current investigation represents a pioneering effort in conducting an acoustic examination of spectral measurements of English vowels produced by EFL male and female learners living in Az Zilfi. This study's findings indicate that there are significant differences between Saudi EFL learners and native British speakers with regard to certain vowels, as reported by Deterding (1990) and Wells (1963). The men produced vowels with shorter durations than the native speakers. Moreover, the women generated vowels that were lower and more front than the native women. Regarding duration, the Saudi learners produced shorter vowels than the native English speakers, whereas the non-native males produced longer vowels than the non-native females. In addition, low vowels generated by the Saudi and native males were longer than non-low vowels. This study also revealed statistically significant gender differences in the production of English vowels between male and female Saudi EFL learners. Compared with the women, the Saudi men had a more centralized vowel space. The men and women overlapped the low vowels, which may cause communication difficulties. Mispronunciations of English vowels by Saudi learners, regardless of whether they have equivalent vowels in L1, indicate that L1 interference is not the only cause of mispronunciations.

The results have the following implications. Specific English vowels require more attention when teaching English sounds to Saudi speakers. Therefore, English teachers in Saudi Arabia may consider placing more emphasis on English pronunciation – a subject typically glossed over. Our findings highlight the need to link the instruction of English phonemes, particularly vowels, to the language's existing orthographic sound patterns. Using this method to teach English may increase students' grasp of English sounds as they occur in actual words. Educators should adjust their present focus on teaching branches of language, such as grammar, to placing equal weight on the creation of intelligible pronunciation in future syllabi for English education at Saudi Arabian schools. Language laboratories, in conjunction with language instruction, may be of practical use for implementing this transition.

6. Limitations and Recommendations for Future Research

The small sample size of this study indicates that the research is only preliminary. Future studies should involve a greater number of participants and a wider range of topics. Moreover, data collection ought to be expanded to include more speech situations as well as diphthongs, so as to extract vowel quality and length contrast from a larger dataset. Furthermore, future studies should incorporate perceptual assessments to investigate speakers' intelligibility, that is, how well listeners from diverse locations understand Saudi speakers and how this relates to their English vowel production. In subsequent research, it may be beneficial to employ uniform standardized word lists in terms of familiarity and length to mitigate any extraneous variables that could potentially affect the participants' auditory recognition capabilities. Furthermore, scholars should consider the effect of learners' English proficiency levels on the diversity of English vowel realizations.

Acknowledgment

The researcher would like to thank the Deanship of Scientific Research at Majmaah University for supporting this research under project No. R-2023-524

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