THESIS

THE PRODUCTION OF ENGLISH VOWELS BY NATIVE ARABIC SPEAKERS

Submitted by

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ABSTRACT

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When Arabic learners first delve into the English language, they may find many difficulties in pronunciation due to the fact that there are vast differences between English and Arabic, especially regarding the number of vowels and their acoustic realizations. Very few studies have investigated this area of English languageacquisition. The aim of this study is to examine the production of English vowels by Arabic speakers and to examine if there are gender differences in the production of English vowels by Arabic English learners. By using the phonetic software Praat, the values of duration and formant of vowel sounds was measured and obtained. English vowels produced by the subjects were recorded and analyzed using Praat, and were compared to results from a research project looking at English native speakers in Colorado. Since the participants were exposed to English and had lived in Colorado, USA, differences in vowel production were discussed and an analysis was conducted. The result of this study displayed that there are significant differences between Saudi ELLs and Colorado English native speakers in almost all the vowels. In addition, this study revealed the significant role of gender and regional dialect in producing English vowels by Arabic speakers.

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DEDICATION

I would like to dedicate my thesis to my beloved mother, my extraordinary husband and my wonderful family.

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CHAPTER ONE

LITERATURE REVIEW

1.1 Introduction

This chapter is devoted to reviewing literature that is related to Arabic native speakers as English language learners. The aim is to provide a theoretical background that is based on the differences between Arabic and English in terms of vowel systems, reading and orthography, and English vowels production. Additionally, this literature review includes a discussion of factors that may affect language acquisition, perception and production like age and gender. The aim is to provide a discussion that will help with interpreting data and results in chapter three and four.

1.2 Differences between Arabic and English Vowel Systems

Different varieties of English have different vowel inventories that differ in number of phonemes and their phonetic realization (Yavas, 2011, p.77). The focus will be on the North American vowel systems, for the purpose of this thesis. American English vowels could be classified into long and short vowels. Long vowels are described as being free since they could occur in different phonetic contexts. On the other hand, short vowels are described as being checked since they should be followed by a consonant and could not occur in word-finally in stressed position (Labov, Ash, & Boberg, 2005). In the American dialectology that was introduced by Kurath, vowels are presented as single symbols, except for the diphthongs /ai, au, oi/. The simplified form of the IPA was adapted by using the phonetic symbol that matches the pronunciation of each vowel (Labov, Ash, & Boberg, 2005, p.11). In the production of vowels, the most important factors are the part of the tongue involved: front, central, and back, and the height of the tongue: high, mid, and low, as shown in table 1 (Yavas, 2011).

Table 1
Phonemes of American English in broad IPA notation (Kurath 1977: 18–19) (as cited in Labov, Ash, & Boberg, 2005, p.11).

Checked				Free vowels					
Front		Back		Front		Central		Back	
bit	/ ɪ /	/ ʊ/	*foot*	*beat*	/i/			/u/	*boot*
bet	/ ɛ/		*hut*	*bait*	/e/	/ ɜ /	*hurt*	/o/	*boat*
bat	/æ/	/ ɑ/	*hot*	*bite*	/ai/			/ɔ/	*bought*
				quoit	/oi/			/au/	*bout*

The vowels in table 1 are usually described as being "simple", however; the /i/ and /u/ are slightly diphthongized, /ij/, /iy/, and /uw/, respectively. In addition, /e/ and /o/ are more diphthongized, /ej/,/ey/, /eɪ/, and /oʊ/, /ow/, respectively (Yavas, 2011, p.78). According to Yavas (2011), /aɪ/, /aʊ/, and /ɔɪ/ are the main diphthongs of American English that can be found in all word positions, which are stressed in the first vowel and all end in a high vowel (p.86).

The production of American English simple vowels and diphthongs vary from one variety to the other. For instance, the front vowel /ɪ/ tend to be produced as /ɛ/ before nasals by African- American Vernacular English (AAVE) and Southern American English speakers (e.g. thing [θɛŋ]). The front vowel /ɛ/ might be raised to /ɪ/ by AAVE before (e.g. pen [p ɛ n]). Before /ʃ, ʒ /, the front vowel /ɛ/ might be realized as [e] by Southern American English speakers (e.g. special [speʃəl]). Furthermore, the merger of the back vowels /ɑ/ and /ɔ/, like in cot-caught [kɑt]-[kɔt], is a typical feature in many American dialects in Maine, New Hampshire, Vermont, north Massachusetts, Western Pennsylvania, Midland territory, and the American west. However, this collapse of the back vowels /ɑ/ and /ɔ/ does not appear when the vowel is followed by tautosyllabic (e,g, born and barn). Regarding diphthongs, /aɪ/ could be produced by southern USA as [ɑ:] or [a:] if not followed by a voiceless consonant. However, in southern Philadelphia

and parts of New York, /aɪ/ becomes /ʌɪ/. In Pennsylvania, Maryland, and Delaware, the diphthong /ɔɪ/ sometimes realized as /oɪ/. In the south and AAVE, /ɔɪ/ is produced as a monophthongized [ɔ:] (e.g. oil [ɔ:l]). With /aʊ/, Virginia, parts of northern New England, Wisconsin, and Minnesota produce /aʊ/ as /ʌʊ/, like in house [hʌʊs]. The southern coastal areas realized /aʊ/ as [aɪ] where thy produce down as dine (Yavas, 2011, p.83-86).

On the other hand, Arabic as a Semitic language has limited vocalic inventory and a rich consonantal system compared to other languages like English (Watson, 2002, p.1). Modern Standard Arabic has three long vowel qualities, /i:, a:, u:/: front, central, and back, and their short counterparts /i, a, u/. Long vowels of Arabic are part of the alphabet, /i:, a:, u;/, whereas their short counterparts are represented as diacritical marks (Huthaily, 2003). A few studies argued that the long vowels vary qualitatively and quantitatively from their short counterparts (e.g. Rosner, & Pickering 1994, as cited in Almbark & Hellmuth, 2015). Gairdner (1925) was the first to describe the three fundamental vowels within the Cardinal Vowel diagram. The Cardinal Vowel diagram is a triangle diagram that represents the three vowel units or phonemes in Modern Standard Arabic: Front, back, and central (as cited in Newman & Verhoeven, 2002).

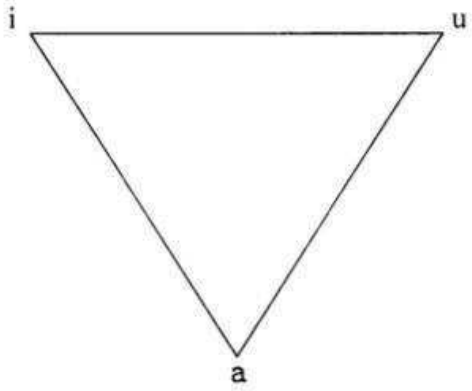

Figure 1. Arabic fundamental vowel triangle

Arabic is a Semitic language that is spoken as a first language (L1) in twenty-five countries in the Arabian Peninsula and North Africa. As a second language (L2), Arabic is spoken in additional countries of Asia and Africa. It is important to note that Arabic is the language of the Holy book Quran and the prophet Mohammad and therefore Muslims want to learn Arabic to be able to understand the message of God and to pray. The language in the Quran is known as the Classical Arabic, which was the dialect of Mecca where the prophet Mohammad was born. Nowadays, the common form of Arabic that is used in education, media, and between educators is called Modern Standard Arabic, which uses less complicated grammar and more modern vocabulary than the Classical Arabic (Huthaily, 2003). Beside the Classical Arabic and the Modern Standard Arabic, each region in the Arabic world has its own variety of spoken Arabic. These different varieties of Arabic vary from each other in pronunciation, grammar, and vocabulary.

Alghamdi (1998) mentioned that the three vowel qualities are in almost all Arabic spoken dialects. However, there are vocalic sounds that are unique to certain spoken varieties of Arabic (Ahmad, 2008). For example, Jordanian Arabic (Barkat-Defradas, Al-Tamimi & Benkirane,

2003), Syrian Arabic (Almbark and Hellmuth, 2015), and Libyan Arabic (Ahmed, 2008) have eight vowels. Some of these studies are reviewed below. Al-Ani (1970) conducted the first study on Arabic vowels using x-ray tracing, and impressionistic judgments. His study examined the production of standard Arabic by Iraqis. In Al-Ani (1970), vowels were recorded in isolation and minimal pairs. However, he focused on the isolated vowels to avoid any consonant-vowel transition that may affect vowel formants. He stated that when long vowels are in isolation the duration is twice the length of short vowels since vowels are spoken more explicitly than in normal speech. By observing the x-ray tracing, Al-Ani (1970) pointed out that there is a little difference between the long high front vowels /i:/ and the high long back vowel /u:/ and their short counterparts. Conversely, he mentioned that the tongue position for the low central vowel /a:/ is lower and more retracted than its short counterpart /a/ in the vowel space (Al-Ani, 1970, p.25).

A more recent study conducted by Alghamdi (1998) examined production of Modern Standard Arabic vowels by different Arabic spoken varieties. The study included 15 male participants from Saudi Arabia, Egypt, and Sudan. The participants produced the vowels in isolated CVC syllables to avoid any effects from the speech context, as Alghamdi (1998) stated. The words for the long vowels were meaningful whereas nonsense words, symbolized by diacritical marks, were used for the short vowels. Alghamdi (1998) revealed that there is a quantitative difference between short and long vowels in the vowel space. Alghamdi (1998) pointed out that long vowels appear to be more marginal, whereas; their short counterparts appear to be more central. In terms of long vowels, the study revealed that Saudi speakers produced significantly lower long vowels, /i:, a:, u:/, than Egyptians and Sudanese. Egyptians produced a higher long central vowel /a:/ than other speakers in this study. With the short vowel

/a/, Saudis, Egyptians and Sudanese produced significantly different F1 values. He concluded his study by stating that participants from Saudi Arabia, Egypt, and Sudan have distinctive implementations of Modern Standard Arabic vowels. Hence, even with the Standard form of Arabic the production of vowels differs considerably across regional spoken varieties of Arabic.

Newman and Verhoeven (2002) examined vowels in the Quranic recitation of Classical Arabic, since it is considered the most prestigious and pure among other forms of Arabic. They pointed out that there are different recitation styles of the Quran, which range from very slow to fast pace. The study analyzed 30 minutes of Quranic recitation by Muhammad Sadiq al-Minshawi since he is known for his classical orthoepy and slow non-musical recitation (Newman & Verhoeven, 2002). For their sample, they eliminated vowels in pharyngealized contexts to avoid any coarticulation effects; an increase in F1 and a lowering of F2. They segmented the Quranic recitation manually in a broadband spectrogram and acoustic evaluation. In their study, they observed 400 different vowel contexts. In addition to the Quranic recitation, Newman and Verhoeven (2002) conducted an acoustic analysis of relevant vowels in colloquial Egyptian Arabic (Cairo) using a translated passage from English to Arabic of the 'North Wind and the Sun', a standard text used in phonetic and acoustic analysis.

Table 2
List of vowel frequencies (Hz) in Cairene and Quranic Arabic (Newman, & Verhoeven, 2002, p. 87)

	i:		i		u:		u		a:		a	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Quranic	390	1725	440	1770	470	1120	480	1170	620	1455	616	1460
Cairene	290	1940	375	1575	290	830	360	912	610	1500	683	1435

Newman and Verhoeven (2002) concluded their study by stating that there is no significant evidence about Classical Arabic being acoustically purer than Modern standard Arabic. Regarding duration, they pointed out that there is no statistically significant difference between the length of long and short vowels, which does not accord with findings in Modern Standard Arabic and other spoken varieties.

Ahmed (2008) investigated vowel production and perception of 20 Libyan Arabic speakers. The production part of his study examined the first and second frequencies, and vowel duration. He stated that Libyan Arabic has eight vowels, with five long vowels /i : /, /u : /, /e: /, /o: / and / æ:/ and three short vowels / ɪ/, / ʊ/, and / ə/. He stated that /e:/ and /o:/ do not have short counterparts and that they are originated from the Modern Standard Arabic diphthongs /ai/ and /au/, respectively. Ahmed (2008) pointed out that the same number of vowels is found in Jordanian Arabic (Barkat-Defradas, Al-Tamimi & Benkirane, 2003) and Egyptian Arabic (Gairdner 1925, Cowan 1970, Norlin 1987). Regarding duration measurements, Ahmed (2008) pointed out that long vowels are more than twice as long as short vowels. Ahmed (2008) stated that the duration ratio of Libyan Arabic is the same as Egyptians and similar to Sudanese (Alghamdi, 1998). Nevertheless, he mentioned that the vowel duration ratio of Libyan Arabic is significantly distinct from Saudi (Alghamdi, 1998), Iraqi (Al-Ani, 1970), Jordanian (Mitleb 1984) and Gulf Arabic (Hussain 1985), 0.51, 0.50, 0.65, and 0.56 respectively.

In their acoustic study, Almbark and Hellmuth (2015) aimed to examine the Syrian Arabic vowel system. The participants in their study were fifteen Damascenes (10 males and 5 females). They used real monosyllabic /CVC/ words in Syrian Arabic beside the nonsense /hVd/ context to ensure correct production of vowels. They analyzed the mid short vowels [e] and [o]

as allophonic variations of /i/ and /u/, respectively. They reported that Syrian Arabic has five long vowels (/i:/, /e:/, /a:/, /o:/, /u:/), and three short vowels (/i/, /a/, /u/), as presented in figure 2.

