

Acoustic Analysis of Modern Standard Arabic Vowels by Jordanian Speakers

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Abstract: *In this study the Modern Standard Arabic (MSA) vowels produced by ten Jordanian males are acoustically analyzed and described. In line with previous studies on MSA produced by speakers from different parts of the Arab world, this study shows that the inventory of MSA vowels consists of six monophthongs and two diphthongs. Moreover, the long monophthongs of MSA are found to be more than double the duration of their short counterparts. In comparison with studies on MSA vowels produced by Palestinian, Saudi, Sudanese and Egyptian speakers, the MSA monophthongs produced by the Jordanian speakers here are found to be significantly shorter than those in the latter studies. Moreover, this study proposes the use of different IPA symbols for the MSA vowels which have been for long inaccurately transcribed as /a:, i:, u:, a, i, u, aj, aw/. This is justified by the finding that long and short MSA monophthongs are significantly different not only in duration but also in vowel quality. This latter finding has been corroborated by many previous studies on MSA vowels.*

Keywords: Arabic diphthongs, Arabic monophthongs, Jordanian speakers, Modern Standard Arabic (MSA)

1. Introduction

The recent segmental research on Arabic phonology focuses on either Modern Standard Arabic (MSA) or the colloquial varieties of Arabic used in the different Arabic speaking countries. MSA and the different Arabic dialects coexist in a diglossic context. Watson (2007) explains that ‘Classical Arabic’ and ‘Modern Standard Arabic’ describe the medieval and modern variants of Arabic, respectively. Classical Arabic was primarily based on the language of the western Hijazi tribe of Quraysh, and was codified in the Qur’an (ibid: 8). MSA differs from Classical Arabic in vocabulary and stylistics; however both have remained basically unchanged in morphology and basic syntactic structures over the centuries (Fischer 1997: 189). Watson (2007) states:

Like a number of other languages, therefore, Arabic came to have one standard variety and a large number of regional and social dialects. Unlike many such languages, however, no one in the Arab world is brought up speaking Standard Arabic as their mother tongue: an Arab child’s mother tongue will be the regional or social variety of Arabic of its home region, while Standard Arabic, if it is mastered at all, is learnt formally at school or at home as part of the child’s education. Standard Arabic is confined to formal written and spoken occasions, and the regional/social variety of Arabic is used at all other times. Standard Arabic now differs

considerably from regional and social colloquial varieties of Arabic in terms of its phonology, morphology, syntax, and lexicon (p.8).

Other studies look at traces of the colloquial dialect of Arabic in MSA speech produced by its speakers (e.g. Ammar, Fougeron and Ridouane 2014). In particular, emerging studies on intonation using the Autosegmental Metrical Approach have started looking at tonal patterns differences and comparable prosodic features between the colloquial variety and the MSA speech produced by its own speakers (El Zarka and Hellmuth 2009).

The first acoustic study to be carried out on the MSA vowels was by Al-Ani (1970) who recorded vowels in isolation (mainly produced by Al-Ani himself; for vowels in contexts he employed data from six other Iraqi speakers and the speech by two Jordanian speakers was only used for pharyngealized consonants). Later, many researchers conducted similar work on other varieties of Arabic and their respective MSA production of vowels (Alghamdi 1998; Newman and Verhoeven 2002; Alotaibi and Husain 2009; Saadah, 2011; Almbark and Hellmuth 2015). Sometimes, the analyses were not comprehensive (not including all eight MSA vowels or the number of speakers was not sufficient enough to represent the dialect under study). Most previous studies tested the vowels in particular syllable structures or in single words, with the exception of Newman and Verhoeven (2002) who investigated the vowels in connected speech in a Quranic recitation (by Al-Minshawi).

The two studies, Al-Tamimi, Carré and Marsico (2004) and Al-Tamimi (2007) conducted acoustic analyses and perception studies on the vowels of Jordanian and Moroccan Arabic dialects. Al-Tamimi et.al. (2004: poster) reports that vowels in isolation represent the canonical form of a vowel; however, they are considered by some researchers as ‘laboratory artefacts’ because:

(a) generally, they [vowels] exist when coarticulated with consonants in a specific syllabic structure, (b) acoustical vowel information merge with those of consonants, (c) formants of vowels are not invariant, due to 2 different sources of variation: inter- and intra-individual variability, and consonant environment (ibid).

Al-Tamimi (2007) adds that Arabic is a non-concatenative language with a triconsonantal root exhibiting consonant~consonant relations, which implies that vowels never occur in isolation in Arabic. These two studies found that in both Jordanian and Moroccan Arabic there was no significant difference between the production of vowels in ‘words’ and in ‘syllables’, but a very significant one when compared with ‘isolated’ vowels. In the perception tests, Tamimi et al. (2004) found that listeners from both dialects found it easier to identify the vowels in a dynamic status (in words and syllables) rather than in a static one (in isolation). These experiments show that since vowels, particularly in Arabic, never occur in isolation, it is useful to analyze them in context as they normally occur in natural speech rather than in isolation.

Strange (1998) traced the evolution of vowel theory studies from the 1970s and 1980s. He reports that “in no study using natural (as opposed to synthetic) stimuli were isolated vowels identified *more* accurately than coarticulated vowels,

as it would be predicated if static targets were the primary source of information for vowel identity” (p. 2084). He concludes that “No single spectral cross section adequately captures all the perceptually relevant information; rather, the acoustic information for vowel identity resides in the changing spectral structure” (p. 2085). In the present study, vowels are not produced in isolation but rather in a stressed CVC syllable within a test word in a carrier sentence, as explained in the methodology below.

Alghamdi (1998) analyzed the MSA monophthongs /a:, i:, u:, a, i, u/ produced by Saudi, Sudanese and Egyptian speakers (using five speakers for each group). The vowels were read in CVC monosyllabic words where C was always /s/; /si:s/ سيسى - /su:s/ سوس - /sa:s/ ساس - /sis/ سيس - /sus/ سُس - /sas/ سَس. Only short vowels contexts were nonsense words. His findings show that the major differences between the MSA vowels across the different speaker backgrounds are in the F1 values of the vowels. He also found that the durations of the long vowels were almost twice those of their short counterparts. The average ratios between long and short vowels were as follows: 0.45 for Saudi speakers, 0.41 for Sudanese speakers and 0.40 for Egyptian speakers. Alghamdi found that long and short vowels “also differ in terms of quality. The long vowels are peripheral while their short counterparts are close to the center when the frequencies of the first two formants are plotted on a formant chart” (ibid: 7). He also concludes "that the phonetic implementation of the MSA vowel system differs according to the dialects. This might be one acoustic cue that listeners use to identify the dialect of an Arabic speaker even when he/she speaks in MSA"(ibid: 8).

Ammar et al. (2014) investigated acoustic cues (F1 and F2 values) for the long-short vowel distinction in MSA produced by 11 Tunisians and five Moroccans in an attempt to find traces from the dialects of Tunisian and Moroccan Arabic in MSA produced by these speakers. They found quantitative and qualitative evidence of the traces of both dialects in their respective productions of MSA. Their findings show that Tunisians maintain the long-short vowel distinction of their original dialect by having significantly longer long vowels in a ratio of 1:63 in MSA. The Moroccan speakers maintain the long-short vowel distinction in MSA by having significantly longer long vowels in a ratio of 1:9 and by having a difference in short vowel quality; which are more centralized than their long counterparts. This reflects traces from the Moroccan Arabic dialect which does not have a clear long-short vowel distinction.

2. Focus of the study

In this study, the vowel inventory of MSA produced by Jordanian speakers is acoustically analyzed and described. The findings are later compared with other studies on MSA vowels produced by Palestinian, Saudi, Sudanese and Egyptian speakers. In light of the findings of the current study and other similar studies, a more precise phonetic transcription of Arabic vowels is proposed which accurately reflects the phonemic differences between the long and short three pairs of MSA vowels.

3. Methodology

3.1. Informants

Ten male students at the University of Jordan were conveniently sampled for the study. The average age was 23 years. The informants are from a fairly homogenous group. All informants are originally from the city of Madaba (30 Kilometers south-west of the capital city of Amman). All have both parents from Madaba and have gone to similar schooling in Madaba. The Informants were students at the Faculty of Arts (except for two informants who were from the Faculties of Tourism and Sharia) and the language of instruction for all informants was Arabic. This is not to deny the issues concerning the homogeneity of a speech community. Romaine (1981) and (1984), for example, emphasize that the individual speaker has an influence on language variation that is different from that of the social community of the individual. This speaker's influence should be taken into consideration when explaining language variation. Romaine (1984) proposes an 'agentivity continuum' which treats both 'speaker' and 'language' as agents influencing each other in the process of language variation. However, she ranks 'syntax and phonetics and phonology' at the bottom of language aspects that are influenced by the speaker stating that

the speaker is conversely more patient-like in the domain of phonetics and phonology, where the mechanical, physiological constraints of executing or realizing meaningful utterances via a channel in real time are operative. In this area the constraints which the language brings to the speaker apply most strongly" (p. 112).

