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The influence of emphatic /dˤ/ on Modern Standard Arabic vowels: An acoustic analysis

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This study is part of a larger project on the influence of Arabic emphatics /tˤ, dˤ, ðˤ, sˤ/ on adjacent Arabic vowels by considering three factors: vowel quality, vowel duration and directionality of emphasis spread. This paper investigates the influence of the voiced alveolar emphatic /dˤ/ on the six Modern Standard Arabic (MSA) monophthongs /æ – ɪ – ʊ – aː – iː – uː/ as produced by ten Jordanian speakers. The monophthongs in the adjacency of /dˤ/ are compared to those adjacent to the non-emphatic alveolar voiced stop /d/. Results indicate that in the emphatic context, the vowels are clearly retracted in the vowel space and that the extent of the emphatic influence in 'preceding' or 'following' contexts is not significantly different.

Keywords: Arabic emphatics, Arabic vowels, Directionality of emphasis spread, Jordanian speakers, Modern Standard Arabic

1. Literature review

Emphasis refers to the phonetic feature that characterizes the articulation of consonants with a primary articulation in the dento-alveolar region and a secondary articulation in the upper region of the pharynx (Kahn 1975; McCarthy 1994; Davis 1995; Zemánek 2006). Emphasis involves a primary articulation and a secondary articulation. It defines consonants with a secondary articulation in the back of the vocal tract, while keeping their primary place of articulation. This results in a set of contrastive phonemes, one being emphatic and the other plain. Both emphatic and plain counterpart segments share the same place and manner of articulation, but differ solely in the feature [+emphatic] or [-emphatic].

Where there is a widespread consensus that the tongue dorsum is the active articulator in the production of emphatics, the place of pharyngeal constriction is debatable whether it is the upper or lower pharynx. This controversy has made some linguists use the phonetic label 'pharyngealisation' to describe the general role of the pharynx in the

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production of emphasis (Bellem 2007), while others adopt the term "uvularisation" (Zawaideh 1998). However, some studies use the terms 'emphatic' and 'pharyngealised' interchangeably as in Thelwall and Sa'Adeddin (1990).

Two types of emphatics are differentiated in literature: primary and secondary (Blanc 1953; Younes 1982; Card 1983; Huneety and Mashaqba 2016). The primary is associated with pharyngealised coronals /tˤ, dˤ, ðˤ, sˤ/ that could spread emphasis over neighboring segments. By contrast, secondary or non-phonemic emphatics refer to segments that become emphatic in the context of a neighboring primary emphatic, with the exception of some incidents where [ɾˤ] and [lˤ] are involved. Secondary emphatics can be marked in small group words where there are the low vowels /ɐ/ and /a:/ (Davis 2009: 637). The [ɾˤ], [lˤ], [mˤ] and [bˤ] are the frequent ones in literature illustrated for /lˤ/ and /mˤ/ in the words *wa-ḷḷa* والله 'by God' and *ṃayy* مَيّ 'water' which contradicts respectively with *walla* ولّاه 'he appointed him' and *mayy* مَيّ 'a female name'.

To phonologists, the reason behind emphasis is a matter of debate. For most, emphasis can be accredited to pharyngealised consonants which involve /tˤ, dˤ, ðˤ, sˤ/ (Ghazeli 1977; Younes 1982; Card 1983; Davis 1993; Sakarnah 1999; Huneety 2015; Mashaqba 2015). Some dialects like Cairene Arabic (Broselow 1976) and Palestinian Arabic (Younes 1994) involve the tap [ɾˤ] as an example of a sonorant emphatic. Similarly, the lateral [lˤ] is an example of a sonorant emphatic in Classical Arabic (Ferguson 1956), in Cairene Arabic (Broselow 1976; Youssef 2013) and in Baghdadi Arabic (Youssef 2013). Moreover, the nasal [mˤ] is considered as a sonorant emphatic as recorded in North Palestinian Arabic (Blanc 1953).

Emphasis has been considered by others as a superasegmental feature that affects the words' vowels and consonants (Ferguson 1956). Youssef (2013) argues that emphasis can be generated by the low back vowel /ɐ/ in the absence of the coronal emphatics (/tˤ, dˤ, ðˤ, sˤ/ and [ɾˤ]). He supports his argument by denoting that in Cairene Arabic, all consonants are exclusively emphatic in words that include the low back vowels /ɐ/ or /a:/, excluding the emphatic coronals /tˤ, dˤ, ðˤ, sˤ/ and [ɾˤ]. Moreover, he indicates that even foreign words used in Cairene Arabic such as the Italian word *lampa* 'light' is articulated as *ḷaṃḅa* لَمبَة which reflects the emphasis spread over low back vowels.