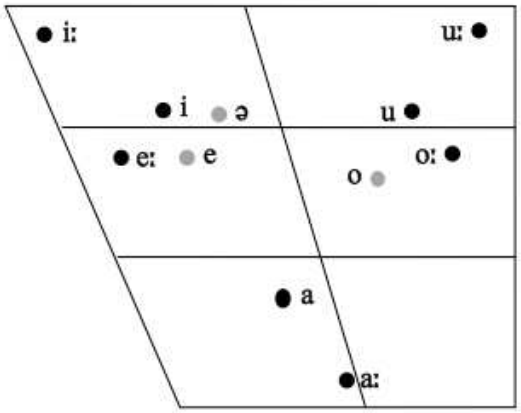

Figure 2. Syrian Arabic phonological vowel categories (black) and allophonic categories (grey) from Almbark and Hellmuth (2015)

Almbark and Hellmuth (2015) pointed out that the vowel space of Syrian Arabic is similar to Modern standard Arabic triangular form, with additional centralized mid vowels. They stated that the long vowels /i: a: u:/ are further than their short counterparts /i a u/, whereas the mid- long vowels /e: o:/ are closer to their short counterparts /e o/ in the Syrian Arabic vowel space.

1.3 Reading in Arabic

Arabic words are based on a root that includes three consonants and different patterns of vowels and consonants are applied to form families of words that are related in meaning. For example, as demonstrated in Table 3 when combining the root k-t-b with different vowel patterns and consonants a whole family of words is created that is related in meaning (Ryan, & Meara, 199, p.533).

Table 3
The root k-t-b in different vowel patterns

kataba	"he wrote"
katabat	"she wrote"
yaktubu	"he writes"
taktub	"she writes"
kātib	"writer"
maktab	"office"
maktabah	"library"

Literary Arabic contains 28 letters, twenty-five consonants and just three long vowels, which is read and written from right to left. Arabic script has a predictable sound-symbol correspondence in which the letters correspond with their sounds, known as homography (Abu-Rabia, 1999). Nevertheless, as stated by Abu-Rabia (1999), there are certain irregularities that need the reader to have substantial textual knowledge of syntax, lexicon and contextual interpretations of the language, especially if the reading is not marked with short vowel signs. The three short vowels /i, a, u/ are represented as diacritics below and above letters that are found in texts for beginner readers. Abu-Rabia (1997) stated that Arabic language is commonly homographic and that advanced readers of Arabic identify the intended words in their text (e.g. newspapers) without the short vowel signs since they have prior contextual and linguistic knowledge. Thus, Abu-Rabia (1997) described reading in Arabic as reading consonants and predicting vowels (as cited in Abu-Rabia, 1999, p.96).

In their study about Arab EFL readers, Alshaboul et al. (2014) examined cross-linguistic transfer, phonological awareness, and the effect of L1 in L2 reading. Alshaboul et al. (2014) included 35 (20 males and 15 females) Jordanian first grade students. All the participants were

native speakers of Arabic and beginner learners of English. They pointed out that Jordanian students performed better and twice easier with Arabic word recognition than in English. They also performed better in letter identification than word recognition in English since the classroom instructions emphasized on letter-focus rather than word-focus, as mentioned by Alshaboul et al. (2014). With adult learners of English, Ryan and Meara (1991) investigated the hypothesis that Arab ELLs tend to rely heavily on consonants when reading English text. They stated that Arabic native speakers tend to ignore vowels and focus on consonant segments to pronounce English words (Ryan, & Meara, 1991). When reading in English Arab learners rely on phonological processing skills from their L1, which may cause many challenges in terms of word recognition and make the reading process slower. That makes the English text presented with too much information for native speakers of Arabic (Ryan, & Meara, 1991, p.533).

In this thesis, the participants in study 2 of the production of English vowels by Arab ELLs were asked to translate the targeted words from Arabic to English instead of reading them since they might focus on consonant segments and guess vowels (Abu-Rabia, 1997, as cited in Abu-Rabia, 1999, p.96). Reading in English might affect the production of English vowels by Arab ELLs since they might rely on phonological processing skills from their L1 that might affect word identification (Ryan, & Meara, 1991, p.533).

1.4 Production of English vowels by Arabic speakers

As a first language, English differs in vowel quality and quantity from one variety to the other. The same phenomenon exists for English as a second language. Regarding adult Arabic learning of English, English vowels appear to be challenging for different reasons. One of the primary difficulties in foreign language learning is the interference caused by the differences between the mother tongue language and the foreign language. The phonetic inventory system

and the differences between L1 and L2 affect learners' production of new sounds. Those sounds that do not exist in the L1 phonetic system will affect speech perception and production of the L2, according to the traditional contrastive analysis (Flege, Munro, and MacKay, 1996.). For example, Arabic language lacks the phoneme /p/, a voiceless bilabial stop, therefore; Arab adult speakers of English tend to produce and perceive /p/ as /b/ by reducing its voice onset time, voicing, and eliminating its aspiration (Buali, 2010).

Regarding vowels, Munro (1993) examined English vowels by Arabic speakers, who had lived in the US for an average of 6 years. He stated that Arabic learners of English produced all English vowels differently than native speakers. He pointed out that a minority of the Arabic speakers had comparable F1 and F2 values to native English speakers in the production of the five front vowels /i, ɪ, e, ɛ, æ/. In addition, Brown and Oyer (2013) examined the production of eleven English vowels produced by Arabic native speakers. This study included a Saudi male participant who was in his early 20's who speaks Arabic as his first language and had lived in the US for nine months. They compared the F1 and F2 measurements of the vowels produced by the Arabic speaker with a study done by Peterson and Barney (1952), which at that time established an acoustic baseline for "Standard American English."

Brown and Oyer (2013) indicated that the Arabic speaker produced lower high vowels and more central back vowels than the native speaker of English. The Arabic speaker also produced /e/ as /ɛ/ or /ɪ/. In the vowel space, the Arabic speaker's production of /i/ and /e/ F1 frequencies were close to /ɪ/. Brown and Oyer (2013) also stated that the Arabic participant produced /ɑ/ as /ɔ/ and that could cause difficulties in distinguishing words like "cot" and "caught." However, it should be noted that the low-back merger of /ɑ/ and /ɔ/ is a typical feature in many American English dialects such as the Midland areas and the West (Yavas, 2011).

Ali (2013) examined the production of English vowels by EFL Sudanese Arabic speakers and compared the findings with British English native speakers. He pointed out that English vowels are challenging for Sudanese Arabic speakers in both isolated words and connected speech. He stated that these challenges are caused by the interference of the participants' L1 and lack of exposure of L2 vowels. The findings of this study showed that Sudanese speakers' production of the central and back vowels of English were different from British nativespeakers. The English tense vowel /i:/ revealed no significant evidence of production difficulties since it is comparable to the Arabic vowel /i/ (Ali, 2013). He mentioned that the English vowel /ɛ/ are produced as /ɪ/ in words like: "enter, envelope, and wet," since in Arabic sounds correspond with letters and that might influence the Sudanese Arabic speakers' production of English vowels (Ali, 2013, p.500).

Al-Badawi (2012) investigated phonetic, morphological and syntactic errors among 20 Saudi participants ranging in age from 19 to 20 years. All the participants studied English in Saudi Arabia. He used a qualitative interview approach using audio-recorded field interviews to identify common errors. Regarding phonetic errors in this study, Saudi EFLs tended to substitute the vowels /ə/ for /ɔ/, /ə/ for / ʊ/and /ɛ/ for /ɪ/, as Al-Badawi (2012) stated. He pointed out that the main cause of these phonetic errors is the absence of knowledge of English vowels. He concluded by stating that Saudi EFLs produced English vowels by relying on their limited Knowledge and not by replacing Arabic equivalents for English vowels since these vocalic equivalents do not exist in their L1.

Khalil (2014) conducted an acoustic analysis to examine the production of English vowels by Egyptian Arabic speakers and to compare the findings with General American English (GAE) vowels. She examined eleven GAE vowel produced in /hVd/ context by 10 Egyptian speakers (5

females and 5 males). The results in her study revealed that the production of English vowels by Egyptians is influenced by their L1. She argued that the most problematic English vowels for Egyptians, /æ, ɛ, o, ɔ, ɑ/, do not exist in the Egyptian vowel system. She stated that Egyptian Arabic vowel system may affect the production of front vowels /e, ɛ, æ / and the back vowels /ɑ, ɔ, ʊ, o/. She concluded by mentioning that back vowels /o, ɔ, ɑ/ are difficult for Egyptian speakers and that they overlap in the vowel space and interfere with /u/ and /ʊ/ of American English.

Preserving a foreign accent has been attributed to different factors such as age of learning, exposure, and the interference of the L1 by different studies about the production of English vowels by Arabic ELLs. The reviewed studies about the production of English vowels by Arabic native speakers revealed that Arabic speakers struggle with back vowels (Munro,1993 and Khalil, 2014) where they produced more central back vowels than the native speaker of English (Brown & Oyer, 2013). Some studies stated that the front English vowels produced by Arabic speakers reveal no statistically significant difference and that they could be comparable to native speakers (Munro, 1993). It is important to note that a limited amount of research has examined the production of English vowels by Saudi ELLs. Therefore, this thesis aims to investigate the English vowels by Arabic ELLs from Saudi Arabia and compare the results with those of a set of native English speakers studied Holland & Brandenburg (2017).

1.5 Age Differences in Vowel Production

During a child's acquisition of their native language, the child develops his/her native language behavior. Thus, when learning a second language, the learning process will be influenced by the native language behavior. Specifically, the transfer from the first language to the second language could be a positive or a negative transfer. According to the contrastive

analysis hypothesis, it is reported that less challenges are estimated when the structure of the two languages is similar, positive transfer. However, when the structures of two languages are distinct, errors in performance are predicted, which are a negative transfer (Derakhshan and Karimi, 2015).

According to the Critical Period Hypothesis, adult learners' decline to achieve native-like levels of production in the target language, which is caused by the loss of neural plasticity (Birdsong, 1999). This indicates that age of exposure is a very significant factor in language acquisition. Flege (1992) Speech Learning Model (SLM) was developed to determine the degree of success in recognizing non-native sounds. The SLM is based on the perceived phonetic elements that exist in the L1 and L2 systems. Flege (1992) pointed out that adult learners will eventually accurately produce "phones" that do not exist in their L1; whereas, the formation of a new category for similar or equivalent phones will be more challenging. For example, Flege and Port (1981) claimed that the duration of the Arabic long vowel /a:/ produced by Saudi speakers sounds like the English vowel /æ/, indicating that this vowel of the L2 is mapped close to the L1 vowel space. He argued that a new category would be formed if the L1 has fewer vowels than the L2.

Flege, MacKay and Meador (1999) conducted a study about 11 English vowels produced by native Italian speakers who had immigrated to Canada at the age of 2 to 23 years. The participants in this study were rank-ordered according to age of second language learning (AOL), where they began learning the language, to ten groups. The participants who were assigned to group 1, for example, were 24 participants who had a mean AOL of 3.1 years, and group 2 contained 24 participants who had a mean AOL of 5.2 years; and so on. They found that Italian participants who arrived to Canada in an earlier age produced more accurate sounds than late-

arriving participants. They argued that neither the absence nor the presence of sounds in the first language could affect acquiring English vowels and not that some sounds are easier than others. In general, Flege, MacKay and Meador (1999) pointed out that late-arriving Italians tend to pay less attention to L2 vowels and focus on consonants. The study was concluded by stating that late-arriving Italians as a group produced the 11 English vowels differently than native speakers.

The reason that children are more successful in learning new languages than are adults is due to the great amount of input that they receive. As pointed by Flege, Munro and MacKay (1995) leaning a second language after the age of 15 will result with a noticeable foreign accent. Thus, early exposure to a language will facilitate the acquisition and perception of these sounds even if they do not exist in their native language. Chang et al. (2009) examined five Mandarin and English fricatives produced by heritage speakers of Mandarin, native speakers of Mandarin, and English L2 learners. They stated that native speakers of Mandarin and English L2 learners tend to merge similar segments in English and Mandarin, however; heritage speakers maintained a better distinction between the categories across languages because of their early exposure to the language. On the other hand, early exposure does not always mean native-like competence. Snow and Hoefnagel-Höhle (1978) in their study tested the Critical Period Hypothesis on 136 British English learners of Dutch who varied between the age of 5 and 31 year-old. The participants were tested three to four times for a year. They concluded their study by stating that youth have longer period of acquisition than older participants. They pointed out that the need to communicate effectively is greater for older participants than younger ones.

1.6 Gender and Phonetic Variation

Gender has been referred as an important factor that might influence the degree of L2 foreign accent (Flege, Munro and MacKay, 1995). Different studies pointed out that variance between males and females do exist in the production of L2 sounds. For example, Simpson and

Ericsdotter (2003) investigated durational differences in English and Swedish across gender. Their study included 48 participants from America and Sweden. They stated that females produced greater vowel duration and greater difference between short and long vowels than males. However, Simpson and Ericsdotter (2003) pointed out that males produced greater duration in the consonantal material. They indicated that women tend to speak clearer than men. In addition, the differences in women and men's articulatory dimensions could cause men to produce greater articulatory speeds, which accord with other findings for English and German, as Simpson and Ericsdotter (2003). Vowel duration differences across gender have been reported in different studies and stated that women tend to produce larger duration variances between short and long vowels (Chládková, Escudero, & Boersma, 2011).

Pépiot (2015) targeted Parisian French speakers and Northeastern American English speakers in an acoustic analysis of dissyllabic words or pseudo-words between females and males. He points out that women show higher fundamental frequency of dissyllabic words in both American and French. He stated that French female speakers show a larger frequency of the voice fundamental range than males, whereas; American English speakers show no significant difference. In terms of consonant / vowel temporal distribution, females produced longer in word consonants than males and that could be linked to women's tendency to form more explicit speech since in oral word recognition, consonants are tending to be more significant than vowels (Pépiot, 2015).