The informants' regional dialect is the Bedouin Jordanian Colloquial dialect. This dialect is considered a North Najdi variety of Arabic, an early version of the Najdi dialect used today in Saudi Arabia (Ingham 1994: 9). Note that Ammani Arabic is originally Bedouin Jordanian with influences from Palestinian Arabic (see Al-Wer (2007:59-60) on the emergence of the dialect of Amman). Therefore, the sample under study represents MSA produced by speakers of Bedouin Jordanian Arabic. None of the informants reported hearing or speech problems (informants were asked to fill in a Participant Information Form prior to their participation). None has lived outside Jordan for over six months with the exception of one speaker (who lived two years in Dubai when he was 17).

3.2. Data collection

Table 1 shows the 16 words used to elicit the tested vowels (short monophthongs = 6, long monophthongs = 6, diphthongs = 4). In total, the produced tokens were (16x2) x 10 informants = 320 (only two tokens were discarded for mispronunciation); therefore, the total analyzed tokens were 318. It should be noted that informants practiced reading the words before recording.

Table 1: The 16 test words used in eliciting the MSA vowels

Arabic Test Words						
Vowel	/h_d/ words	IPA	English gloss	/ʕ_d/ words	IPA	English gloss
i:	زَهْدٌ	/zahi:d/	'cheap'	عِيدٌ	/ʕi:d/	'Eid holiday'
i	عَهْدُنَا بِالْحَقِّ	/ʕahidna/	'we have entrusted'	عِدْنَا أَنْ تَأْتِي	/ʕidna:/	'promise us'
a:	سُهْدٌ	/suha:d/	'female's name'	سُعَادٌ	/suʕa:d/	'female's name'
a	هَدْرٌ	/hadr/	'waste'	عَدْلٌ	/ʕadl/	'justice'
u:	هُودٌ	/hu:d/	'Prophet Huud'	عُودٌ	/ʕu:d/	'lute'
u	هُدُودٌ	/hudhud/	'hoopoe'	عُدْنَا الْبَارِحَةَ	/ʕudna:/	'we came back'
aj	قَدْ سَهَّيْتُ	/sahajt/	'I was distracted'	سَعَّيْتُ	/saʕajt/	'I have sought'
aw	قَدْ سَهَّوْتُ	/sahawt/	'I was distracted'	عَوْدٌ	/ʕawd/	'a return'

The test words were elicited in the stressed syllables /h_d/ and /ʕ_d/. Each word was placed in the carrier sentence 'Write ___ once.' - "أكتب ___ مرةً" and was presented on a Powerpoint slide. The list of words was randomized twice and read from a computer screen. Informants clicked for the next sentence at their own pace. The recordings took place at the University of Jordan's Radio station (49.9FM) recording studio. The recording software was Sony Sound Forge (Pro. 11.0) 2013 - recording frequency: 44 KHz, computer: HP Elie7500: Windows 10 - core i 7 - 64bits. The informant's mouth was approximately 5 cm away from a RODE Procaster (Broadcast Quality Dynamic Microphone). The vowels were analyzed using the Praat software (Boersma and Weenink 2009).

4. Results

The results are presented on acoustic charts of the averaged F1 and F2 values for each tested vowel averaged across all ten informants. The first two formants are considered the acoustic correlates of vowel quality and are used in acoustic studies on vowels to represent the vowel's tongue height (F1) and the vowel's frontness/backness dimension (F2). Therefore, the vowel position in the acoustic chart represents its position in the actual human vowel space.

4.1. Short monophthongs

The MSA short monophthongs /a, i, u/ are commonly referred to in Arabic as the diacritics 'Al Harakat' and have names contrary to vowels of most other languages; hence; 'fatha, kasra, and damma', respectively (English vowels were only given names in 1982 following John Wells' Lexical Sets introduced in his seminal work *Accents of English*). Figure 1 shows the averaged F1 and F2 values

for ‘fatha’ /a/ in the words عدل /ʕadl/ ‘justice’ and هدر /hadr/ ‘waste’ across all ten informants.

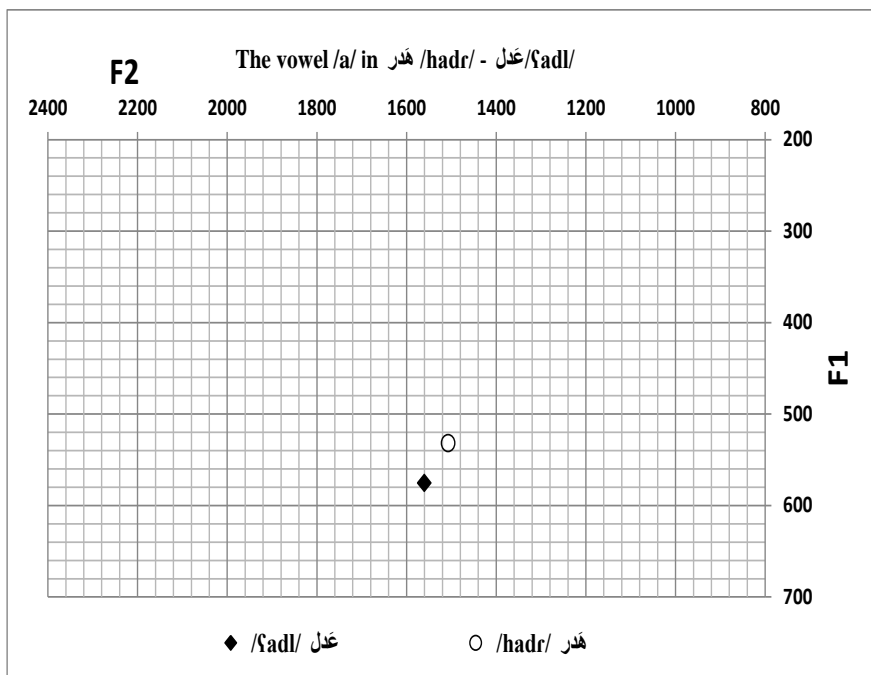


Figure 1: Averaged F1 and F2 values of /a/ across all informants in the words: /hadr/ هدر - /ʕadl/ عدل

The vowel /a/ occupies a low and central position in the vowel space (i.e. it is a low-central vowel) with a height (F1) in the range (500-600Hz) and F2 in the range (1480-1600Hz). The context of the two words is very similar /'hadr/ and /'ʕadl/, where the tested vowel is preceded by a fricative and followed by a consonant cluster beginning with /d/.

Figure 2 shows the averaged F1 and F2 values for ‘kasra’ /i/ in the words عهدنا /ʕidna:/ ‘promise us’ and عهدنا /ʕahidna:/ ‘we have entrusted’ across all ten informants.

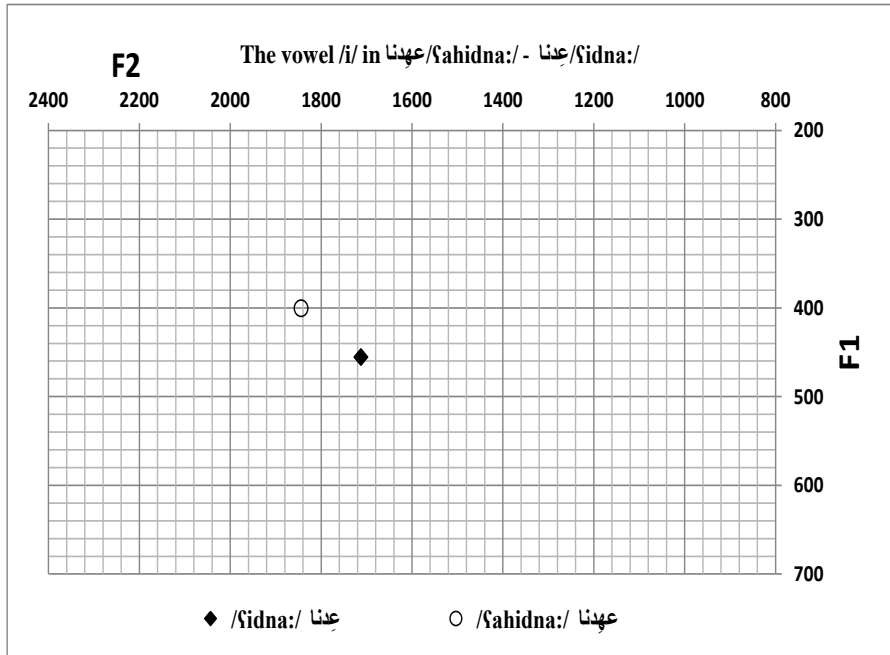


Figure 2: Averaged F1 and F2 values of /i/ across all informants in the words: عهنا /ʕahidna:/ - عِدنا /ʕidna:/

The ‘kasra’ /i/ clearly occupies a centralized-front and mid-high position in the vowel space. F1 is in the range (400-500Hz) and F2 is in the range (1680-1840Hz). The context is almost identical to minimize differences due to influence from adjacent consonants; the stressed syllables in both words are followed by the same syllable /na:/ in /ʕa.'hid.na:/ and /'ʕid.na:/.