Arabic dialects exhibit some differences in terms of the domain, direction and blockers of emphasis. Zawaydeh (1998) acoustically analyzes the spread of uvularisation in Ammani Arabic from the set of coronal consonants /tˤ, dˤ, ðˤ, sˤ/ and from the uvular stop /q/. The analysis shows that uvularisation from the coronal consonants works rightward and leftward unblocked by any segments. Where rightward spread of uvularisation from the uvular stop /q/ is weak, it is blocked by /ɪ/, /i:/ and /j/. Examining Jordanian Arabic, Al Masri & Jongman (2004) show that emphasis spreads bi-directionally in Jordanian Arabic, with the high vowels /i:/ and /u:/ blocking rightward spread.

Sakarnah (1999) maintains that emphasis in Abbadi Arabic spreads bi-directionally within the phonological word unconditionally, i.e. without being blocked by any segments. In Wadi Ramm Arabic, Mashaqba (2015) points that where leftward spread is unbounded, rightward spread is blocked by the high front segments /ɪ/, /i:/ and /j/. Such blockage is optional when tautosyllabic, but absolute when non-tautosyllabic.

In Jerusalem Arabic, Card (1983) finds that emphasis spreads bi-directionally minimally to adjacent segments and maximally over the whole phonological word. Leftward spread is absolute, but rightward spread is blocked by the high vowels /i:/ and /u:/. In a similar fashion, emphasis is bi-directional in Palestinian Arabic (Herzallah 1990) rightward spread of emphasis is blocked by the set of palatals /i:/, /j/ and /ʃ/.

In a similar account, Davis (1995) notices that in southern and northern Palestinian Arabic, the emphasis spreads bi-directionally in a similar fashion to the previously mentioned dialects. Where leftward emphasis is absolute, rightward is blocked by some opaque segments. The set of opaque segments differs regarding the dialect; the southern one refers to high front opaque segments that are /i:/, /j/, /ʤ/, and /ʃ/, while the northern refers to high segments of /i:/, /ʊ/, /j/, /ʃ/ and /w/. Al-Omar (2008) investigates pharyngealisation in Syrian Arabic within the scope of Optimality Theory. Emphasis also appears to be bi-directional in Syrian Arabic observed in the word that has an emphatic segment. He also indicates that emphasis can cross word boundaries where it covers the initial empathic segment of a word as well as the final segment of the word.

2. Research questions

Previous studies have focused on the directionality of the emphatic influence and more specifically on its scope within the word. Some studies found the influence of the emphatic to spread over the whole syllable (e.g. Hassan 2005; Mashaqba 2015) and often over the whole word (e.g. Al-Omar 2008; Sakarnah 1999; Zawaydeh 1999; Davis 1995; Card 1983). However, the present study focuses on the extent of the emphatic's influence as governed by vowel quality and vowel duration. Additionally, this extent on the vowel is investigated both before and after the emphatic, where the vowel is tauto-syllabic with the emphatic. More specifically, this study presents the first findings of a larger project on the four main emphatics /tˤ, dˤ, ðˤ, sˤ/. The investigation here, is concerned with the influence of the voiced alveolar emphatic /dˤ/ on the six MSA monopthongs /ɐ – ɪ – ʊ – a: – i: – u:/.

The symbols used to transcribe the MSA phonemes in this paper mostly follow the IPA illustrations for Arabic as proposed by Thelwall & Sa'Adeddin (1990) and which were also adopted by the Handbook of the International Phonetic Association (2005). However, for vowels, we opt to follow the symbols proposed by Kalaldeh (2018). The IPA symbols for MSA monophthongs reported by Thelwall & Sa'Adeddin (1990) (based on the speech of a single speaker) are /aa, a, ij, i, uw, u/ and the two diphthongs /aj, aw/. Kalaldeh (2018) proved that the three short MSA vowels are distinct from their longer counterparts not only in length but also in quality and should therefore warrant a different symbol; /a: – ɐ/, /i: – ɪ/ and /u: – ʊ/. The suggested symbols by (Kalaldeh 2018) are accurate and represent the fine grain differences in quality between long and short MSA vowels. These distinctions are clear and evident in acoustic analyses and are crucial for the present study.

Figure 1 shows the IPA vowel chart (right) and a schematic representation of the eight MSA vowels following (Kalaldeh 2018) where grey circles represent long vowels and

dotted arrows show the direction of the diphthongs /ɐj/ and /ɐw/ (left). Accordingly, the symbols for the MSA vowels are: /a: – i: – u:/ for the long monophthongs, /ɐ – ɪ – ʊ/ for the short monophthongs and /ɐj/ and /ɐw/ for the two diphthongs.