In their study, Martland, Whiteside, Beet, and Baghai-Ravary (1996) compared 10 vowels across gender and accent. The result in the study showed that females produced far lower front vowels /ae/, /ih/, and /eh/ than males in the British English GN accent. In addition, females

produced lower back vowels in the vowel space than males. According to their findings, on average, females tended to produce lower vowels than males. Flege, Bohn, and Jang (1997) indicated in their study about the non-native speakers' production and perception of English vowels and the influence of experience that the variance in the men's' and women's ''intelligibility'' scores were non-significant and did not interact considerably with any other factor. Additionally, Kassaian (2011) examined the perception and production of English speech sounds and the influence of age and gender by Persian speakers. He reported that gender does not impact the perception and production of English sounds. Moreover, in his literature review of gender-based studies and pronunciation accuracy, Hariri (2012) stated that there is no significant difference between female and male learners in terms of English vowels. However, he pointed out that females produced more accurate consonants than males.

In this thesis, the production of 11 English vowels was different across Saudi females and males. The findings revealed that females and males were distinct in the production of English vowels. It was predicted to find differences in the production of English language as their second language due to the fact that in Saudi Arabia men and women are separated in education, and sometimes work. Additionally, men and women are separated in many social activities like gatherings and weddings.

CHAPTER TWO

METHODOLOGY

2.1 Participants

Saudi English learners. This investigation examined the pronunciation of English vowels by 32 participants (16 females and 16 males) from Saudi Arabia, as shown in table 4. The age of the participants varied between 18 and 38, with an average of 26. They were all international students in the United States living in Colorado. The data was collected from undergrad and graduate students studying in a university in Colorado. In addition, data was collected from beginning and intermediate students from an intensive English program in the same university, as presented in table 4. A placement test used by the intensive English program determined their proficiency level in English. The participants in this group had lived in Colorado from 4 months to 6 years, with an average of 2 years. The participants' first language is the Saudi Arabic local dialect, which is the language of daily life communication in Saudi Arabia. Their Saudi Arabic local dialect was classified into 4 regions: middle, west, east, and south, according to the geographical area.

Table 4
Saudi English learners

Participants'	Males	Females	Group	Number
Level of Education	5	2	Beginner	7
	3	7	Intermediate	10
	5	1	Undergrad	6
	3	6	Grad	9
Dialect	4	5	South	9
	3	7	Middle	10
	5	3	East	8
	3	2	West	5

Native English speakers. The native speakers of English are a subset of speakers from Holland & Brandenburg (2017) selected to match the age range of the Saudi English learners in this study. This group consisted of 16 native English speakers (8 female and 8 males) from Colorado, USA. Their age ranged from 18 to 30, with an average of 24.5.

Native Arabic Speakers. The Arabic native speakers in this study were 4 participants (2 females and 2 males) from Riyadh, Saudi Arabia. The age of the participants varied between 21 and 29, with an average of 24.5. The first language of the participants is the central Najdi dialect, which is a variety of Arabic and the language of daily life across the middle of Saudi Arabia, especially in the capital city. The central Najdi dialect is considered as prestigious across all dialects in Saudi Arabia since it is spoken by the royal family (Aldosaree, 2016). All the participants speak and write Modern Standard Arabic, the language of media, and education.

2.2 Materials

Saudi English learners. The data in this study were collected using two instruments: (1) A reading passage, and (2) A word list (Appendix A and B). For the reading passage the participants read the "North Wind and the Sun," which is a standard text used in phonetic and auditory analysis to study vowel inventories and variation (Krug, 2013, p.229). For the word list task, the interviewer said the word in Arabic and asked the participants to say it in English since Arabic English learners might ignore vowels and focus on consonants to pronounce English words (Ryan & Meara, 1991). It is also important to note, that this strategy was done to avoid any interference between the interviewer's accent and the participants' productions.

Moreover, the word list consisted of the basic vowels of English (Appendix B), /e/, /ɛ/, /i/, /ɪ/, /o/, /ɑ /, /ɔ/, /u/, /æ/, /ʌ/, and /ʊ/. The target words were followed by stops and fricatives since they minimize the influence on vowel frequencies and ensure easy identification in the

waveform. Liquids and nasals were avoided after the vowel since they affect the values of the formant frequencies (Tunley, 1999). In addition, for the word list liquids and nasals were avoided and words with stops and fricatives endings were chosen. It is important to note that liquids, /1/and/r/, and nasals, /n/, /m/ and /ŋ/, affect the values of the formant frequencies. The liquid /r/ lower the frequencies of F2 and F3 of high vowels, whereas in /l/ context the frequencies of F2 and F3 increase (Tunley, 1999). Nasals, /n/, /m/ and /ŋ/, rise the amplitude between the F2 and F3 frequencies and lower the amplitudes at F2 for the vowel /i/ (Hawkins & Stevens, 1985).

Native English speakers. Data from the Colorado native English speakers was taken from a modified version of the "Comma gets a cure" reading passage. See Holland and Brandenburg (2017) for more details.

Native Arabic speakers. The data in this study was collected using an informal text written in Saudi central Najdi dialect, which is the dialect of the participants. The text contained informal sentences that targeted the long Arabic vowels /a:, i:, u:/ and their corresponding short vowels /a, i, u/. The sentences were formed in text message conversations that are commonly found in informal writing (Appendix C).

2.3 Data analysis

All steps were audio-recorded using the phonetic software Praat, digitized at a 44.1-kHz rate (Boersma, 2001). Praat was used to analyze and measure vowel duration and the first, and second formant values of each vowel since they are considered to be essential for the perception of vowel quality. The first and second formant frequencies are the acoustic measurements that reflect the tongue movement in the oral cavity. The first formant reflects the larynx to the top of the throat and the second formants reflects the top of the throat to the lips, the higher the stricture

in the mouth the lower the first formant and vice versa. The back-front dimension and the position of the lips are usually represented by the second formant. The rounding and protrusion of the lips increase the length of the vocal tract (Ladefodged, 2001, as cited in Ahmed 2008). After calculating the F1 and F2 values for 704 vowel sounds produced by 32 participants, the data was normalized using ANAE/Labov method with the TELSUR G value by the NORM online vowel normalization suite (Thomas & Kendall, 2007). The normalization process is a very significant step in this data analysis since normalizing a vowel quality will reduce the physiological (i.e., differences in mouth sizes) variation between speakers to make the values comparable (Adank, Smits, & Van Hout, 2004).

Furthermore, to determine the relationship between a dependent variable and multiple independent variables, a variable rule analysis was conducted using Rbrul, multiple logistic regression, which uses the R mixed-effects modelling function *glmer* (Johnson 2016). Using Johnson's (2016) program, Rbrul, the p-value, mean of vowel formants, and coefficient were collected. With the analysis of grouped data, mixed-effects modeling is considered as a useful tool since it differentiates between two distinctive factors that can affect a response. Fixedeffects are used with small number of levels, for instance, male/female, and they are replicable. Random effects are factors chosen from a larger population, for example, speakers or participants in a study, usually not replicable (Johnson 2016). In this case, since the variation in the population is more significant than the individual effects, random effects are used to summarize the variation in the response and to ensure that any significant factors affecting the data are not an outcome of individual differences in the sample.

In the majority of analysis, when a p-value is less than 0.05, we could determine that a significant variance does exist. The mixed effects model recognizes in what degree a significant

factor affect the response variable. By multiple regression analysis, when the p-value is less than 0.05, the effect is considered statistically significant. The sum contrasts report factor effects where each coefficient signifies a deviation from the mean (Johnson, 2009, p.361). In addition, for more statistical and graphical findings about different variables, we used the R language and environment. R gives a range of statistical, and graphical techniques such as linear and nonlinear modelling, classical statistical tests and classification (R Core Team, 2017). To determine significant variances between individual levels within factors, our analysis made use of the core statistical functions in R, namely analysis of variance – aov() - and the Tukey test – TukeyHSD().

CHAPTER THREE

STUDY 1: SAUDI ARABIC VOWELS

3.1 Introduction

English vowel space has been broadly researched, whereas; many fewer studies have been carried out on the Arabic language simple vowels and diphthongs. A few studies focused on Modern Standard Arabic vowels, and Quraanic vowels forms of Arabic (Alotaibi & Hussain 2009). Fewer studies have been carried out on the spoken varieties of Arabic since they are considered to be unworthy of research or linguistic studies (Palmer, 2007). It is important to note that the acoustic characteristics of Arabic vowels vary considerably across dialects the further the distance from one origin to another. Alghamdi (1998) stated that the implementation of the Modern Standard Arabic vowel system varies across dialects (as cited in Ahmed, 2008, p.56). Hence, the dialectal and linguistic features of a spoken variety will influence the production of Modern Standard Arabic. For comparison purposes, in this study the emphasis is on the Saudi dialect vowel system.

In Saudi Arabia, dialects differ from one region to the other according to the geographic location and various social statuses (Aldosaree, 2016). For example, the west part of Saudi Arabia is influenced by Egypt, the north part by Jordan and Iraq, the east part by other neighbor Gulf countries, and the south part by Yemen (Alghamdi et al., 2008). In terms of the central of Saudi Arabia, Ingham (1994) stated that Najdi dialect, associated with tribal lineages, has very little non-Arabic influence (as cited in Aldosaree, 2016, p. 1). Najdi, which spoken in the middle of Saudi Arabia could be classified into three dialects: Central Najdi, Qasimi Najdi, and Bedouin Najdi (Aldosaree, 2016).

Aldosaree (2016) pointed out that the central Najdi is considered most prestigious among all dialects since it is spoken by the royal family. Additionally, the central Najdi dialect is commonly used in local media and spoken across the middle of Saudi Arabia, especially in urban areas like the capital city, therefore; speakers of other Saudi dialects are familiar with the central Najdi dialect. For these reasons, this study included participants from the capital city of Saudi Arabia, Riyadh, who speak the central Najdi dialect. This study aimed to investigate and measure the first and second frequencies of Saudi Arabic simple vowels, /a:, a, i:, i, u:, u/, and compare the findings with English vowels produced by Saudi learners.

3.2 Results of study 1

Saudi Arabic vowel space. Figure 3 gives group averages of normalized F1 and F2 values of the six vowels under investigation. The vowel space of Saudi Arabic speakers in figure 3 indicates that the ellipse for/i:/, /u:/ and /a:/ is more peripheral than their short counterparts. The long front vowel /i:/ is fronter than its short counterpart /i/ and the long back vowel /u:/ is backer than its short counterpart /u/ in the vowel space, as figure 3 reveals. The long vowel /a:/ is lower than its short counterpart /a/. The front vowels /i:/ and /i/ are more aligned compared to low and back vowels dimension in the vowel space of Saudi Arabic, as shown in Figure 3.

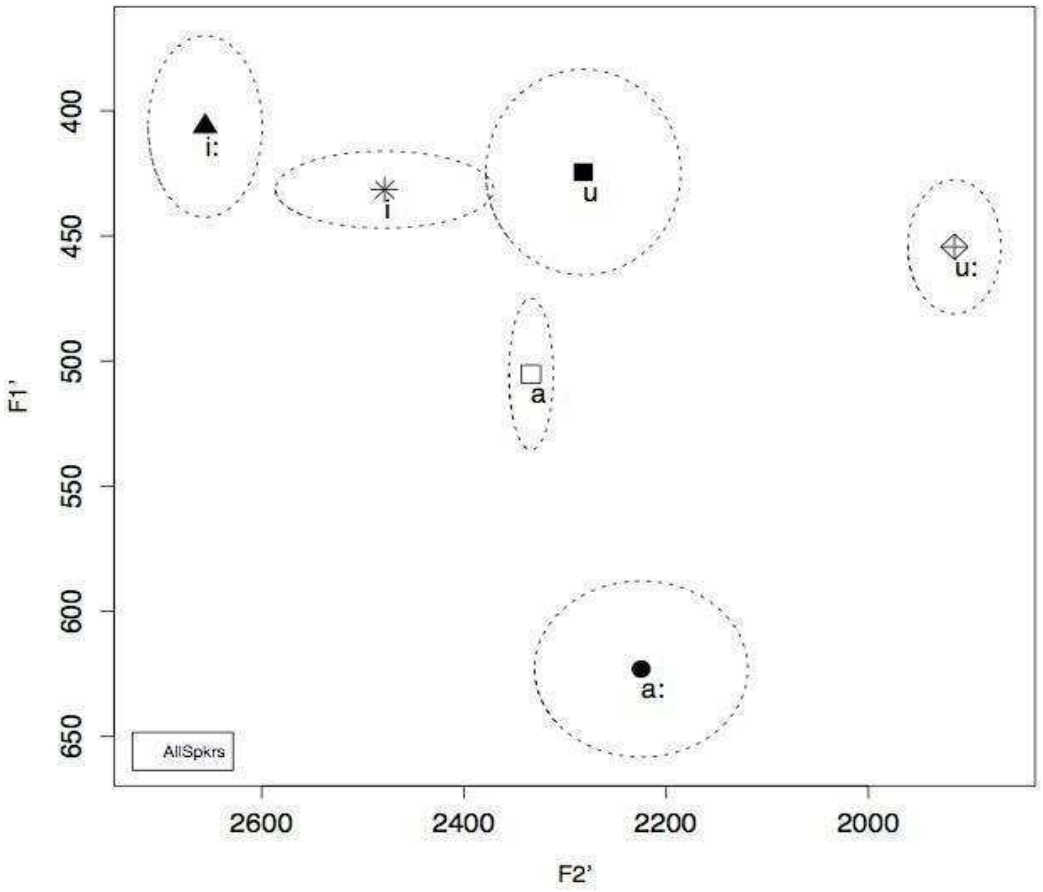

Figure 3. Saudi Arabic vowel space

Mean values of normalized F1 and F2 frequencies. Table 5 indicates the mean values of F1 and F2 frequencies in HZ. In term of the first formant value, /a:/ has a higher F1 value than /a/, whereas; /i:/ and /u:/ have lower F1 values than their short counterparts. For the second formant values, /a:/ and /u:/ have lower F2 values than their short counterpart, whereas; /i:/ has higher F2 than its short counterpart, /i/. As shown in table 5, long vowels have higher mean F1 values and lower F2 values than their short counterparts except for the front vowel /i:/.