Figure 3 shows the averaged F1 and F2 values for ‘damma’ /u/ in the words عُدنا /ʕudna:/ ‘we are back’ and هُدهد /hudhud/ ‘hoopoe’ across all ten informants.

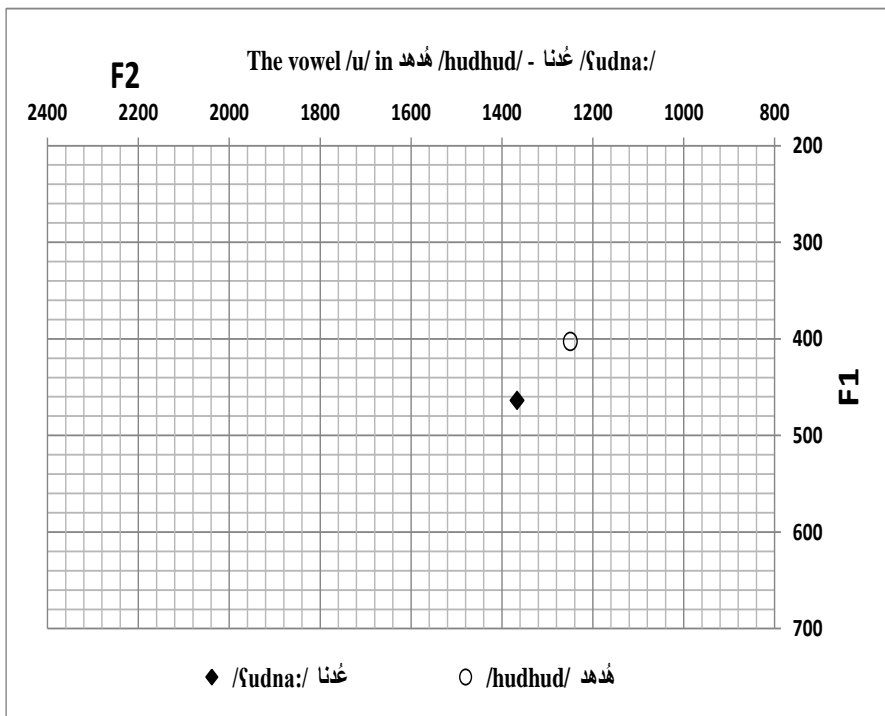


Figure 3: Averaged F1 and F2 values of /u/ across all informants in the words: **هُدُود** /hudhud/ - **عُدْنَا** /ʕudna:/

The ‘damma’ occupies a rather back and mid-high position in the vowel space, where the height (F1) range is (400-500Hz) and F2 range is (1200-1400Hz). The context of the stressed syllables in the two words is quite similar /'hud.hud / and /'ʕud.na:/.

Figure 4 shows the realizations of the three short monophthongs /a, i, u/ in all six words across all informants.

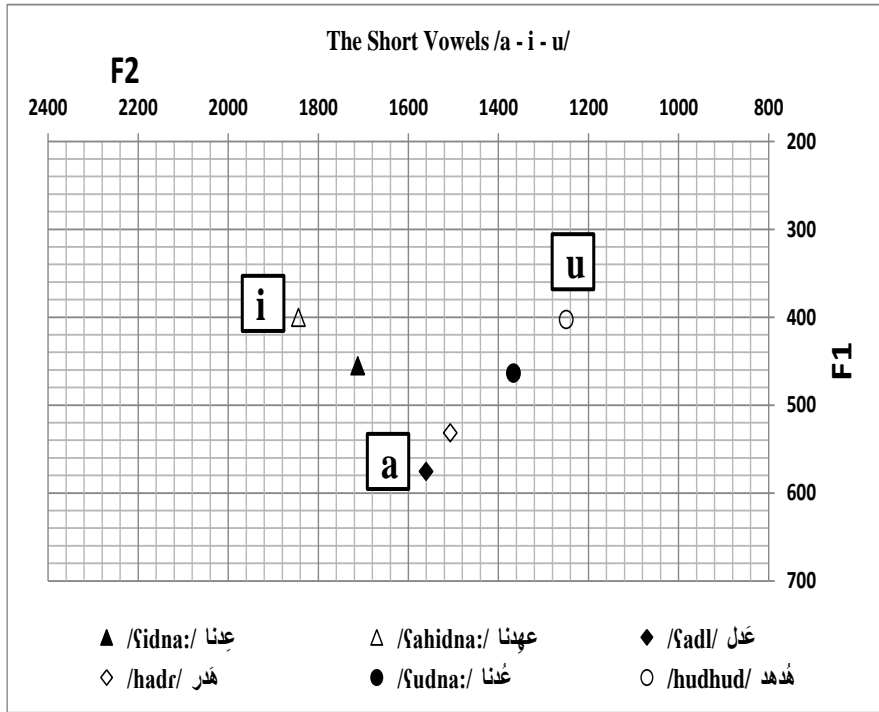


Figure 4: Averaged F1 and F2 values of /a, i, u/ across all informants in the words: /hadr/ هَدْر - /ʔadl/ عَدَل - عهدنا /ʔahidna:/ - عِدْنَا /ʔidna:/ - هُدْهَد /hudhud/ - عُدْنَا /ʔudna:/

Figure 4 shows the basic triangular vowel space of /a, i, u/. These three vowels are the short variants of the long monophthongs, presented below.

4.2. Long monophthongs

The three long monophthongs are /a:, i:, u:/ and are the phonetic representations of the letters ‘alif’ (أ), ‘yaa?’ (ي), and ‘waaw’ (و). These three vowel qualities are the most common in vowel inventories of almost all languages (Lindblom 1986, Newman 2002).

Figure 5 shows the averaged F1 and F2 values for ‘alif’ /a:/ in the female names سعاد /suʔa:d/ and سهاد /suha:d/ across all ten informants.

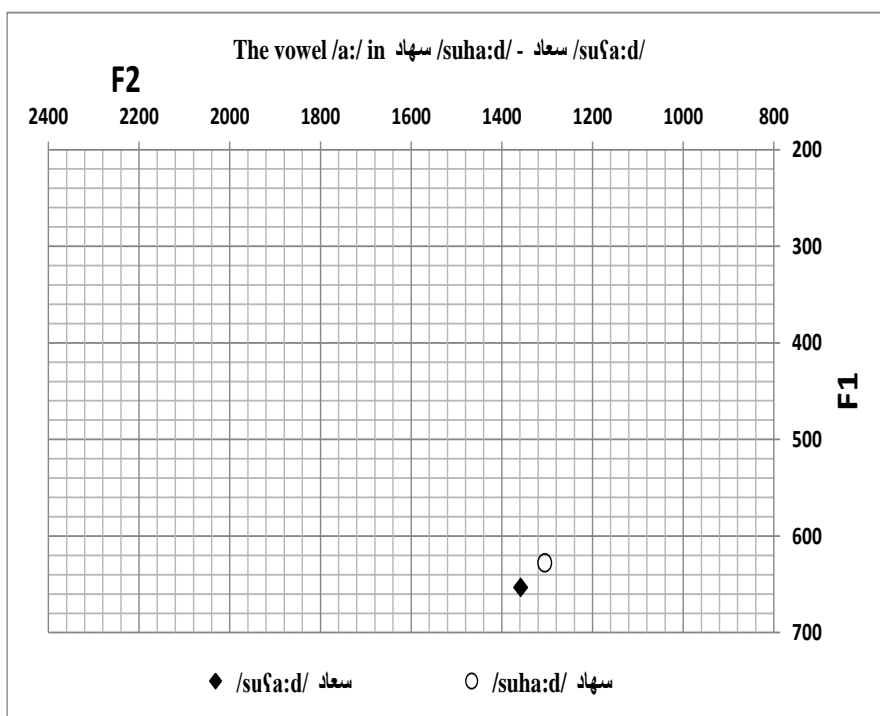


Figure 5: Averaged F1 and F2 values of /a:/ across all informants in the female names: سهاد /suha:d/ - سعاد /suʕa:d/

The vowel /a:/ is located at a low and central-back position in the vowel space with a height (F1) in the range (600-700Hz) while F2 is in the range (1200-1400Hz). The context of the stressed syllables is almost identical in /su.'ha:d/ and /su.'ʕa:d/.