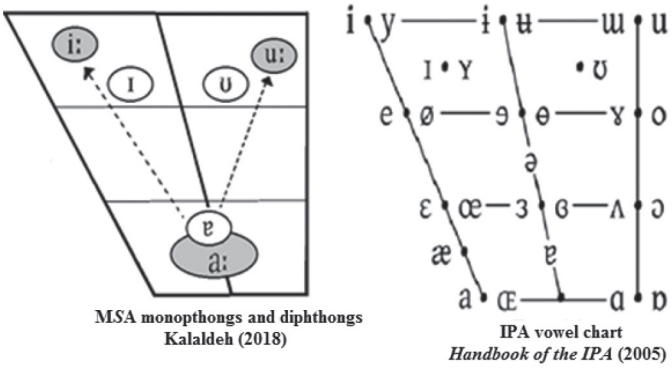

Figure 1. IPA vowel chart (right) and the schematic representation of the MSA vowels symbols proposed in (Kalaldeh 2018) (left). Grey circles represent long vowels and the dotted arrows show the direction of the diphthongs /ɐj/ and /ɐw/

This paper looks at the influence of the emphatic /dˤ/ on adjacent MSA vowels. All tested vowels are placed in stressed syllables tauto-syllabic with the intended consonant (/dˤ/ or /d/) as in هضاب 'hills' /hɪ.'dˤa:b/ and أهداب 'eyelashes' /ʔɐh.'da:b/ for the long vowel /a:/. The influence of /dˤ/ on the realization of the six MSA monophthongs is also investigated in two contexts; 'preceding' the vowel /dˤV/ as in هضاب 'hills' /hɪ.'dˤa:b/ and 'following' the vowel /Vdˤ/ as in أنقاض 'rubble' /ʔɐn.'qa:dˤ/ for the long vowel /a:/.

It follows that there are three research questions:

1. Does the influence of /dˤ/ on the vowels vary according to vowel quality?
2. Does the influence of /dˤ/ on the vowels vary according to vowel duration?
3. Is the /dˤ/ influence on MSA vowels more prominent preceding or following the vowel?

3. 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.

All 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 was Arabic. 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 Najidi 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. For ease of reference, the variety under study here will be referred to as 'MSA produced by Jordanian speakers'. 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).

4. Methodology

Table 1 shows the 24 words used to elicit the tested vowels (12 words for the /dˤ/ and 12 for the /d/). Each 12 words represent the six monophthongs in two contexts (preceding/following the consonant). In total, the produced tokens were 24 × 2 repetitions × 10 informants = 480 (only 20 tokens were discarded for mispronunciation); therefore, the total analyzed tokens were 460. Informants practiced reading the words before recording. All tested vowels were elicited in stressed syllables and were tauto-syllabic with the intended consonant (/dˤ/ or /d/). It should be noted that the word ضُوء 'light' /'dˤu:ʔ/ is pronounced in MSA with a diphthong as /'dˤɐwʔ/, but for the purposes of this study the diacritic (ʾ) was placed over the emphatic so it was read by the informants as /'dˤu:ʔ/.

Each word was placed in the carrier sentence 'say _ _ _ _ again.' and was presented on a Powerpoint slide. The words list was randomized twice and read from a computer screen. Each informant 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).

Acoustic analysis of the data was carried out using Praat (version 6.0.15). Formants measurements and segmentation criteria are based on the segmentation procedure described in Peterson and Lehiste (1960). This procedure separates vowels based on the sudden change in voicing and intensity apparent in the spectrogram. The fact that the procedure operates on vowels makes it applicable (portable) to other languages (e.g. Hassan (2005). In our study, three main measurements were extracted for each vowel: F1, F2, and the vowel duration. The formant measurements were determined by the standard analysis parameters in Praat. Formant values were measured in the middle of the steady state part of the vowel using a specific Praat script. The beginning and end times of the vowels were determined by hand on the basis of visual information from wide band spectrograms

and aligned waveforms. The onset of the vowel was marked by the onset of voicing or the sudden change in intensity or formant frequency. The offset of the vowel was marked by the offset of voicing or a sudden drop in intensity. In cases where the onset or the offset of the vowel was not clear, measurement points were determined by visual inspection of the waveform and spectrogram as well as by ear. Tokens that were not suitable for analysis due to factors such as disfluencies were excluded. All measurements were hand-checked and corrected prior to analysis.