Table 5
Descriptive statistics (mean and standard deviation) for F2 and F1 in (Hz) Saudi Arabic native speakers

Vowel	F1 Mean (HZ)	SD	F2 Mean (HZ)	SD
a:	623	35	2224	105
a	505	30	2333	21
i:	406	36	2655	56
i	431	15	2478	107
u:	454	26	1914	46
u	424	41	2281	96

Tukey HSD post-hoc tests were conducted to compare the difference in vowel frequencies. Table 6 compares first and second formant frequencies between long and short vowels a p-value. P- value less than 0.001 is considered statistically significant. The results reveal a significant difference in vowel F1 and F2 between the long low vowel /a:/ and its short counterpart /a/. The results show significant difference in F1 and F2 between the back vowel /u:/ and its short counterpart /u/. In terms of the long front vowel /i:/ and its short counterpart /i/, the results indicate that there is no significant difference in F1, whereas with the F2 frequency there is a close significant difference (p=0.05). It should be noted that although the p-value for F2 is not <0.001, however; it is <0.05, which indicates a possibility of difference.

Table 6
Comparison of F2 – F1 in (Hz) of long and short Arabic vowels produced by Saudi Arabic native speakers using p-value.

Pair	F1	F2
/a/-/a:/	< 0.001	< 0.001
/i/-/i:/	0.86	0.05
/u/-/u:/	< 0.001	< 0.001

Vowel duration. Table 7 indicates the mean duration value of the six vowels under investigation, /a:, a, i:, i, u:, u/. The average duration of length differs between the pairs of vowels. The difference in length is statistically significant. The mean duration of long vowels:

/a:/, /i:/, and /u:/ is longer than the mean duration value of their short counterpart, /a/, /i/, and /u/. The mean value of duration of short vowels together is 0.043 seconds whereas for long vowels the mean value of duration is 0.078 seconds. The ratio between short and long vowels is 0.55.

Table 7
Mean duration values (in seconds) for /a a: u u: i i:/of native Saudi Speakers.

	/a/	/a:/	/u/	/u:/	/i/	/i:/
Vowel Duration	0.039	0.079	0.042	0.073	0.049	0.082

Table 8 compares length between long and short vowels using Tukey HSD post-hoc tests. The results reveal a significant difference in vowel length between the long low vowel /a:/ and its short counterpart /a/. Additionally, the results show significant difference in vowel length between the back vowel /u:/ and its short counterpart /u/. In terms of the long front vowel /i:/ and its short counterpart /i/, the results indicate that there is a close significant difference in vowel length (p=0.05).

Table 8.
Length of Arabic vowels produced by Saudi Arabic native speakers using p-value.

Pair	Length p-value
/a/-/a:/	< 0.001
/i/-/i:/	0.05
/u/-/u:/	< 0.001

Saudi speakers in this study use formant differences to distinguish vowel pairs /a:/ and /u:/. They also use second formant differences to distinguish vowel pair /i:/ and /i/. They use length to distinguish /i:/, and both to distinguish /a:/ and /u:/ and their short counterparts.

Arabic ELLs and Saudi Arabic vowel space. The results reveal an overlap between the Arabic vowels in study 1 and the high/mid front English produced by Arabic ELLs in study 2. The English vowels produced by Arabic ELLs in study 2 inhibit a much larger overall vowel space than Saudi Arabic vowels in study 1, as displayed in figure 4.

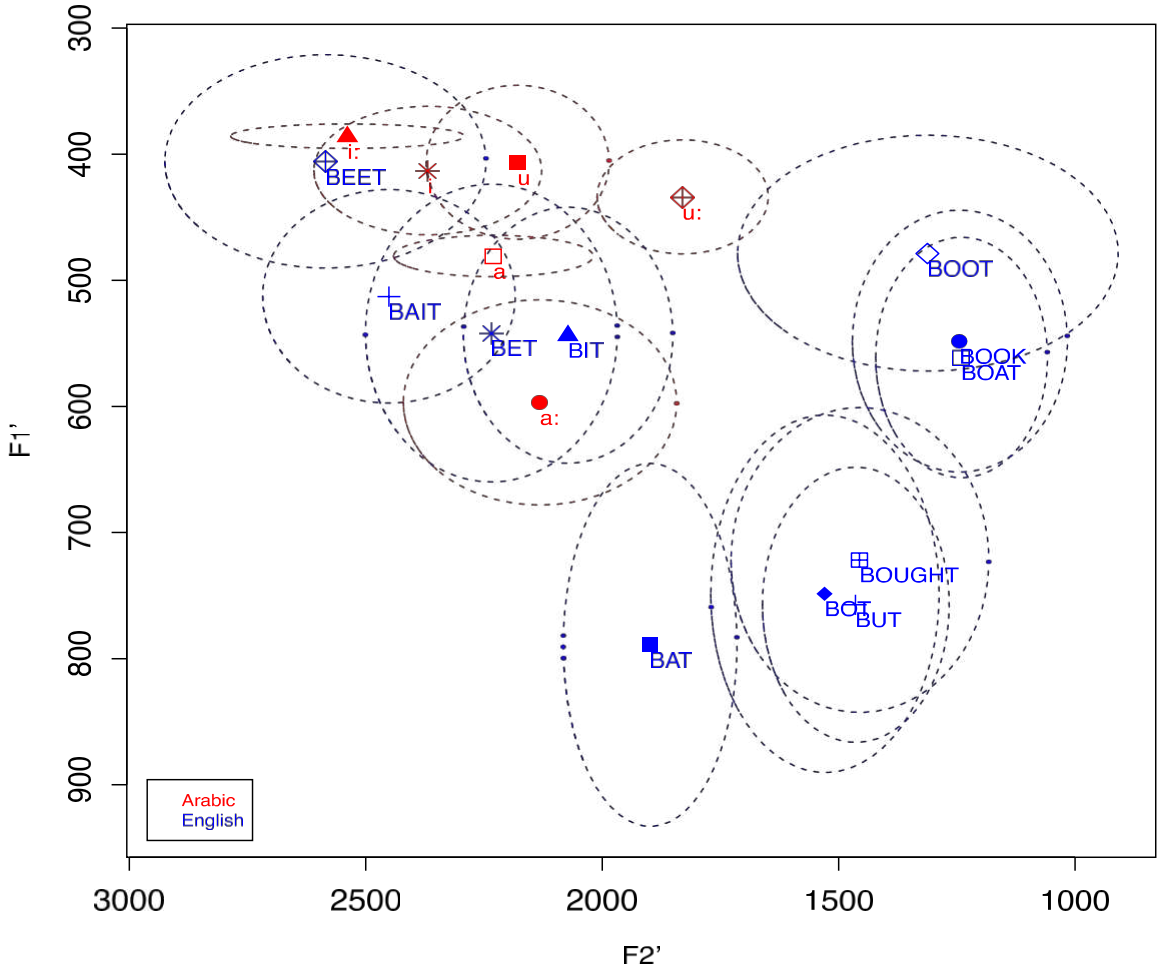

Figure 4. Arabic ELLs and Saudi Arabic vowel space.

CHAPTER FOUR

STUDY 2: THE PRODUCTION OF ENGLISH VOWELS BY ARABIC SPEAKERS

4.1 Introduction

Very few studies have investigated English vowel production by Arabic speakers and little attention has been paid to Saudi English Learners. This phonetic investigation aimed to examine the production of English vowels by Saudi Arabic speakers and to compare the findings with Colorado English native speakers investigated by Holland and Brandenburg (2017). It is important to note that the vowel space of American English differs considerably across regions and states. Thus, since the participants were English language learners in Colorado, a comparison was made between the data in this study and a subset of speakers reported by Holland & Brandenburg (2017) who looked specifically the Colorado vowel space.

The study also aimed to find if there are demographic differences in the production of English vowels by Arabic English learners such as: gender, regional dialect, age, and level of education. The result of this study shows that there is a significant variance between Saudi ELLs and Colorado English native speakers in almost all the vowels. In addition, this study revealed the significant role of gender and regional dialect in the production of English vowels by Saudi Arabic speakers.

4.2 Research questions

This study aims to answer the following research questions:

1. How do Saudi learners produce English vowels compared to native speakers in their community?

2. Are there any differences in the Saudi production of English vowels based on demographic categories such as: gender, age, dialect, and level of education?

4.3 Results of study 2

Vowel space of Arabic ELLs and Colorado native English speakers. The group mean value for all vowels produced by Arabic ELLs was measured in Hz for F1 and F2 frequencies. Figure 5 gives group averages of normalized F1 and F2 values of the 11 vowels under investigation for Arabic ELLs. Figure 6 gives group averages of normalized F1 and F2 values of the 11 vowels under investigation for Colorado native speakers of English. It is important to note that native speakers of English in this study are a subset of speakers from Holland & Brandenburg (2017) that match the age range of Arabic English learners. Figure 7 compares the Arabic ELLs and native speakers of English vowel space.

As figure 5, figure 6, and figure 7 reveal, statistically significant differences between Saudi ELLs and Colorado English native speakers in F1 and/or F2 are seen in all vowels except for the front vowels BAIT, BEET, and BIT. In terms of back vowels like BOAT, BOOT, BOUGHT, and BOT, which vary in height for Colorado English speakers (Holland& Brandenburg, 2017), the group averages for Arabic ELLs are to the mid central with BOUGHT and BOT where BOT is higher than BOUGHT. Specific differences will be described in the following sections.