Figure 6 shows the averaged F1 and F2 values for 'yaa?' /i:/ in the words عيد /ʕi:d/ 'Eid holiday' and زهيد /zahi:d/ 'cheap' across all ten informants.

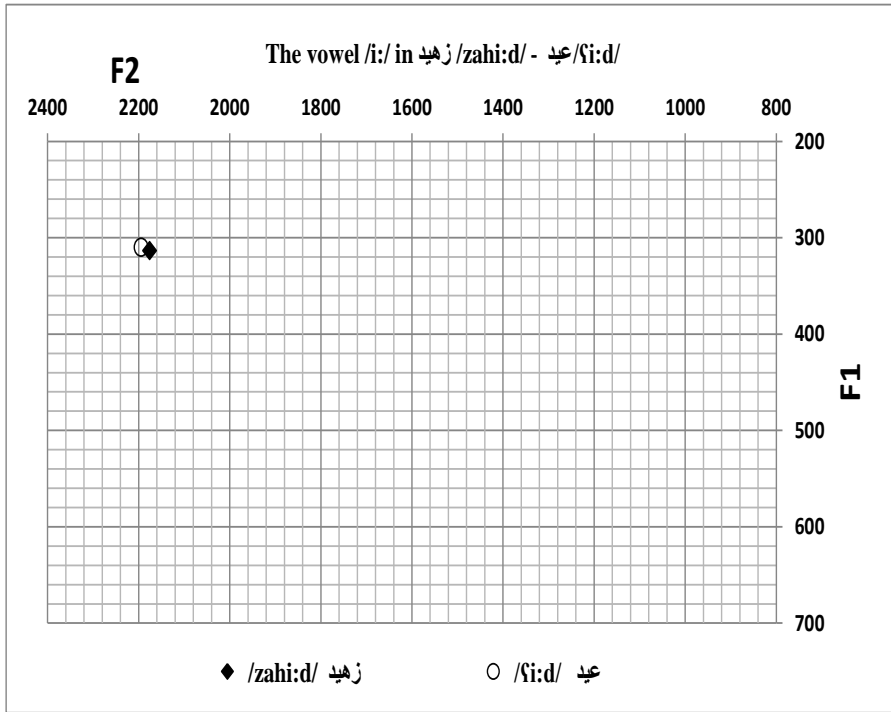


Figure 6: Averaged F1 and F2 values of /i:/ across all informants in the words: زهيد /zahi:d/ - عيد /ʕi:d/

The points representing /i:/ overlap. The vowel is quite high and front. F1 is (~300Hz) while F2 is (~2200Hz). The contexts of the stressed syllables are almost identical /ʕi:d/ and /za.'hi:d/. It should be noted that in Arabic, the ‘yaa?’ can function as a palatal approximant consonant in onset positions only as in /ja:.sa.'mi:n/ ياسمين ‘Jasmine’.

Figure 7 shows the averaged F1 and F2 values of ‘waaw’ /u:/ in the words عود /ʕu:d/ ‘lute’ and هود /hu:d/ ‘Prophet Huud’ across all ten informants.

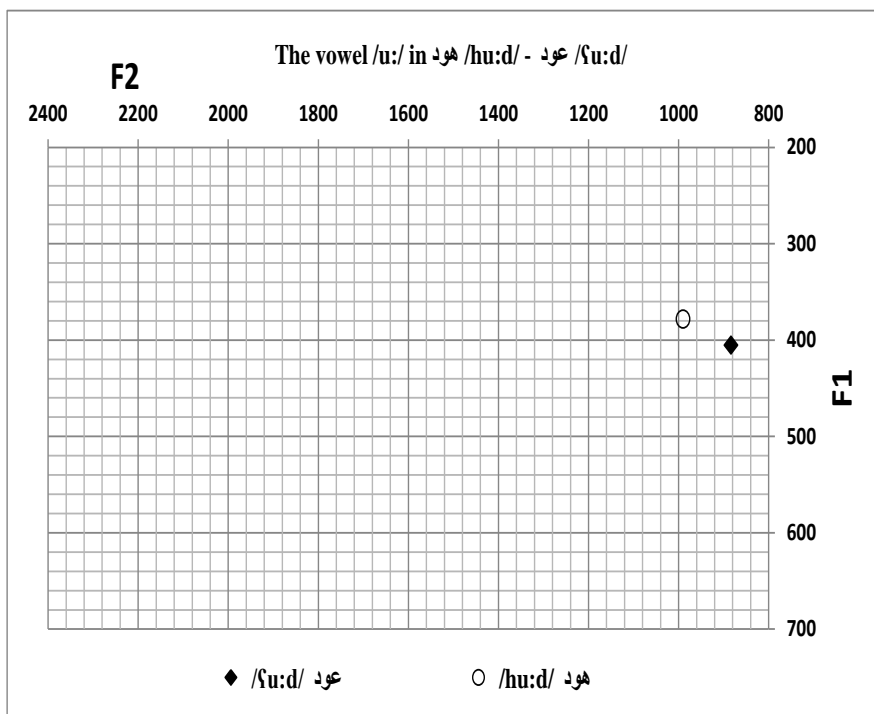


Figure 7: Averaged F1 and F2 values of /u:/ across all informants in the words: هود /hu:d/ - عود /ʕu:d/

The vowel is clearly located in the high and back position in the vowel space. F1 is in the range (350-420Hz) and F2 is in the range (840-1000Hz). The contexts are almost identical /'hu:d/ and /'ʕu:d/. Similar to the 'yaa?', the 'waaw' in Arabic can function as a labio-velar approximant consonant in onset positions only, as in /wu.'ru:d/ ورود 'flowers'.

Figure 8 shows the realizations of the three long monophthongs /a:, i:, u:/ in all six words across all informants.

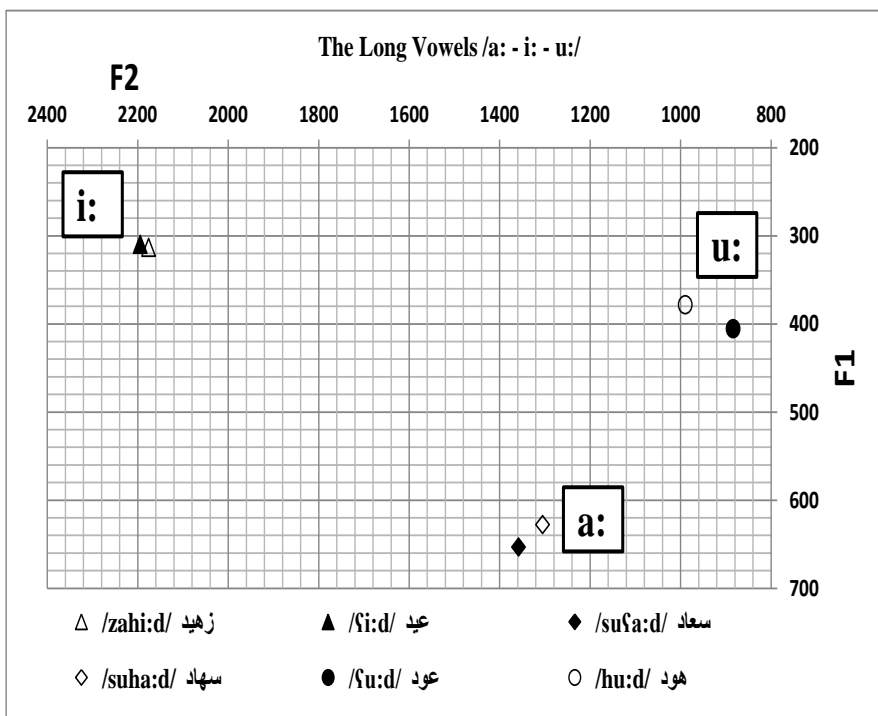


Figure 8: Averaged F1 and F2 values of /a:, i:, u:/ across all informants in the words: سهاد /suha:d/ - سعاد /suʕa:d/ - زهيد /zahi:d/ - عيد /ʕi:d/ - هود /hu:d/ - عود /ʕu:d/

It is clear that the triangular vowel space formed by the three long vowels has more peripheral points than that shown in Figure 4 for the short vowels. This indicates that the long-short vowels in Arabic are distinct not only in duration but also in vowel quality, since the short vowels are more centralized. In Figure 9, the long vowel data is superimposed over the chart of the short vowels. The outer triangle represents the long vowels whereas the inner triangle represents the short vowels. The triangles are connected for the words in the /h-d/ context only, for clarity.