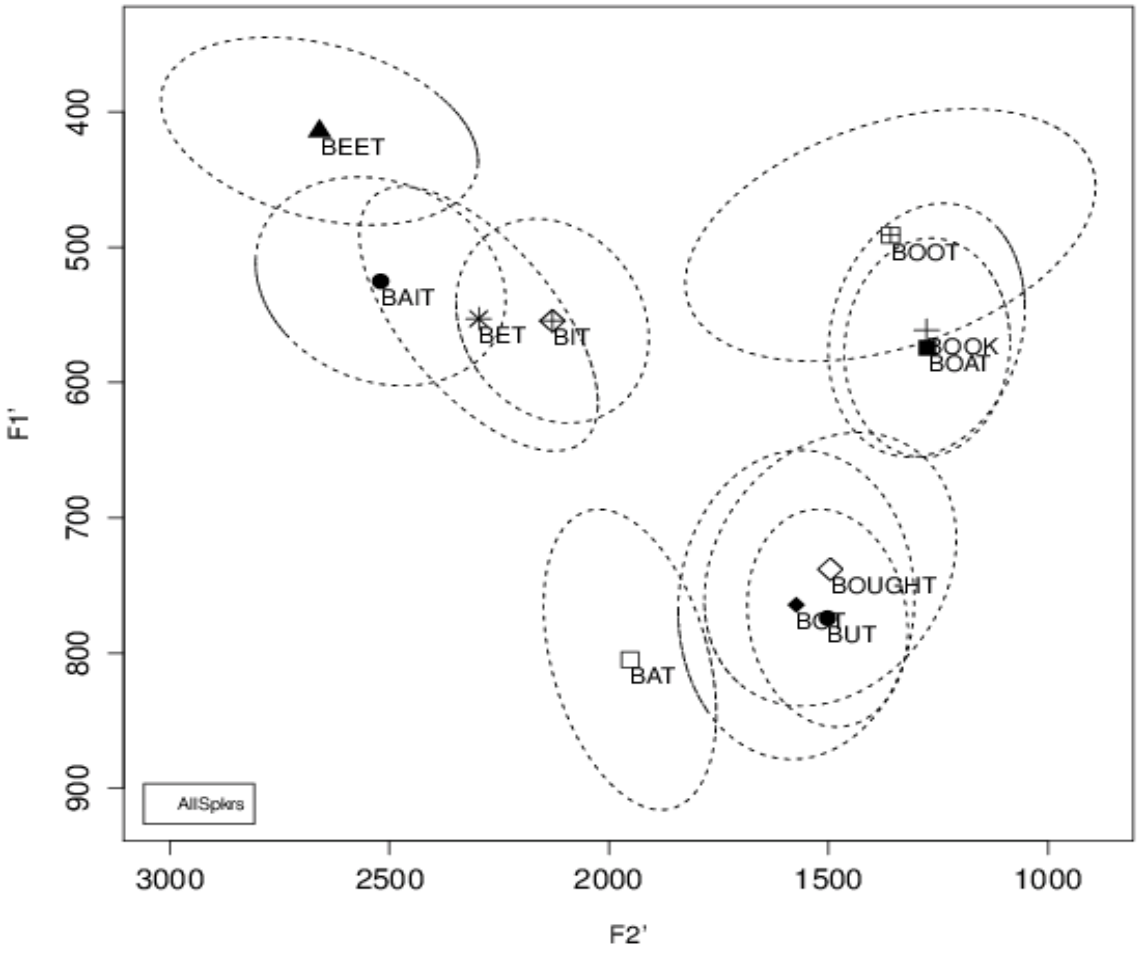

Figure 5. Arabic ELLs vowel space of 11 English vowels

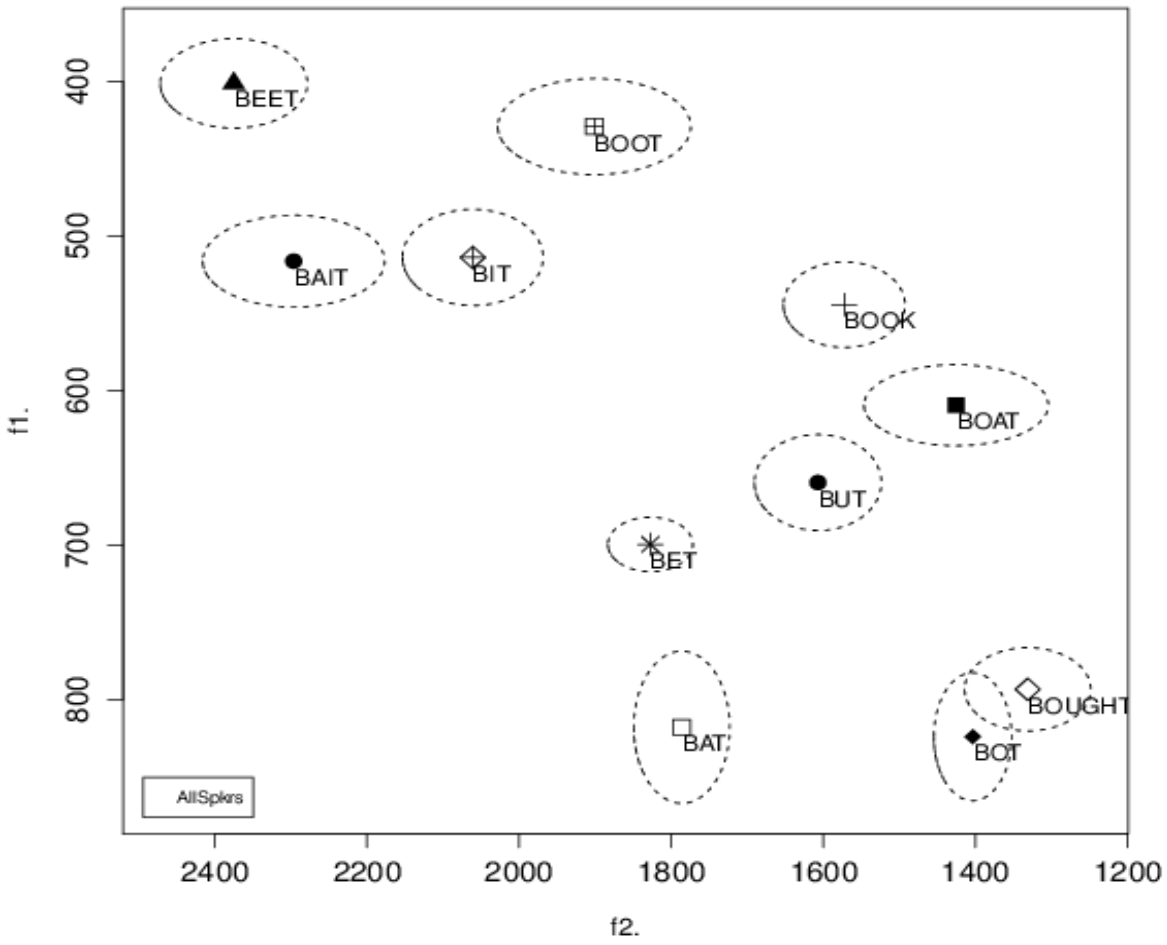

Figure 6. Colorado vowel space (Holland & Brandenburg, 2017).

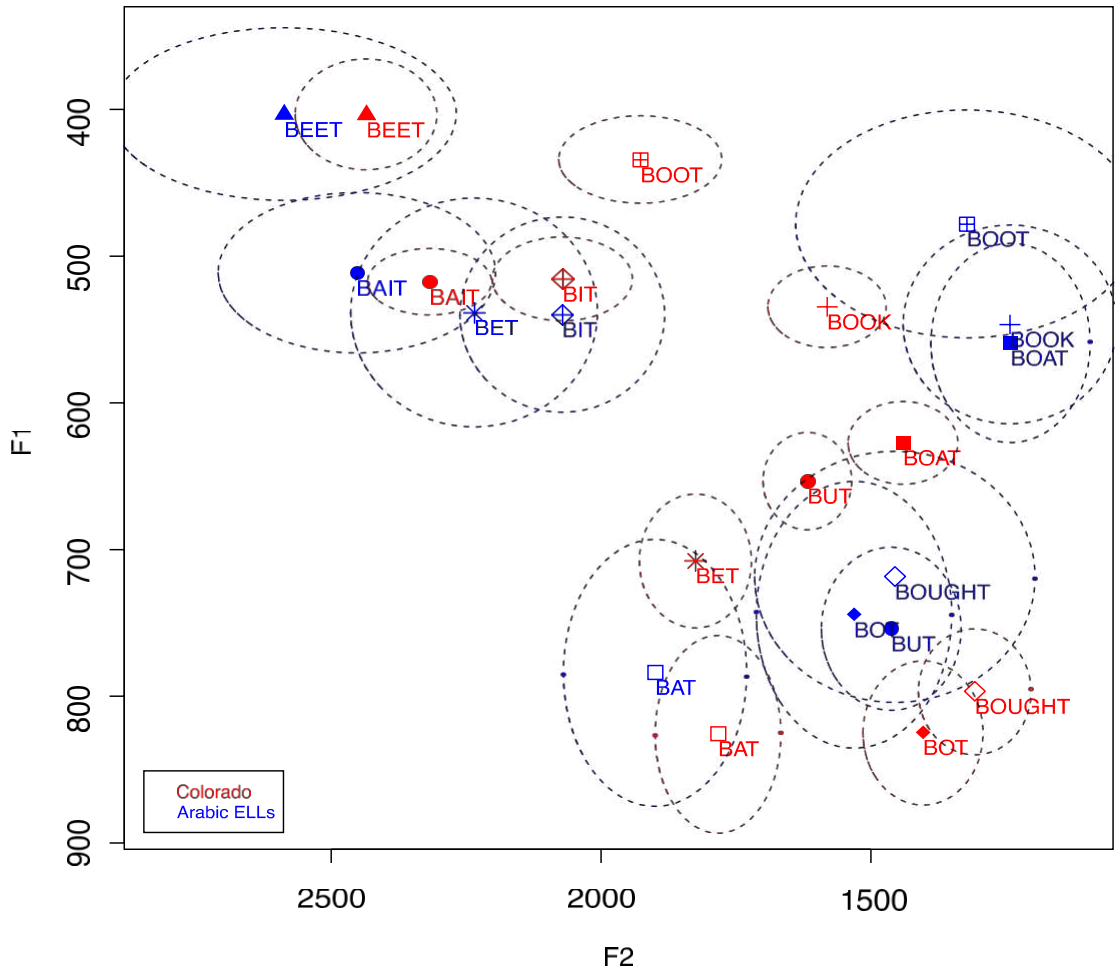

Figure 7. Comparison of vowel space of 11 English produced by Colorado English native speakers and Arabic ELLs.

Vowel F1 and F2 Frequencies of Arabic ELLs and Colorado Native English Speakers.

Table 7 shows partial result of this study (see Appendix for full statistical results). The coefficient here shows how much each group is higher or lower than the average. We compared the F1 and F2 frequencies of vowels produced by Coloradoan English native speakers and Arabic ELLs using linear regression. The mixed effects linear regression reveals significant results between Saudi ELLs production of English vowels and Colorado native speakers, therefore; ANOVA and Tukey HSD post-hoc tests are conducted. It is important to indicate that

a statistically significant value is $p< 0.05$ and statistically highly significant value is $p< 0.001$. As revealed in table 7, the group mean of BAT, BET, BOAT, BOOK, BOOT, BOT, BOUGHT, and BUT are statistically distinct between Saudi ELLs and Colorado English native speakers. In contrast, The F1 frequencies of BAT and BOOK show no evidence of significant difference. The F1 and F2 frequencies in BAIT, BEET, and BIT reveal no evidence of significant difference.

The result in Table 9 reveals that the F2 of BAT and BOOK produced by Arabic ELLs is statistically distinct than Coloradoan native speakers with a p-value of (p<0.026 and <0.0001, respectively). BET F1 and F2 values show significant distinct with a p-value of (p<0.0001and <0.0001respectively). BOAT F1 and F2 reveal a significant variance with a p-value of (p<0.0001 and <0.0001, respectively). BOOT F1 and F2 values show significant distinct with a p-value of (p<0.0228 and <0.0001, respectively). BOT F1 and F2 values display significant distinct with a p-value of (p<0.0001and 0.0145, respectively). BOUGHT F1 and F2 values display significant distinct with a p-value of (p<0.0001and 0.0236, respectively). Finally, BUT F1 and F2 values display significant distinct with a p-value of (p<0.0001and <0.0001, respectively).

Table 9
Comparison of F2 – F1 in (Hz) vowel space of 11 English produced by Colorado English native speakers and Arabic ELLs showing coefficient, mean in HZ, and p-value. Values in bold are statistically significant.

Vowel	Format	Coefficient	Mean (HZ)	P-value
BAIT	F1			n.s
	F2			n.s
BAT	F1			n.s
	F2	Arabic=51.461	1899	P<0.026
		Colorado= -51.461	1782	
BEET	F1			n.s
	F2			n.s
BET	**F1**	Colorado= 82.286	707	P<0.0001
		Arabic= -82.286	538	
	F2	Arabic= 191.716	1824	P <0.0001
		Colorado=-191.716	2234	

BIT	F1			n.s
	F2			n.s
BOAT	**F1**	Colorado=32.255	627	P <0.0001
		Arabic= -32.255	559	
	F2	Colorado= 92.229	1440	P <0.0001
		Arabic=-92.229	1240	
BOOK	F1			n.s
	F2	Colorado=176.875	1580	P <0.0001
		Arabic=-176.875	1242	
BOOT	**F1**	Arabic=32.095	478	P<0.0228
		Colorado= -23.095	434	
	F2	Colorado=299.74	1926	P <0.0001
		Arabic=-299.74	1321	
BOT	**F1**	Colorado=40.458	824	P <0.0001
		Arabic=-40.458	744	
	F2	Arabic=60.209	1530	P<0.0145
		Colorado=-60.209	1403	
BOUGHT	**F1**	Colorado= 39.647	796	P <0.0001
		Arabic= -39.647	718	
	F2	Arabic= 77.551	1455	P<0.0236
		Colorado= -77.551	1307	
BUT	**F1**	Arabic= 49.805	753	P <0.0001
		Colorado=-49.805	653	
	F2	Colorado= 72.798	1617	P <0.0001
		Arabic= -72.798	1462	

Table 10 shows the mean values of F1 and F2 frequencies in HZ for Arabic ELLs. In addition, the standard deviation of each vowel formant is computed. The linear regression analysis reveals significant results about Saudi ELLs production of English vowels, therefore; an ANOVA with Tukey HSD post-hoc tests are conducted to determine which English vowel

categories do or do not overlap in the productions of Arabic speakers. The results show significant overlaps in F1 and F2 in BIT and BET, BOOK and BOAT, and BUT, BOT and BOUGHT produced by Saudi Arabic Speakers in the F1 and F2 dimensions.

Table 10
Descriptive statistics (mean and standard deviation) for F2 and F1in (Hz) Arabic ELLs. Values in bold are statistically significant according to the TukeyHSD analysis.

Vowel	F1 Mean (HZ)	SD	F2 Mean(HZ)	SD
BAIT	525	78	2519	248
BAT	804	133	1952	170
BEET	414	78	2659	315
BET	**552**	109	**2296**	247
BIT	**554**	94	**2128**	205
BOAT	**574**	88	**1275**	168
BOOK	**561**	96	**1276**	211
BOOT	491	86	1358	374
BOT	**764**	131	**1573**	224
BOUGHT	**738**	112	**1495**	253
BUT	**774**	101	**1502**	183

Demographic differences in the production of English vowels by Arabic ELLs. Table 11 shows the mean and standard deviation for F1 and F2 of Saudi females. Table 12 reveals the mean and standard deviation for F1 and F2 of Saudi males. Mean values of F1 frequencies for BAT, BET, BOT, and BUT and the mean values of F2 frequency for BEET differ across gender. Mean values of F1 and F2 frequencies vary from females and males in the production of: BIT and BOOT (see Appendix for full statistical results). The mean value of the F1 frequencies for BAT, BET, and BUT produced by Saudi females are higher than Saudi males. In terms of the F2 frequencies, the vowels BEET produced by Saudi females is higher than Saudi males. Mean values of both F1 and F2 frequencies of BOOT produced by Saudi females are lower than Saudi males. Saudi females produced higher F1 and lower F2 frequencies for BIT than Saudi males.

Table 11
Descriptive statistics: mean and standard deviation (SD) for F1 and F2 of Saudi females

Vowel	F1 Mean (HZ)	SD	F2 Mean(HZ)	SD
BAIT	524	72	2490	287
BAT	826	117	1930	166
BEET	425	74	2656	418
BET	566	118	2277	276
BIT	573	87	2066	206
BOAT	572	91	1223	143
BOOK	554	100	1231	159
BOOT	465	80	1163	293
BOT	699	128	1520	157
BOUGHT	760	97	1443	228
BUT	779	78	1488	178

Table 12
Descriptive statistics: mean and standard deviation (SD) for F1 and F2 of Saudi males

Vowel	F1 Mean (HZ)	SD	F2 Mean(HZ)	SD
BAIT	527	77	2541	138
BAT	740	95	1968	130
BEET	381	59	2517	134
BET	510	65	2308	159
BIT	506	54	2075	148
BOAT	580	78	1329	191
BOOK	571	88	1327	254
BOOT	507	92	1480	431
BOT	699	73	1624	274
BOUGHT	717	96	1550	276
BUT	727	79	1518	167

Figure 8 compares the vowel space of Saudi females and males. In terms of the front vowels in the Saudi vowel space, males produced BEET fronter and higher than females. Males produced BAIT fronter than females. Males produced higher and fronter BET and BIT than females. The low central vowel BAT is higher and fronter for males than females. With the low

back vowels, Saudi females produced lower and backer BOT, BOUGHT, and BUT than Saudi males. In terms of high back vowels, Saudi males produced fronter and lower BOOK, BOOT, BOAT than Saudi females.

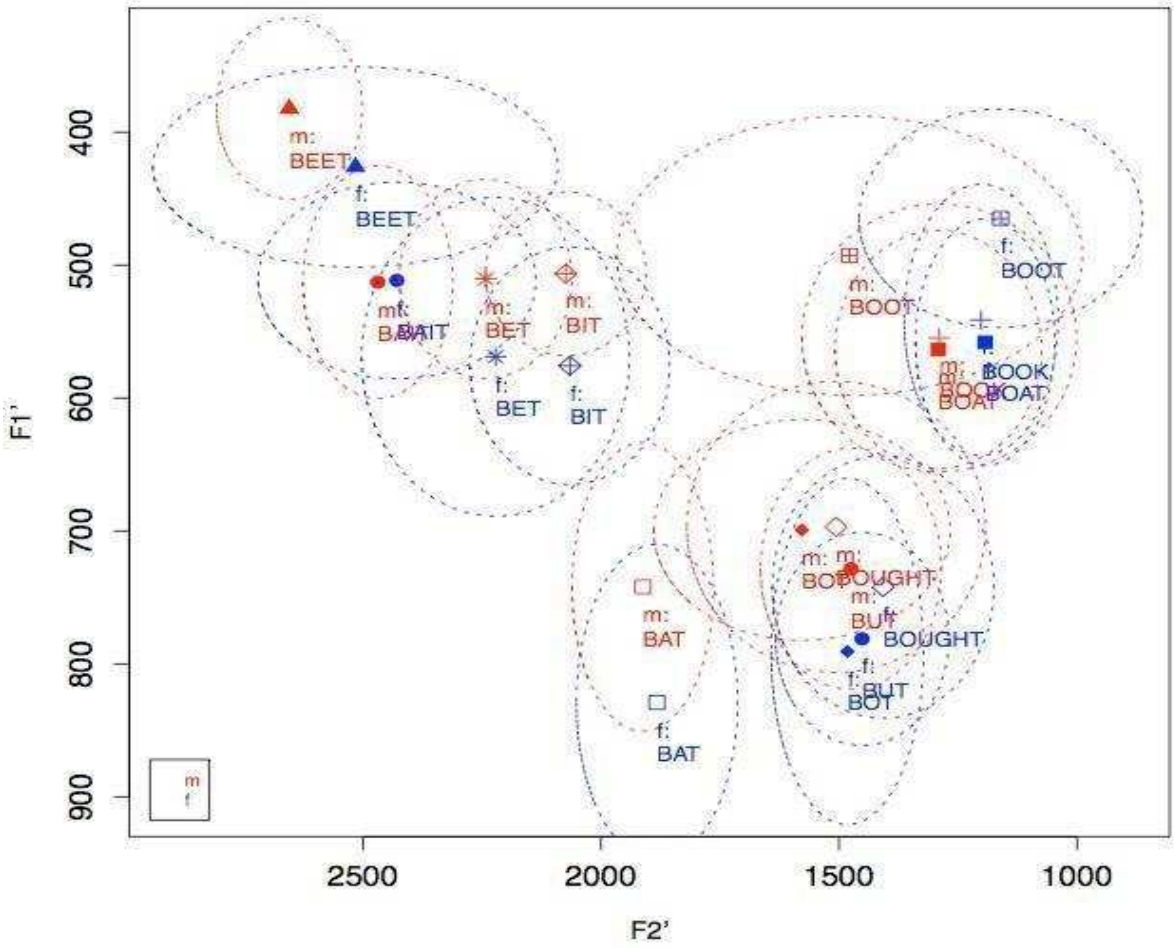

Figure 8. Comparison of Vowel Space of 11 English Produced by Saudi Females and Males. Females in (blue) and Males in (red).

Figure 9 shows Saudi dialects from middle, east, west, and south. Statistical significant differences in dialect appear with the vowel sound of BAT, BET, BOOT, and BUT. The F2 frequency of BAT and BUT displayed a statistical difference according to the regional dialect of the subjects participated in this study. The F1 and F2 frequencies of BET and BOOT showed statistical difference according to the regional dialect of the subjects. As presented in figure 9,

the front vowel BET is higher and fronter in the vowel space for Saudi speakers from the south and west than Saudi speakers from the middle and east of Saudi Arabia. The production of the central vowel BAT is higher and fronter by Saudi speakers from the south and west than Saudi speakers from the middle and east of Saudi Arabia. The back vowel BOOT is fronter in the vowel space for Saudi speakers from the south and west than Saudi speakers from the middle and east of Saudi Arabia. The back vowel BUT produced by Saudi speakers from the middle is backer than Saudi speakers from the south, west, and east.

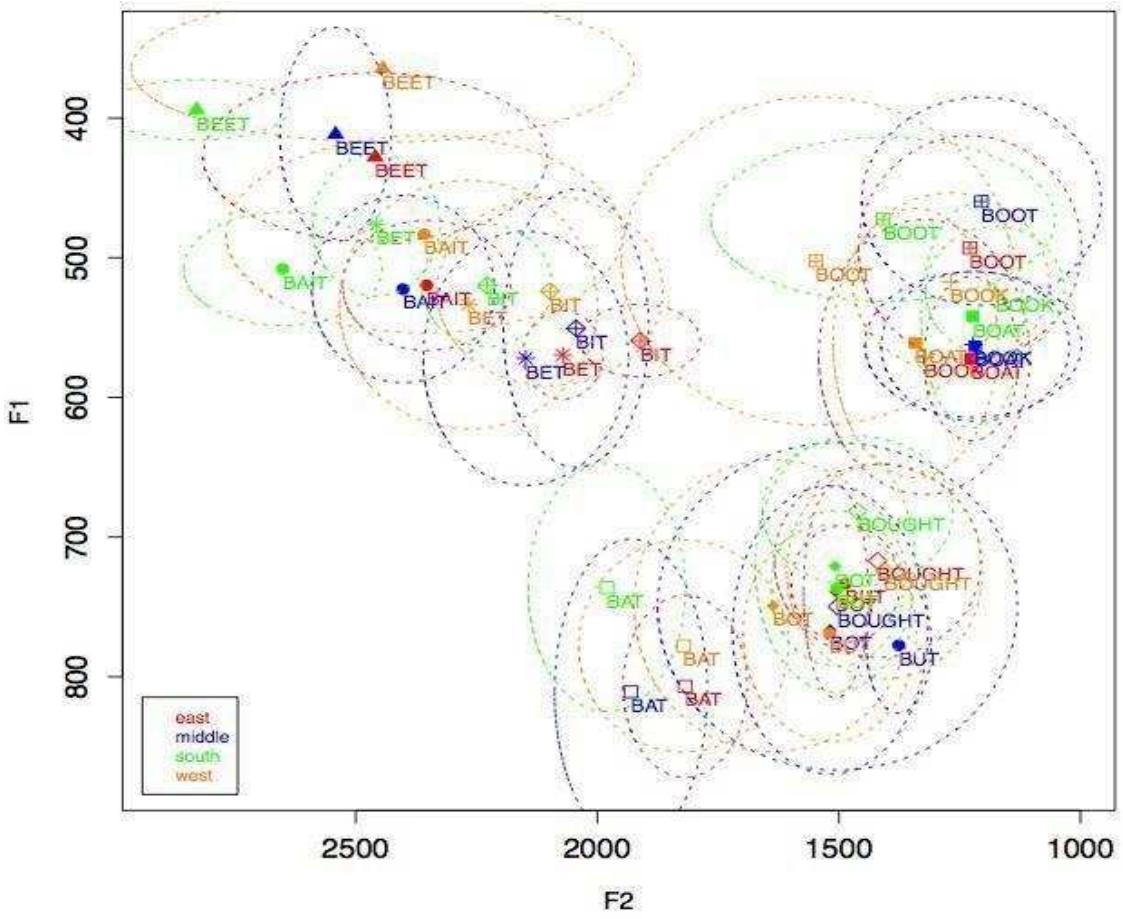

Figure 9. Comparison of vowel space of 11 English produced by Saudi dialects: east, middle, south, and west.

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

5.1 Discussion of Study 1: Saudi Arabic Vowels

Study 1 aimed to examine Saudi Arabic vowels produced by native speakers from the capital city of Saudi Arabia, Riyadh. This investigation examined six vowels, /a:, i:, u:/ and their corresponding short vowels /a, i, u/. The production of Arabic vowels by Saudi speakers in this discussion will be compared with other studies on Arabic vowels.

The vowel space of Saudi Arabic speakers. As presented in the Saudi Arabic vowel space in chapter 3, short vowels are more central and long vowels are more peripheral. The ellipse for the front vowel /i:/ is higher than its short counterpart, whereas; the mean for the low vowel /a:/ and the back vowel /u:/ are lower than their short counterparts in the vowel space. The long front vowel /i:/ is fronter than its short counterpart /i/ and more aligned with its short counterpart in the vowel dimension than other vowels. The long back vowel /u:/ and the long low vowel /a:/are backer and more peripheral than their short counterparts in the vowel space of Saudi Arabic. In other words, the vowels /a:/ and /u:/ occupied more further positions in the vowel space comparing to their short counterparts.

Regarding vowel space of other Arabic varieties, Ahmed (2008) pointed out that in the Libyan Arabic vowel space the short front vowel /i/ is lower and more centralized than its long counterpart. He stated that the short /u/ is lower and fronter and /a/ is higher and more retracted comparing to their long counterparts. He pointed out that /i:/ and /i/ are more affected than back vowels /u:/ and /u/ since the tongue movement is longer for front vowels than back vowels (Ahmed, 2008, p. 69). Al- Ani (1970) conducted the first acoustic study on Arabic vowels and found that with the Standard Arabic produced by Iraqis the distance between /a/ and /a:/ is

greater than the distance between the other short/long pairs due to the high F1 and low F2, which accord with our findings. On the other hand, Saadah (2011) pointed out that the vowels /a:/ and /u:/ and their short counterparts are closer in the Palestinian Arabic vowel space comparing to front vowels, /i:/ and /i/. That indicates how the implementation of Arabic vowel system varies across different dialects of Arabic (Alghamdi 1998, cited in Ahmed, 2008, p.56). The vowel space of the Saudi speakers in this study shows some similarities with other Arabic dialect where the short vowels are more central and long vowels are more peripheral.

Mean values of normalized F1 and F1 frequencies for Saudi Arabic vowels. Long Saudi Arabic vowels have higher mean F1 values and lower F2 values than their short counterparts except for the front vowel /i:/. The long front vowel /i:/ has higher F1 frequency and lower F2 frequency than its short counterpart /i/. The difference between the F1 and F2 frequencies for long and short vowels is significant for /a:/ and /u:/. In terms of the long front vowel /i:/ and its short counterpart /i/, the results show that there is no significant difference in F1 and F2 values, signifying that Saudi participants in this study produced both /i:/ and /i/ vowels in an equivalent position of the highest part of the tongue.

Regarding other research on Arabic vowels, Alghamdi (1989) reported that the implementation of Arabic vowel system varies qualitatively across the three groups. In Alghamdi (1998), the F1 for all vowels in Saudi Arabic was higher than Sudanese and Egyptian. The production of the low long vowel /a:/ by Egyptians was significantly lower than Sudanese and Saudi. It should be noted that only males mean values of F1 and F2 were used from this study to compare the results with the three Arabic dialects in Alghamdi (1998), as presented in table 13.

Table 13
Comparison of F1 and F2 mean values (in Hertz) for /i: i u: u a: a/ between male Saudis in this study and Alghamdi's study. Values in bold are significant.

	a		a:		i		i:		u		u:	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Saudi/ Alqarni	529	**2330**	609	**2163**	420	**2457**	435	**2641**	413	**2306**	448	**1913**
Saudi/ Alghamdi	**573**	1537	**655**	1587	**402**	1841	**292**	2286	**451**	1302	**350**	958
Sudanese/ Alghamdi	525	1564	635	1492	331	2066	272	2255	354	1308	319	984
Egyptian/ Alghamdi	468	1505	**462**	1677	357	1749	256	2175	370	1285	319	942

The F2 values for all vowels produced by male Saudi participants in this study are higher than all the three groups in Alghamdi (1998) study. Sudanese produced the lowest F1 frequency for the front short vowel /i/ and the short back vowel /u/. For the long back vowel /u:/, Sudanese and Egyptian produced lower F1 frequency than the Saudi groups. In terms of the vowel space, the Saudi participants in this study produced backer vowels comparing to other dialects in Alghamdi (1998). Egyptians in Alghamdi (1998) produced higher central vowels, /a:/ and /a/ whereas Saudis in his study produced lower /a:/ and /a/ than the other dialects. Sudanese and Egyptians in Alghamdi (1998) produced higher /i/ than the other dialects in table 13. Saudis in Alghamdi (1998) produced higher /i:/ comparing Saudis in this study and other dialects. Sudanese in Alghamdi (1998) produced higher /u/ and Saudis in Alghamdi (1998) produced higher /u:/ comparing the other dialects.

Vowel duration. The results for the duration measurement reveal that there is a difference between long and short vowels produced by Saudi Arabic speakers. The pairs of vowels /a:/, /i:/, and /u:/ have longer duration value than their short counterpart, /a/, /i/, and /u/. The low vowel

/a:/ and the back vowel /u:/ are significantly longer than their short counterparts. However, the results reveal that the front vowel /i:/ and its short counterpart /i/ are close to being statistically significant different in vowel length (p=0.05). It should be noted that vowel length is very significant for making the distinction between long and short vowels in Arabic language since there are minimal pairs of words that differ in meaning and vary from each other by vowel duration. In addition, the syllable length, the vowel length, defines the syllable stress in Modern Standard Arabic (Most, Levin & Sarsour, 2007). Thus, Saudi participants in study 1 could be attending to use stress to distinguish which vowel is being produced the long vowel /i:/ and its shot counterpart /i/.

Saadah (2011) compared the duration of long and short vowels, /a a: u u: i i:/, of Palestinians in her study and other Arabic dialects from Alghamdi (1998). Saadah (2011) pointed out that the mean duration values from Alghamdi (1998) are distinct from Palestinians. She stated that Palestinians duration values are lower than all speakers followed by Egyptians, then Saudi and finally Sudanese. In terms of the long vowels /i:, a:, u:/ Egyptian and Saudi produced close duration values and similar to Palestinians, whereas; Sudanese duration values were distinct. The duration values from this study are all shorter than other dialects. However, the relative difference is the ratio between long and short vowels that indicates similar ratio values for long and short vowels, as presented in table 14.