Figure 10 shows the average durations of the six vowels /a, i, u, a:, i:, u:/ in all tested words across all informants in milliseconds (ms).

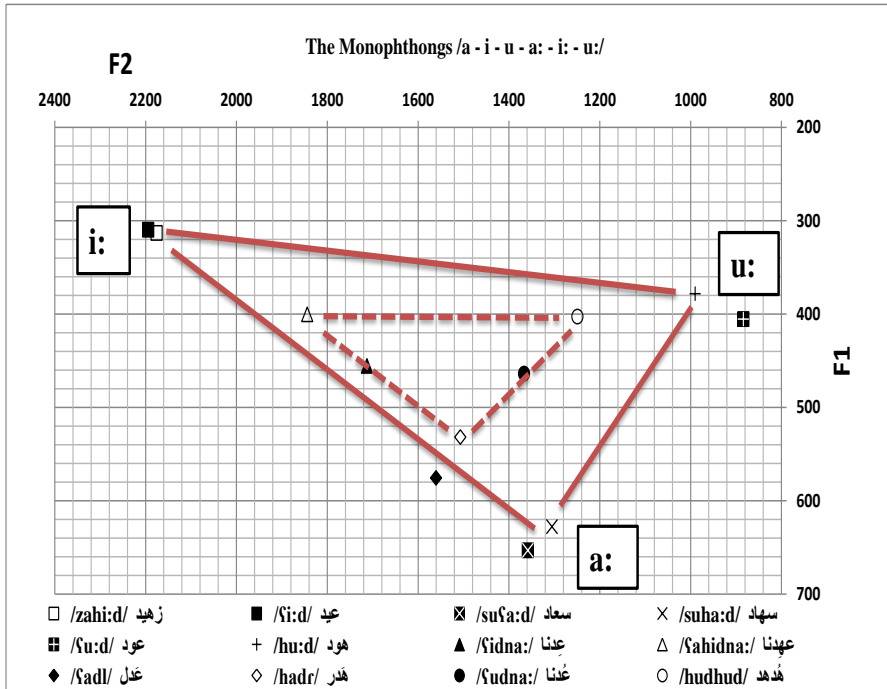


Figure 9: Averaged F1 and F2 values for /a, i, u, a:, i:, u:/ across all informants in all test words. The outer triangle represents the long vowels; the inner triangle represents the short vowels.

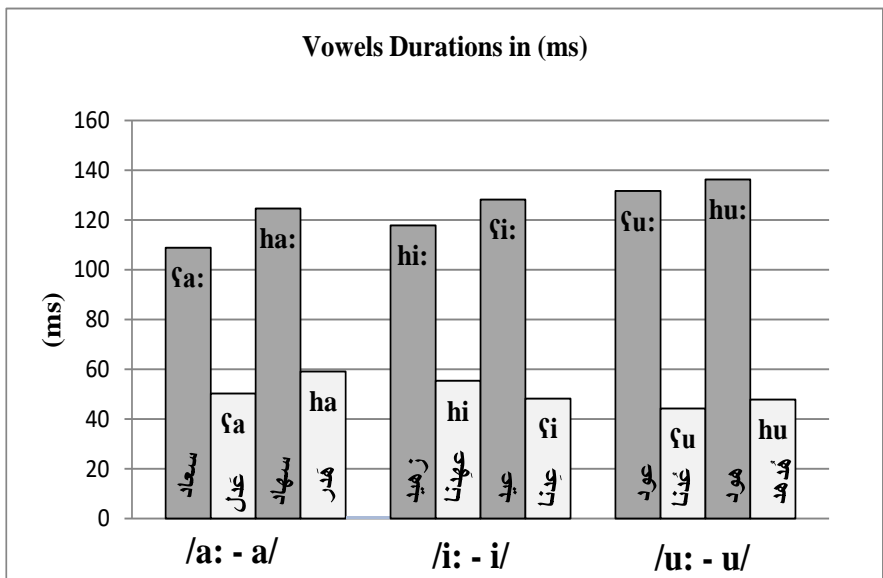


Figure 10: Averaged durations of /a, i, u, a:, i:, u:/ across all informants in all the tested words

It should be noted that all vowels were tested in the same contexts for the short-long vowel distinction: /had/-/ha:d/ (هَدْر- سَهَاد), /hid/-/hi:d/ (عَهْدِنَا- زَهِيد) and /hud/-/hu:d/ (هُدْهُد- هُود). The same contexts were also maintained in /ʕ-d/: /ʕad/-/ʕa:d/ (عَدَل- سَعَاد), /ʕid/-/ʕi:d/ (عِدْنَا- عِيد) and /ʕud/-/ʕu:d/ (عُدْنَا- عُود). Three observations can be made from Figure 10. First, the duration of each long monophthong is more than double that of its short counterpart; /a:/ is (~110ms) in سَعَاد /suʕa:d/ compared to /a/ which is (~50ms) in عَدَل /ʕad/, /i:/ is almost three times longer in عِيد /ʕi:d/ (130ms) than /i/ which is (~45ms) in عِدْنَا /ʕidna:/ and /u:/ is over (130ms) in عُود /ʕu:d/ compared to /u/ which is (~45ms) in عُدْنَا /ʕudna:/. Second, it seems that /u:/ is the longest long vowel followed by /i:/ then /a:/. Unequivocally, durations differences in the same long or short vowel in the two contexts /h_d/ and /ʕ_d/ are non-significant compared to duration differences between the same long and short vowel. For example, the duration difference of /u:/ in both contexts is (4ms); however, it is (88ms) between /hu:d/ and /hud/ and (88ms) between /ʕu:d/ and /ʕud/ (see Table 2 below). Third, the length difference in short vowels takes an opposite direction; the longest short vowel is /a/ followed by /i/ and the shortest short vowel is /u/. The last two observations are consistent in all renditions of the vowels in the different words.

Table 2 shows the averaged monophthong formant values in (Hz) and their averaged durations in (ms) for all twelve test words across all ten informants.

Table 2: Averaged monophthong formant values in (Hz) and averaged durations in (ms)

Vowels in the /h-d/ context					
Vowel	F1	F2	F3	F4	Duration
/a/	628	1305	2655	3715	125
/i:/	313	2176	2772	3667	118
/u:/	378	990	2855	3727	136
/a/	532	1507	2669	3835	59
/i/	400	1844	2775	3914	55
/u/	403	1249	2646	3617	48
Vowels in the /ʕ- d/ context					
/a/	653	1358	2526	3808	109
/i:/	310	2194	2810	3792	128
/u:/	406	884	2853	3679	132
/a/	576	1561	2590	3885	50
/i/	456	1712	2710	3825	48
/u/	464	1367	2590	3690	44

4.3. Diphthongs

Arabic has two closing diphthongs /aj/ and /aw/. This transcription is the one used by most Arab linguists and the one adopted in the *Handbook of IPA* (2005). An alternative transcription is /ai:/ and /au:/ which indicates that the second element in

each diphthong is longer than the first. However, the transcription /aj/ and /aw/ is justifiable since it reflects Arabic orthography. The two diphthongs in Arabic occur whenever ‘fatha’ is followed by ‘yaa?’ in /aj/ as in سَعَيْت /sa.ʕajt/ ‘I sought’ or when it is followed by ‘waaw’ in /aw/ as in عود /ʕawd/ ‘a return’. Hence, this latter transcription will be adopted here.

Figure 11 shows the realizations of /aj/ in the words سَهَيْت /sahajt/ ‘I was distracted’ and سَعَيْت /saʕajt/ ‘I have sought’ across all informants. The empty points represent the first element /a/ and the dark ones represent the second element /j/.