Table 14

Mean duration values (in milliseconds) for /a a: u u: i i:/ for male Palestinian, Saudi, Sudanese, and Egyptian speakers. Palestinian values are obtained from Saadah (2011). Saudi, Sudanese, and Egyptian values from Alghamdi (1998) (as cited in Saddah, 2011)

	/i/	/i:/	/a/	/a:/	/u/	/u:/
Palestinians	84	219	97	247	90	226
Saudi	110.8	247.6	132.8	311.4	113.73	237.33
Sudanese	116.53	275.13	128.27	294.8	116.27	304.47
Egyptian	98.4	255	122	315.5	109.53	253.4
Saudi/ Alqarni	49	82	39	79	42	73

Arabic ELLs and Saudi Arabic vowel space. The results reveal an overlap between the Arabic vowels in study 1 and the high/mid front English produced by Arabic ELLs in study 2. It should be noted that the English vowels produced by Arabic ELLs inhibit a much larger overall vowel space than Saudi Arabic vowels in study 1.

Limitations in study 1. This investigation examined the production of Arabic vowels for four Sauid Najdi speakers, which considered as a disadvantage. Having more participants could provide more information on Saudi Najdi dialect patterns in producing Arabic vowels. As indicated in chapter one, different studies on Arabic vowels collected data using text in Modern standard Arabic, isolated words, isolated vowels, or nonsense words. This study applied a method in collecting data that have not been seen in many studies about Arabic vowels, as the best of researcher knowledge. The data in this study was collected using a conversational text that included informal regional words from the target Saudi dialect. As indicated by studies in

Arabic vowels in chapter one, measuring vowels in context could affect the F1 and F2 frequencies and duration. Therefore, for further research, isolated words, and vowels could be collected and compared to this data set.

5.2 Discussion of Study 2: The Production of English Vowels by Arabic Speakers

Arabic ELLs and Coloradan native English speaker's vowel space and formants. The most important finding of this study was the variance between Colorado English native speakers and Arabic ELLs in most of the vowels studied. The F1 and F2 frequencies for the front vowels: BAIT, BEET, BIT revealed no evidence of significant difference from those vowels produced by Coloradans and could be considered as the closest vowels to native speakers in this study. Arabic ELLs produced BET statistically different from native speakers. Arabic speakers produced the front mid vowel BET with lower F1 and higher F2 frequency, fronter and higher, than Coloradan speakers. Holland and Brandenburg (2017) pointed out that the lowering of the short front lax vowels BIT and BET is a feature of Colorado English, and that for Coloradans BET is particularly low and back. The results showed that Arabic ELLs production of BIT and BET were as nearly identical and co-located with the Colorado English production of BIT.

Munro (1993) in his study about Arabic production of English vowels stated that Arabic speakers produced the front vowel /i/ close to native speakers, which accord with our findings. In addition, Al-Badawi (2012) in his study referred that Saudi speakers tend to substitute the vowel /e/ with /ɪ/. He pointed out that /e/ has no equivalent in Arabic language and therefore Arabic learners of English tend to substitute /e/ with /ɪ/, which does not accord with our findings. The results indicate an overlap in the production of some English vowels by Arabic ELLs. In this study, the participants overlapped the front vowels BIT with BET, and the back vowels BOOK with BOAT. They also overlapped the production of BOUGHT, BOT, and BUT in the vowel

space. The overlap of BOT and BOUGHT is typical of many dialects of English, including the dialect spoken in Colorado, however, the overlap of BUT with these two vowels is not typical.

With back vowels, there was a considerable difference obtained for the F1 and F2 values between the Arabic ELLs in Colorado in this study and Coloradan English native speakers by Holland and Brandenburg (2017). When comparing the F1 and F2 frequencies of vowels produced by Coloradoan English native speakers and Arabic ELLs it was found that back vowels: BOAT, BOOK, BOOT, BOUGHT and BOT were statistically distinct from Coloradoan English. Regarding high back vowels, the results in this study reveal that Arabic ELLs tended to merge BOOK with BOAT. Arabic ELLs produced BOOK, and BOOT backer and lower in the vowel space than Colorado English native speakers with a higher F1 and lower F2. BOAT for Arabic ELLs was backer and higher in the vowel space comparing to native speakers with a lower F1 and F2. Munro (1993) in his study about English vowels by native speakers of Arabicpointed out that Arabic ELLs tend to produce low F2 for back vowels, which accords with BOOK, BOOT, and BOAT in this study. The fronting of BOOT, BOAT and BOOK are typical for Colorado and all west coast English, nevertheless; Arabic ELLs are not producing this dialect feature. However, Arabic ELLs are closer to a more standard generic version of English (Labov, Ash, & Boberg, 2005).

In terms of the low back vowels, the results in this study reveal that Arabic ELLs tended to merge BOT with BOUGHT. Data reveals that the mean F2 value produced by Arabic ELLs for BOT and BOUGHT were higher, and fronter in the vowel space than English native speakers in Colorado. In this study, BOT and BOUGHT were produced by Arabic ELLs more in the center of the vowel space where BOT is higher than BOUGHT. Holland and Brandenburg (2017) pointed out that “BOUGHT [is] more to the back of the vowel space than BOT” for Colorado

English speakers. In their study, Holland and Brandenburg (2017) pointed out that BOT and BOUGHT are moving in parallel towards retracting, which is typical for Colorado speakers, however; Arabic ELLs are not producing this dialect feature. BOUGHT, BOT, and BUT are statistically indistinguishable (ie. co-locate) for Arabic ELLs. With the central vowel BUT, Arabic ELLs produced higher F1 frequency and lower F2 frequency, backer and lower in the vowel space, than Coloradan native speakers of English. In addition, Arabic ELLs produced the central vowel BAT fronter and higher in the vowel space than Colorado English speakers with a lower F1 and lower F2. BAT retraction is a typical feature of Colorado English that Arabic ELLs are not producing.

Differences in the Saudi production of English vowels based on demographic categories such as: gender, age, dialect, and level of education. In Saudi Arabia dialects vary from the middle, east, west, south and north. In this study, statistical significant differences in dialect appear with the vowel sound of BAT, BET, BOOT, and BUT. The F2 frequency of BAT and BUT displayed a statistical difference according to the regional dialect of the subjects participated in this study. The F1 and F2 frequencies of BET and BOOT showed statistical difference according to the regional dialect of the subjects. Saudi speakers from the south and west of Saudi Arabia produced fronter BET, BAT, and BOOT than speakers from the middle and east of Saudi Arabia. Geographically, the south and west are closer than the middle and east of Saudi Arabia what may cause the similarities in the production of English vowels.

This acoustic analysis has given interesting findings about the difference between Arabic ELLs' English vowel production in terms of gender. The most important finding of this study is the variance between Saudi men and women in the production of the front vowels: BET, BIT, BEET, back vowels: BOOT and BOT, and central vowels: BUT and BAT. For front vowels,

females produced higher F1 frequencies for BET, BIT, and BEET than males. BEET was backer and lower in the vowel space for females than males in this study. Males produced higher F2 frequencies for BET and BIT, fronter and higher, than females. In terms of back vowels, Saudi females produced backer and higher BOOT than males with a higher F1 value and lower F2. Males produced the back vowel BOT fronter and higher than females with higher F2 dimension. The central vowels: BUT and BAT were significantly different for females than males. Females produced BUT and BAT with higher F1and lower F2 frequencies, lower and backer in the vowel space, than males (see the appendix for full results).

As shown in chapter 4, the vowel space of Saudi females and males vary in the front vowels BET, BEET, and BIT and back vowels BOOT, BOT, and BUT. In terms of front vowels, Saudi females produced lower and backer BEET, BET and BIT than Saudi males. With back vowels, females produced lower and backer BOT and BUT than Saudi males. Saudi females produced the vowel BOOT backer and higher than Saudi males. It is important to note that females and males in Saudi Arabia are separated in social gathering, education, and sometimes work, which can cause sociolinguistic variances.

5.3 Conclusion

This phonetic investigation aimed to examine the production of English vowels by Arabic speakers and to compare the findings with Colorado English native speakers by Holland and Brandenburg (2017) since the subjects were ELLs in Colorado. The study also aimed to investigate variation among Saudi ELLs according to gender, dialect, age, and level of education years in the US. The results of this study show that there is a significant variance between Saudi ELLs and Colorado English native speakers in almost all the vowels.

In terms of the front vowels: BAIT, BEET, BIT produced by Arab ELLs, the results revealed no evidence of significant difference from those vowels produced by Coloradans and could be considered as the closest vowels to native speakers in this study. However, Arabic ELLs produced BET the front vowel fronter and higher than Coloradan speakers. The statistical analysis shows that Arabic ELLS tend to merge BIT with BET, which accord with different studies about Arabic speakers' production of English vowels. The central vowel BAT was fronter and higher in the vowel space of Arabic ELLs than Colorado English native speakers.

The statistical analysis in this study reveals significant difference between Arabic ELLs and Colorado English native speakers in the production of back vowels: BOAT, BOOK, BOOT, BOUGHT and BOT. In addition, the data reveals that Arabic ELLS merge the production of some back vowels like BOOK with BOAT. Additionally, we could indicate that the production of BOUGHT, BOT, and BUT are statistically indistinguishable in the vowel space of Arabic ELLs, which is typical of many dialects of English. However, the overlap of BUT with BOUGHT and BOT is not typical.

Furthermore, this study revealed the significant role of regional dialect and gender in producing English vowels by Arabic speakers. Age, level of education and years in the US, the statistical analysis shows no significant difference in English vowel production. In this study, statistical significant differences in the production of BAT, BET, BOOT, and BUT appear across regional Saudi dialects. Across Saudi females and males, this study reveals a significant variance in the production of the front vowels: BET, BIT, BEET, back vowels: BOOT and BOT, and central vowels: BUT and BAT.

5.4 Implications

Acknowledging struggles and challenges that Arabic speakers face when learning English vowels would help teachers to create activities that could help promoting the Arab learners' "noticing" of vowel sounds in English. For example, teachers can do minimal pair activities to enable the learners to differentiate between vowels that they struggle with. In addition, trading questions and reading aloud activities will help the students to practice new sounds and improve their pronunciation of the common mispronounced vowel sounds. These activities could be very useful and engaging, which will help to enhance the learners' uptake and improve their "noticing" of the mispronounced sounds.

5.5 Limitations and further research

Further research could be conducted to determine the effect of the Saudi Arabic local dialects in the production and perception of English vowels with a larger population. Measuring Saudi Arabic dialect from different regions could inform the L1 influence on the production of English vowels. In addition, further research could be conducted to investigate a wider range of English vowel sounds since this study focused on the English basic vowel sounds.

REFERENCES

Abu–Rabia, S. (1997). The Need for Cross–Cultural Considerations in Reading Theory: The Effects of Arabic Sentence Context in Skilled and Poor Readers. *Journal of Research in Reading*, *20*(2), 137-147.

Abu-Rabia, S. (1999). The effect of Arabic vowels on the reading comprehension of second-and sixth-grade native Arab children. *Journal of Psycholinguistic Research*, *28*(1), 93-101.

Adank, P., Smits, R., & Van Hout, R. (2004). A comparison of vowel normalization procedures for language variation research. *The Journal of the Acoustical Society of America*, *116*(5), 3099-3107.

Al-Ani, S. H. (1970). *Arabic phonology: An acoustical and physiological investigation* (Vol. 61). Walter de Gruyter.

Ahmed, A. (2008) Production and perception of Libyan Arabic vowels. PhD thesis. Newcastle University.

Al-Badawi, K. (2012). An analysis of phonetic, morphological and syntactic errors in English: a case study of Saudi BA students at King Khalid University. *International Journal of Social Science and Humanity*, *2*(6), 536.

Aldosaree, O. M. (2016). *Language attitudes toward Saudi dialects*. California State University, Long Beach.

Alghamdi, M. M. (1998). A spectrographic analysis of Arabic vowels: A cross-dialect study. *Journal of King Saud University*, *10*(1), 3-24.

Ali, E. M. T. (2013). Pronunciation problems: Acoustic analysis of the English vowels produced by Sudanese learners of English. *International Journal of English and Literature*, *4*(10), 495-507.

Almbark, R., & Hellmuth, S. (2015). Acoustic analysis of the Syrian vowel system. In *The 18th I CPhS*. University of Glasgow.

Alotaibi, Y. A., & Husain, A. (2009, September). Formant based analysis of spoken Arabic vowels. In *European Workshop on Biometrics and Identity Management* (pp. 162-169). Springer, Berlin, Heidelberg.

Alshaboul, Y., Asassfeh, S., Alshboul, S., & Alodwan, T. (2014). The contribution of L1 phonemic awareness into L2 reading: The case of Arab EFL readers. *International Education Studies*, *7*(3), 99.

Barkat-Defradas, M., Al-Tamimi, J., & Benkirane, T. (2003). Phonetic variation in production and perception of speech: a comparative study of two Arabic dialects. In *proc. of the 15th International Congress of Phonetic Sciences (ICPhS)*.

Birdsong, D. (Ed.). (1999). *Second language acquisition and the critical period hypothesis*. Routledge.

Boersma, Paul (2001). Praat, a system for doing phonetics by computer. *Glot International* 5:9/10, 341-345.

Brown, A., & Oyer, S. (2013). Vowel Project: Analysis of a Native-Arabic Speaker. *Linguistic Portfolios*, *2*(1), 4.

Buali, I. (2010). *The Perception and Production of/p/in Saudi Gulf Arabic English: A Variationist Perspective* (Doctoral dissertation, Concordia University).

Chang, C. B., Haynes, E. F., Yao, Y., & Rhodes, R. (2009). A tale of five fricatives: Consonantal contrast in heritage speakers of Mandarin. *University of Pennsylvania Working Papers in Linguistics*, *15*(1), 37-43.

Chládková, K., Escudero, P., & Boersma, P. (2011). Context-specific acoustic differences between Peruvian and Iberian Spanish vowels. *The Journal of the Acoustical Society of America*, *130*(1), 416-428.

Cowan, W. (1970). The vowels of Egyptian Arabic. *Word*, *26*(1), 94-100.

Derakhshan, A., & Karimi, E. (2015). The interference of first language and second language acquisition. *Theory and Practice in Language Studies*, *5*(10), 2112.

Flege, J. E., & Port, R. (1981). Cross-language phonetic interference: Arabic to English. *Language and speech*, *24*(2), 125-146.

Flege, J. E. (1992). The intelligibility of English vowels spoken by British and Dutch talkers. *Intelligibility in speech disorders: Theory, measurement, and management*, *1*, 157-232.

Flege, J. E., Munro, M. J., & MacKay, I. R. (1995). Factors affecting strength of perceived foreign accent in a second language. *The Journal of the Acoustical Society of America*, *97*(5), 3125-3134.

Flege, J. E., MacKay, I. R., & Meador, D. (1999). Native Italian speakers' perception and production of English vowels. *The Journal of the Acoustical Society of America*, *106*(5), 2973-2987.

Gairdner, W. H. T. (1925). *The phonetics of Arabic*. Milford.

Holes, C. (1990). Gulf Arabic. New York: Routledge.

Holland, Cory and Tara Brandenburg. (in press) Beyond *the Front Range: The Coloradan Vowel Space*. In Valerie Fridland, Betsy Evans, Tyler Kendall and Alicia Wassink (Eds.) *Speech in the West II: The Inland West*. Publications of the American Dialect Society (PADS).

Huthaily, K. (2003). Contrastive phonological analysis of Arabic and English. Master's thesis, The University of Montana, MT.

Ingham, B. (1994). *Najdi Arabic: Central Arabian* (Vol. 1). John Benjamins Publishing.

Johnson, D. E. (2016, May 9). Rbrul version 3.0. Retrieved from https://danielezrajohnson.shinyapps.io/Rbrul/

Krug, M. (Ed.). (2013). *Research methods in language variation and change*. Cambridge University Press.

Hawkins, S., & Stevens, K. N. (1985). Acoustic and perceptual correlates of the non- nasal–nasal distinction for vowels. *The Journal of the Acoustical Society of America*, *77*(4), 1560-1575.

Hussain, A. A. A. (1985). *An experimental investigation of some aspects of the sound system of the Gulf Arabic dialect with special reference to duration* (Doctoral dissertation, University of Essex).

Labov, W., Ash, S., & Boberg, C. (2005). *The atlas of North American English: Phonetics, phonology and sound change*. Walter de Gruyter.

Martland, Paul, Sandra P. Whiteside, Steve W. Beet, and Ladan Baghai-Ravary. "Analysis of ten vowel sounds across gender and regional/cultural accent." In *Spoken Language, 1996. ICSLP 96. Proceedings., Fourth International Conference on*, vol. 4, pp. 2231-2234. IEEE, 1996.

Mitleb, F. (1984). Vowel length contrast in Arabic and English-a spectrographic test. *Journal of Phonetics*, *12*(3), 229-235.

Most, T., Levin, I., & Sarsour, M. (2007). The effect of modern standard Arabic orthography on speech production by Arab children with hearing loss. *Journal of deaf studies and deaf*

education, *13*(3), 417-431.

Munro, M. J. (1993). Productions of English vowels by native speakers of Arabic: Acoustic measurements and accentedness ratings. *Language and Speech*, *36*(1), 39-66.

Munro, M. J., Flege, J. E., & MacKay, I. R. (1996). The effects of age of second language learning on the production of English vowels. *Applied psycholinguistics*, *17*(3), 313-334.

Newman, D., & Verhoeven, J. (2002). Frequency analysis of Arabic vowels in connected speech. *Antwerp papers in linguistics.*, *100*, 77-86.

Palmer, J. (2007). Arabic diglossia: Teaching only the standard variety is a disservice to students. *The Arizona Working Papers in Second Language Acquisition and Teaching*, *14*, 111-122.

Peterson, G. E., & Barney, H. L. (1952). Control methods used in a study of the vowels. *The Journal of the acoustical society of America*, *24*(2), 175-184.

Rosner, B. S., & Pickering, J. B. (1994). *Vowel perception and production*. Oxford University Press.

Saadah, E. (2011). *The production of Arabic vowels by English L2 learners and heritage speakers of Arabic*. University of Illinois at Urbana-Champaign.

Snow, C. E., & Hoefnagel-Höhle, M. (1977). Age differences in the pronunciation of foreign sounds. *Language and speech*, *20*(4), 357-365.

Simpson, A. P., & Ericsdotter, C. (2003, August). Sex-specific durational differences in English and Swedish. In *Proceedings of the 15th International Congress of Phonetic Sciences, Barcelona, (*pp. 1113-1116).

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.URL https://www.R-project.org/.

Ryan, A., & Meara, P. (1992). The case of the invisible vowels: Arabic speakers reading English words. *Reading in a foreign language*, *7*, 531-531.

Thomas, Erik, and Tyler Kendall. 2007. "NORM: Vowel Normalization Suite 1.1 | About NORM." *NORM: The Vowel Normalization and Plotting Suite.*

Tunley, A. (1999). *Coarticulatory influences of liquids on vowels in English* (Doctoral dissertation, University of Cambridge).

Watson, J. C. (2002). *The phonology and morphology of Arabic*. Oxford: Oxford University Press.

Yavas, M. (2011). *Applied English Phonology*. Malden, MA: Blackwell Publishing.

APPENDICES

1. Appendix A

The North Wind and the Sun

The North Wind and the Sun were disputing which was the stronger, when a traveller came along wrapped in a warm cloak. They agreed that the one who first succeeded in making the traveller take his cloak off should be considered stronger than the other. Then the North Wind blew as hard as he could, but the more he blew the more closely did the traveller fold his cloak around him, and at last the North Wind gave up the attempt. Then the Sun shone out warmly, and immediately the traveller took off his cloak. And so the North Wind was obliged to confess that the Sun was the stronger of the two.

2. Appendix B

Word List of 11 English Vowels

BAIT	Day
	Make
BAT	Cat
	Mad
BEET	Meet
	See
BET	Get
	Met
BIT	Bit
	Tip
BOAT	Boat
	Go
BOOK	Book
	Foot
BOOT	Boot
	Move
BOT	Job
	Not
BOUGHT	Coffee
	Dog
BUT	But
	Cup

3. Appendix C

Arabic Vowels Materials

4. Appendix D

Full Statistical Analysis of 11 English Vowels

BAIT F1					
Arabic speakers $r^2 = 0.207$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age	+1=8.343			0.0294
	Dialect				n.s
	Year in U.S				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.014$					
	Language				n.s
	Sex				n.s

BAIT F2					
Arabic speakers $r^2 = 0.456$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level	Beginner=-21.138 Intermediate= -71.476 Undergrad=-114.014 Grad= 206.628	7 10 6 9	2385.151 2303.269 2393.783 2707.040	0.0174
Arabic vs. CO $r^2 = 0.095$					
	Language				n.s
	Sex				n.s

BAT F1					
Arabic speakers $r^2 = 0.355$					
		Coefficient	N	Mean	P value
	Sex	F= 52.989 M= -52.989	16 16	826 740	7.87e-04
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.0584$					
	Language				n.s
	Sex				n.s

BAT F2					
Arabic speakers $r^2 = 0.325$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.287$					
	Language	Arabic=51.461 Colorado= -51.461	32 16	1899.452 1782.812	0.026
	Sex				n.s

BEET F1					
Arabic speakers $r^2 = 0.472$					
		Coefficient	N	Mean	P value
	Sex	F= 24.128 M= -24.128	16 16	425 381	5.95e-03
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.0645$					
	Language				n.s
	Sex				n.s

BEET F2					
Arabic speakers $r^2 = 0.453$					
		Coefficient	N	Mean	P value
	Sex	F= -101.009 M= 101.009	16 16	2656 2517	0.0336
	Age				
	Dialect	South=247.538 Middle=55.407 East= -58.658 West= -244.287	9 10 8 5	2829 2541 2459 2444	0.0173
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.124$					
	Language				n.s
	Sex				n.s

BET F1					
Arabic speakers $r^2 = 0.367$					
		Coefficient	N	Mean	P value
	Sex	F=26.721 M=-26.721	16 16	566 510	0.0346
	Age				n.s
	Dialect	South=-60.899 Middle=25.139 East= 33.688 West= 2.072	9 10 8 5	476 571 569 533	0.0198
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.539$					
	Language	Colorado= 82.286 Arabic= -82.286	16 32	707 538	2.57e-11
	Sex	F= 28.357 M= -28.357	24 24	620 568	3.03e-03

BET F2					
Arabic speakers $r^2 = 0.492$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age				n.s
	Dialect	South=213.591 Middle=-78.401 East=-134.884 West=-0.306	9 10 8 5	2457 2148 2071 2266	8.37e-04
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.638$					
	Language	Colorado=-191.716 Arabic= 191.716	16 32	1824 2234	1.54e-08
	Sex	F= -29.387 M= 29.387	24 24	2083 2112	0.0224

BIT F1					
Arabic speakers $r^2 = 0.409$					
		Coefficient	N	Mean	P value
	Sex	F= 38.179 M=-38.179	16 16	573 506	5.22e-04
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.19$					
	Language				n.s
	Sex	F= 21.015 M=-21.015	24 24	554 509	7.30e-03

BIT F2					
Arabic speakers $r^2 = 0.485$					
		Coefficient	N	Mean	P value
	Sex	F=11.76 M= -11.76	16 16	2066 2075	1.12e-03
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.0308$					
	Language				n.s
	Sex				n.s

BOAT F1					
Arabic speakers $r^2 = 0.288$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.245$					
	Language	Colorado=32.255 Arabic= -32.255	16 32	627 559	5.59e-04
	Sex				n.s

BOAT F2					
Arabic speakers $r^2 = 0.247$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.389$					
	Language	Colorado= 92.229 Arabic=-92.229	16 32	1440 1240	1.83e-05
	Sex				n.s

BOOK F1					
Arabic speakers $r^2 = 0.165$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.0232$					
	Language				n.s
	Sex				n.s

BOOK F2					
Arabic speakers $r^2 = 0.327$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age				n.s
	Dialect				n.s
	Year in us	+1= 87.796			0.0301
	Education level				n.s
Arabic vs. CO $r^2 = 0.492$					
	Language	Colorado=176.875 Arabic=-176.875	16 31	1580 1242	8.55e-09
	Sex				n.s

BOOT F1					
Arabic speakers $r^2 =$ 0.597					
		Coefficient	N	Mean	P value
	Sex	M=20.83 F=-20.838	16 16	491 465	0.0313
	Age	+1=14.225			1.89e-04
	Dialect	South=-28.79 Middle=-52.645 East=11.355 West=70.08	9 10 8 5	472 459 492 502	1.31e-03
	Year in us	+1= -55.901			1.97e-05
	Education level				n.s
Arabic vs. CO $r^2 =$ 0.124					
	Language	Colorado= -23.095 Arabic=32.095	16 32	434 478	0.0228
	Sex				n.s

BOOT F2					
Arabic speakers r^2 = 0.403					
		Coefficient	N	Mean	P value
	Sex	M=145.799 F=-145.799	16 16	1480 1163	4.41e-03
	Age				n.s
	Dialect	South=-18.806 Middle=-80.522 East=-152.193 West=251.521	9 10 8 5	1408 1205 1229 1547	0.0448
	Year in us	+1=-118.564			0.0477
	Education level				n.s
Arabic vs. CO r^2 = 0.583					
	Language	Colorado=299.74 Arabic=-299.74	16 32	1926 1321	4.73e-10
	Sex	M=98.942 F=-98.942	24 24	1625 1421	9.42e-03

BOT F1					
Arabic speakers $r^2 = 0.245$					
		Coefficient	N	Mean	P value
	Sex	F=49.8 M=-49.8	16 16	788 699	3.44e-03
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.32$					
	Language	Colorado=40.458 Aravic=-40.458	16 32	824 744	5.87e-04
	Sex	F=32.587 M=-32.587	24 24	803 738	2.99e-03

BOT F2					
Arabic speakers $r^2 = 0.156$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.177$					
	Language	Arabic=60.209 Colorado=-60.209	32 16	1530 1403	0.0145
	Sex				n.s

BOUGHT F1					
Arabic speakers $r^2 = 0.274$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.267$					
	Language	Colorado= 39.647 Arabic= -39.647	16 32	796 718	5.81e-04
	Sex	F=21.662 M=-21.662	24 24	766 722	0.0389

BOUGHT F2					
Arabic speakers $r^2 = 0.353$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age	+1= -40.376			0.0109
	Dialect				n.s
	Year in us				n.s
	Education level	Beginner= -34.644 Intermediate=89.086 Undergrad=-288.943 Grad=234.501	7 10 6 9	1428 1467 1297 1567	3.43e-03
Arabic vs. CO $r^2 = 0.116$					
	Language	Colorado= -77.551 Arabic= 77.551	16 32	1307 1455	0.0236
	Sex				n.s

BUT F1					
Arabic speakers $r^2 = 0.297$					
		Coefficient	N	Mean	P value
	Sex	F=24.218 M=-24.218	16 16	779 727	0.013
	Age				n.s
	Dialect				n.s
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.574$					
	Language	Colorado=-49.805 Arabic= 49.805	16 32	653 753	1.72e-09
	Sex	F=20.953 M=-20.953	24 24	741 698	1.91e-03

BUT F2					
Arabic speakers $r^2 = 0.316$					
		Coefficient	N	Mean	P value
	Sex				n.s
	Age				n.s
	Dialect	South=15.761 Middle=-103.02 East=6.006 West=81.253	9 10 8 5	1504 1376 1486 1519	0.0233
	Year in us				n.s
	Education level				n.s
Arabic vs. CO $r^2 = 0.309$					
	Language	Colorado= 72.798 Arabic= -72.798	16 32	1617 1462	1.12e-04
	Sex				n.s