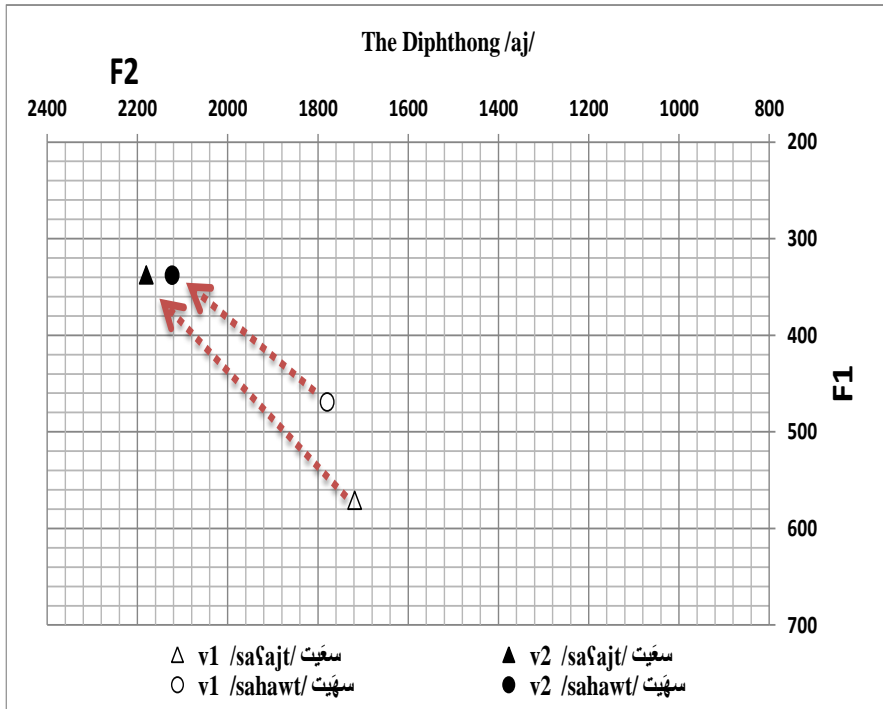


Figure 11: Averaged F1 and F2 values of v1 and v2 for /aj/ across all informants in the words: /saʕajt/ سَعَيْت - /sahajt/ سَهَيْت

The first element is clearly a fronted /a/ vowel whereas the second element is /i:/ (compare with Figure 9). The two words have almost identical contexts to minimize influence from adjacent consonants; /sa.ʕajt/ and /sa.hajt/.

Figure 12 shows the realizations of /aw/ in the words سَهَوْتُ /sahawt/ ‘I was distracted’ and عود /ʕawd/ ‘a return’ across all informants. The empty points represent the first element /a/ and the dark ones represent the second element /w/.

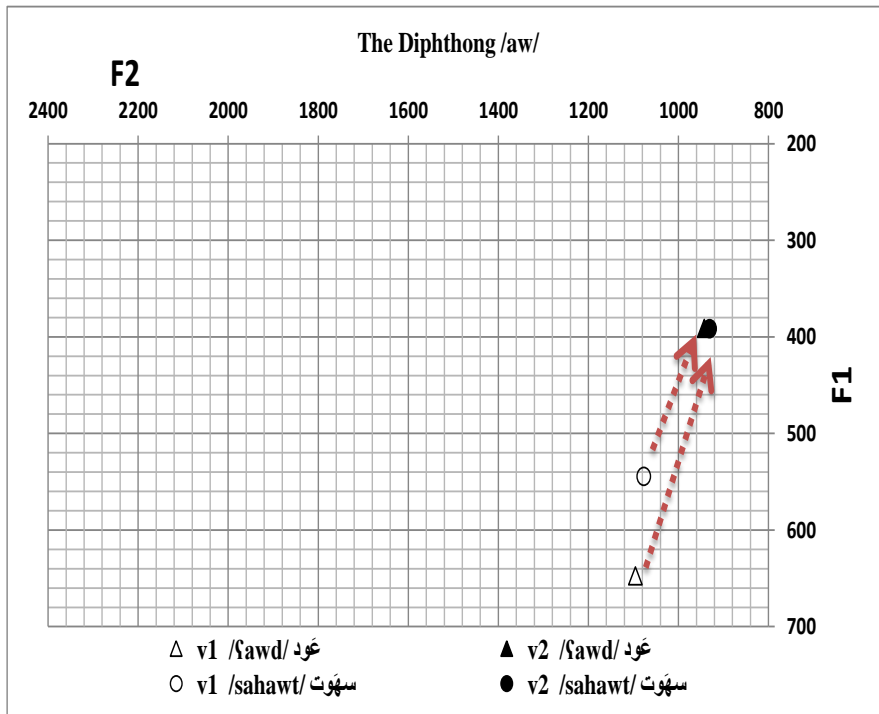


Figure 12: Averaged F1 and F2 values of v1 and v2 for /aw/ across all informants in the words: /sahawt/ سهوت - /ʕawd/ عود

The first element is a retracted /a/ vowel whereas the second element is /u:/ (compare with Figure 9). The two words have similar contexts to minimize influence from adjacent consonants; /sa.'hawt/ and /'ʕawd/.

It should be noted that the first element in both diphthongs is the low and central phoneme /a/. However, this phoneme is realized differently in /aj/ and /aw/. A more fronted variant is realized in /aj/, represented by the allophone [a]; whereas a more retracted form is realized in /aw/, represented by the allophone [ʌ]. This is due to coarticulation where /a/ is realized in the region close to the ensuing and the more dominant element of the diphthong; a high-front /i:/ in /aj/ and a high-back /u:/ in /aw/.

Figure 13 shows the vowel durations for /aj/ and /aw/ in the tested words averaged across all informants in milliseconds (ms).

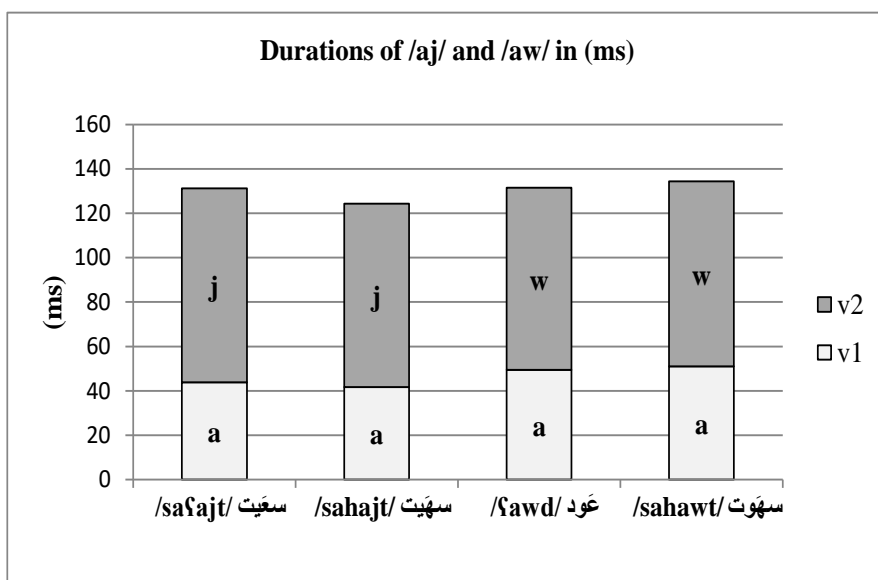


Figure 13: Averaged durations of /aj/ and /aw/ across all informants in all test words

It can be noticed that the durations of both diphthongs are (~130ms). Moreover, the duration of the second element (whether /j/ or /w/) is almost double that of the first element /a/. Interestingly, the two MSA diphthongs /aj/ and /aw/ are the most common diphthongs across universal vowel systems (Lindblom 1986, Merit 1998). Table 3 shows the averaged diphthong formant values in (Hz) and their averaged durations in (ms) (for the first and the second elements of the vowel) in all four test words across all ten informants.

Table 3: Averaged diphthong formant values in (Hz) and averaged durations in (ms) of the first element and the second elements of /aj/ and /aw/ in both /h_d/ and /ʕ_d/ contexts

Vowels in /h-d/ context										
Vowel	First Element					Second Element				
	F1	F2	F3	F4	Duration	F1	F2	F3	F4	Duration
/aj/	469	1779	2615	3691	42	338	2123	2619	3685	83
/aw/	545	1077	2690	3612	51	392	930	2771	3649	83
Vowels in the /ʕ-d/ context										
/aj/	571	1718	2628	3645	44	337	2180	2751	3769	87
/aw/	648	1095	2579	3606	49	391	942	2756	3618	82

5. Discussion

The results of this study support similar findings in other studies on MSA vowels. In this section, the present findings are compared to those of two studies: Saadah (2011) on Palestinian MSA vowels and Alghamdi (1998) on Saudi, Sudanese and Egyptian MSA vowels. These two studies employ comparable data and methodology to the present study. Saadah (2011) has six Palestinian speakers and Alghamdi (1998) has five speakers per group. Both studies investigated vowels in CVC syllables, speakers read randomized lists of the test words, and Saadah (2011) used the carrier sentence "Say ___twice". Alotaibi and Husain (2009) is another acoustic study on MSA vowels by Saudi speakers. However, they included data by one child and an Egyptian speaker to represent MSA vowels produced by Saudi speakers.

Similar to (Saadah 2011: 37) and (Alghamdi 1998: 6), MSA long vowels by Jordanian speakers were found to be more than twice the durations of their short counterparts.

Figure 14 presents a comparison of MSA monophthongs durations produced by five groups of Arabic speakers: Jordanian speakers of this study, Palestinian speakers (Saadah 2011) and Saudi, Sudanese and Egyptian speakers (Alghamdi 1998).

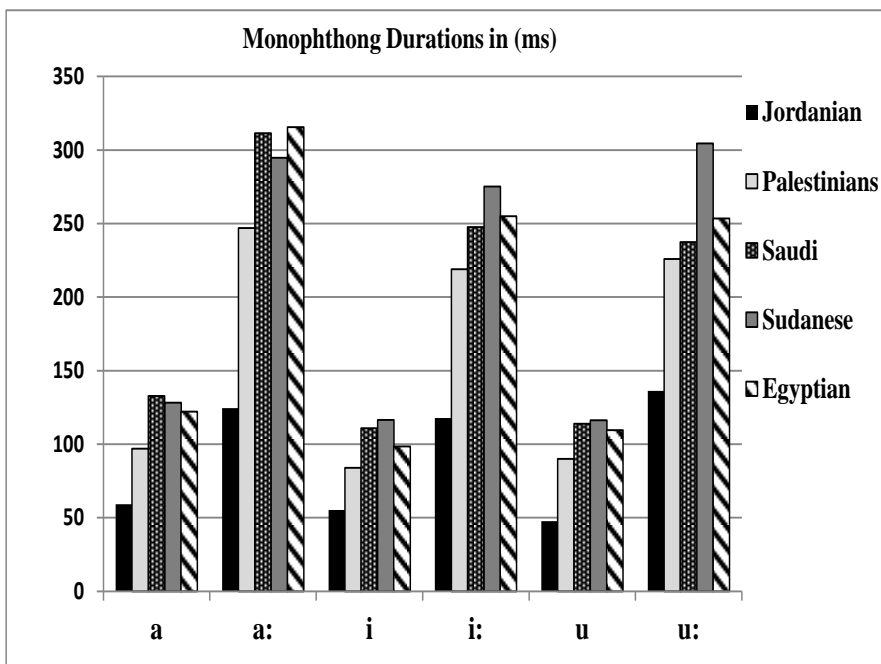


Figure 14: Averaged durations of MSA monophthongs from three comparable studies for five groups of Arabic speakers: Jordanian speakers of this study, Palestinian speakers (Saadah 2011) and Saudi, Sudanese and Egyptian speakers (Alghamdi 1998)

The data in Figure 14 suggests that Jordanian MSA vowels are the shortest, the closet in comparison are MSA vowels by Palestinians.

Figure 15 compares the averaged F1 and F2 values of MSA short vowels by Jordanian speakers, Palestinian speakers (Saadah 2011) and Saudi, Sudanese and Egyptian speakers (Alghamdi 1998). The Jordanian, Sudanese and Palestinian short vowel triangles are shown for comparison.

In Figures 15 and 16, the F1 and F2 values of the Palestinian MSA vowels from (Saadah 2011) were converted from Bark to Hz using the frequency converter from the website <http://www2.ling.su.se/staff/hartmut/umrechnung.htm>. It should be noted that only vowels in the /h-d/ context هَدْر - عهدنا - هُدهد - سهداد - زهديد - هود - are used to represent the Jordanian MSA vowels in the comparison with the other two studies.

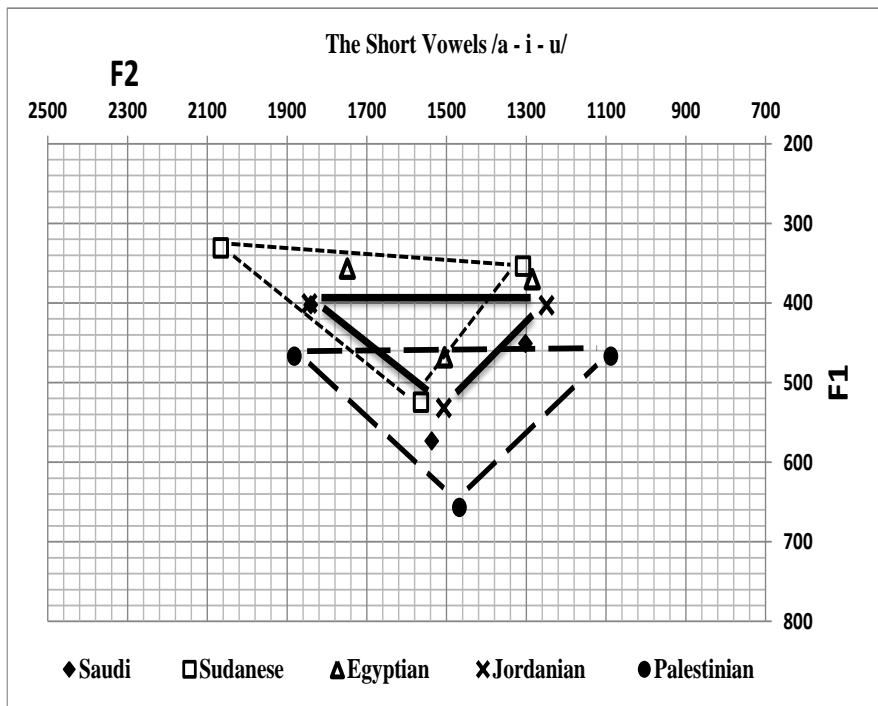


Figure 15: Averaged F1 and F2 values of MSA short vowels by Jordanian speakers, Palestinian speakers (Saadah 2011) and Saudi, Sudanese and Egyptian speakers (Alghamdi 1998). The Jordanian, Sudanese and Palestinian vowel triangles are shown for comparison.

It is clear that the Jordanian short vowel area is centralized compared to the other systems in Figure 15. The Sudanese short vowels system is more fronted and higher than the other systems. The Palestinian short vowels system; however, is the most retracted and most pulled downward.

Figure 16 compares the averaged F1 and F2 values of MSA long vowels by Jordanian speakers, Palestinian speakers (Saadah 2011) and Saudi, Sudanese and Egyptian speakers (Alghamdi 1998). The triangle of the long vowel system for each group is shown for comparison. The Jordanian triangle is represented in full dark lines, whereas the other triangles are in dotted and dashed lines.

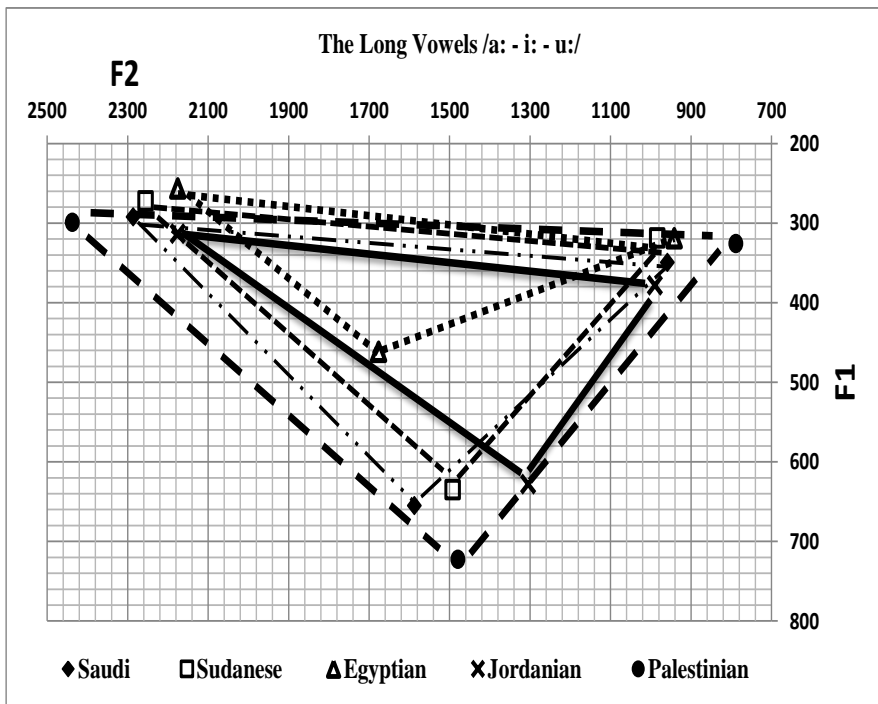


Figure 16: Averaged F1 and F2 values of MSA long vowels by Jordanian speakers, Palestinian speakers (Saadah 2011) and Saudi, Sudanese and Egyptian speakers (Alghamdi 1998). The long vowel triangle for each group is shown for comparison. The Jordanian triangle is in full dark lines.

It can be deduced from Figure 16 that the Jordanian long vowel system occupies a central position among the other systems. Interestingly, the Egyptian system has a very raised and fronted quality for the /a:/ compared to all the other systems. The Palestinian long vowel system is the most peripheral as shown by its large triangle area. The closest system in both short and long vowels positions to the Jordanian one is the Saudi MSA vowel system.

The other two studies did not include diphthongs. The present findings suggest that the first element in both /aj/ and /aw/ is a short vowel followed by a longer glide as shown in Figure 13 above. It is worth noting that the MSA diphthongs /aj/ and /aw/ differ from the English /aɪ/ and /aʊ/ diphthongs. Diphthongs can be categorized into ‘falling’ when the prominent element comes

first and ‘rising’ when the less prominent element comes first (Mateescu 2003: Ch.4). In English, both /aɪ/ and /aʊ/ are ‘falling’ diphthongs where /a/ is longer and more prominent than the second shorter element (e.g. see Kalaldehy (2013) for diphthongs of Irish English). MSA has two ‘rising’ diphthongs which start with a short vowel and glide towards a longer and more prominent target.

Merit (1998) suggests that the best diphthongs are the ones that are tautosyllabic. Accordingly, rising diphthongs are seen as more prototypical since they are completely part of the vowel nucleus whereas falling diphthongs are mostly a split between the nucleus and the coda.

6. New MSA vowel symbols

In almost all studies on MSA vowels (e.g. Alghamdi 1998; Alotaibi and Husain 2009; Saadah 2011) or vowels of dialects of Arabic (e.g. Almbark and Hellmuth 2015) the phonemic distinction between long and short vowels was found to be durational and qualitative. The primary distinction between long and short vowels is duration which is usually reported to be an over 50% ratio.

However, another important difference is vowel quality. The realization of the short vowel in the vowel space is different from that of its long counterpart. The short vowels are significantly more centralized in the vowel space compared to the peripheral positions of the long vowels. In Figure 9, the difference in F2 values is apparent between /i:/ and /i/ (~360Hz), between /u:/ and /u/ (~240Hz) and between /a:/ and /a/ (~200 Hz). The phenomenon of the smaller triangle inside the larger triangle is almost universal in studies on Arabic vowels.

Therefore, it would only be logical to have IPA symbols that reflect both the duration and the quality distinctions between long and short MSA vowels. However, in all studies on MSA vowels the symbols used are /a:, i:, u:, a, i, u/ which only reflect the durational difference indicated by the colon after the symbol or by doubling the long vowel symbols /aa, ii, uu/ as used in Al-Ani (1970: 23-24).

In this study, the proposed symbols for the short MSA monophthongs are /ɐ, ɪ, ʊ/ whereas the long MSA monophthongs maintain the symbols /a:, i:, u:/. Hence, the short-long MSA vowel distinction is as follows:

- /ɪ/ is centralized and lower than long /i:/,
- /ʊ/ is more to the front and lower than long /u:/ and
- /ɐ/ is more centralized and higher than long /a:/.

In most Arabic vowel studies, /a:/ is found to be a retracted vowel with a lower F2 than the short /ɐ/ (Al-Ani 1970; Newman and Verhoeven 2002; Tamimi et al. 2004; Ammar et al. 2014 for MSA produced by the Tunisian speakers; Alhussein and Hellmuth 2015). In other studies both /ɐ/ and /a:/ occupy the same F2 region (Alghamdi 1998; Saadah 2011; Ammar et al. 2014 for MSA produced by Moroccan speakers). Finally, the proposed symbols imply that the diphthongs should be transcribed as /ɐj/ and /ɐw/, since both start with a short low vowel ‘fatha’ and end with a front-high long vowel ‘yaa?’ or a back-high long vowel ‘waaw’, respectively.

Figure 17 shows the IPA vowel chart (right) and the schematic representation of the MSA vowels in the proposed symbols in this study (left) where the grey circles represent long vowels and the dotted arrows show the direction of the diphthongs /ej/ and /ew/.

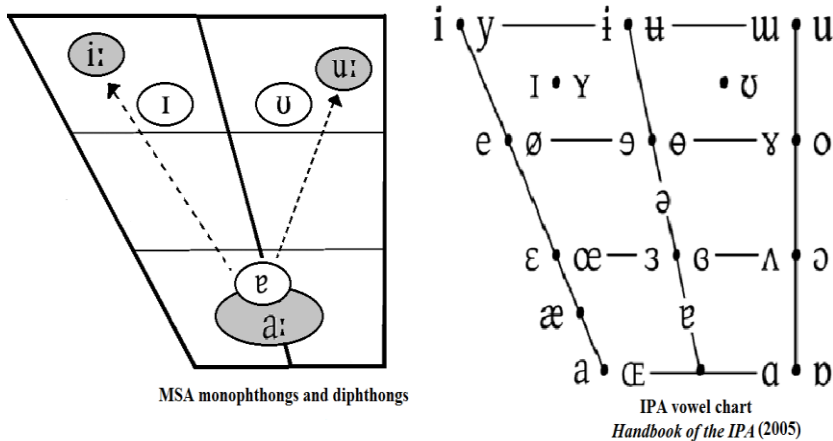


Figure 17: IPA vowel chart (right) and the schematic representation of the MSA vowels in the proposed symbols in this study (left). Grey circles represent long vowels and the dotted arrows show the direction of the diphthongs /ej/ and /ew/.

Lindblom (1986) argues that it is F1 (which correlates with articulatory opening and vowel height) rather than higher formants which is more critical for the distinction between vowels. In MSA, this is true for the distinction between the three short vowel qualities /e - ɪ - ʊ/ and between the three long vowels /a: - i: - u:/. F1 values are also crucial in distinguishing between the long-short MSA vowel pairs /i: - ɪ/ and /u: - ʊ/. This explains why the distinction between the long-short MSA pair /a: - e/ is not always clear-cut. The difference between /a: - e/ is essentially in their F2 values (a correlate for the frontness/backness of vowels).

7. Conclusion

In this study, the MSA vowels produced by Jordanian speakers were acoustically analyzed and described accordingly. The findings are compared with similar studies on MSA vowels produced by other Arab speakers. It was found that MSA vowels, produced by the Jordanian speakers, occupy a central position among their counterparts by other Arab speakers. Most notably, Jordanian MSA vowels were found to be quite shorter than their MSA counterparts by Palestinian, Saudi, Sudanese, and Egyptian speakers. The closest vowel durations to the Jordanian data were the Palestinian vowels. This is not surprising; Jordanian and Palestinian Arabic are Levantine Arabic dialects that share many phonetic features. These features of the Jordanian dialect are likely to have carry-over effect in the MSA speech.

In terms of vowel quality, the Saudi MSA system was the closest to the Jordanian system. Bedouin Jordanian originates from an early version of the Najidi dialect used today in Saudi Arabia. Thus, it is very likely that traces from the Jordanian dialect have surfaced in MSA speech.

In light of the findings of this study and of those in previous studies on MA vowels, a new set of symbols for representing MSA vowels were proposed namely: short vowels /e - i - u/ and diphthongs /ej/ and /ew/. The previously used long vowel symbols /a: - i: - u:/ were maintained.

8. Limitations

The current study describes the MSA vowels produced by Jordanian speakers. This is carried out by acoustically analyzing the vowels and plotting their F1 and F2 averaged values on acoustic charts in an attempt to describe the vowel quality for each MSA vowel. Vowel durations were also calculated to further verify the short-long vowel distinction. However, this study was not without limitations.

The ten informants of the study were all males who come from the city of Madaba (only 30 Km south-west of Amman). Including female speakers, not only gives a more comprehensive description of the MSA vocalic system under study, but also allows for a sociolinguistic comparison between the vowel-systems of the two sexes.

The comparison with other studies on MSA vowels has its own limitations. It is not always feasible to find studies that are completely comparable with one's own study. The two studies of Saadah (2011) and Alghamdi (1998) employed data and methodology that was most similar to the current study compared to other studies on MSA vowels. However, this does not discount the influence of the different CVC test words in both studies that were not the same as the /ʕ_d/ and /h_d/ syllables used here.

An interesting finding was the similarity of Jordanian and Palestinian MSA vowels in terms of duration, on the one hand, and the similarity between Jordanian and Saudi MSA vowels in terms of quality, on the other hand. This dichotomy of similarity to Palestinian MSA vowels in one aspect but to Saudi MSA vowels in another aspect merits further research. For instance, why were the Jordanian MSA vowels similar to the Saudi ones in quality only and not in duration?

Finally, it is hoped that in future research, the significance of differences in formant values and durations are statistically verified in order to accurately describe a difference as 'significant' or 'non-significant'. This necessitates increasing test word repetitions; five repetitions per word, for example.

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