Table 1: The 24 test words with the MSA vowels preceding and following /dˤ/ and /d/

Arabic Test Words						
Vowel	/dˤ/ words	IPA	English Gloss	/d/ words	IPA	English Gloss
- i:	رَضـيْع	/ɾɐ.ʾdˤi:ʕ/	‘infant’	رَديء	/ɾɐ.ʾdi:ʔ/	‘bad’
- ɪ	مُضِرٌّ	/mʊ.ʾdˤɪɾɾ/	‘harmful’	مُدِرٌّ	/mʊ.ʾdɪɾɾ/	‘diuretic’
- a:	هِضَـاب	/hɪ.ʾdˤa:b/	‘hills’	أهداب	/ʔɐh.ʾda:b/	‘eyelashes’
- ɐ	ضَبْع	/ʾdˤɐbʕ/	‘hyena’	دَبْغ	/ʾdɐbʁ/	‘leather tanning’
- u:	ضُـوء	/ʾdˤu:ʔ/	‘light’	هـدُوء	/hʊ.ʾdu:ʔ/	‘calmness’
- ʊ	يَضُـخُّ	/jɐ.ʾdˤʊχχ/	‘he pumps’	يَـدُقُّ	/jɐ.ʾdʊqq/	‘he knocks’
i: -	مَـخـيْـض	/mɐ.ʾχi:dˤ/	‘buttermilk’	حَـفـيْـد	/ħɐ.ʾfi:d/	‘grandson’
ɪ -	بِـضْـع	/ʾbɪdˤʕ/	‘a few’	بِـدْء	/ʾbɪdʔ/	‘starting’
a: -	أنقَـاض	/ʔɐn.ʾqa:dˤ/	‘rubble’	أحـفَـاد	/ʔɐh.ʾfa:d/	‘grandchildren’
ɐ -	فَـضْـل	/ʾfɐdˤl/	‘grace/favor’	عَـدْل	/ʾʕɐdl/	‘justice’
u: -	مَـقـبُـوض	/mɐq.ʾbu:dˤ/	‘caught’	مَـعـبُـود	/mɐʕ.ʾbu:d/	‘worshipped’
ʊ -	تُـضْـرب الأمثال	/ʾtʊdˤ.ɾɐb/	‘proverbs are provided’	تُـدْرج الأوقات	/ʾtʊd.ɾɐʤ/	‘times are scheduled’

5. Results

Results are shown in acoustic charts indicating the position of the vowels by showing the averaged values of F1 and F2 (in Hz) for each vowel in the test words. The values are averaged for the two repetitions of each informant and then averaged for all values of the ten informants.

The results are presented in order of the three research questions factors; vowel quality, vowel duration and directionality of influence. First, the results for the central-back/central vowels /a: – ɐ/ are presented, followed by the high front vowels /i: – ɪ/ and then the

high back vowels /u: – ʊ/. In each pair the long vowel results are presented before the short vowels. Finally, in each case, the 'preceding' context results are presented before the 'following' contexts results.

5.1. The vowel /a:/

Figure 2 shows the averaged F1 and F2 values of the long vowel /a:/ across all ten informants in the contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤa:/ – /da:/ in the words هضاب 'hills' /hɪ.'dˤa:b/ – أهداب 'eyelashes' /ʔɐh.'da:b/ and in 'following' contexts; /a:dˤ/ – /a:d/ in the words أنقاض 'rubble' /ʔɐn.'qa:dˤ/ – أحفاد 'grandchildren' /ʔɐħ.'fa:d/.

In the 'preceding' context, it can be noted that both F1 and (more so) F2 values of

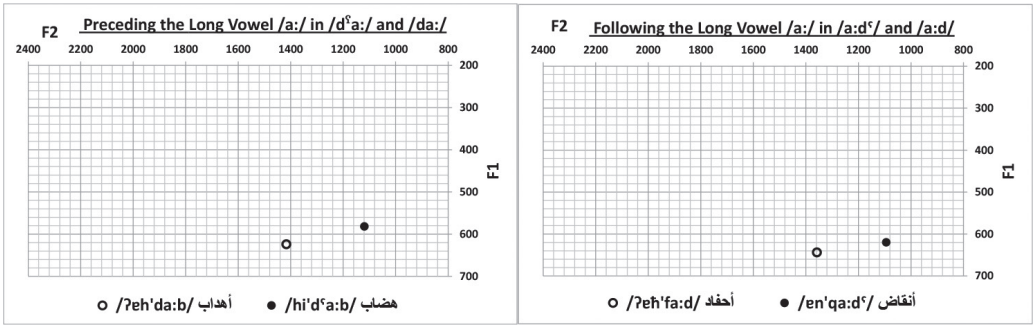

Figure 2. Averaged F1 and F2 values of the long vowel /a:/ across all ten informants in contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤa:/ – /da:/ in the words هضاب 'hills' /hɪ.'dˤa:b/ - أهداب 'eyelashes' /ʔɐh.'da:b/ and in 'following' contexts; /a:dˤ/ – /a:d/ in the words أنقاض 'rubble' /ʔɐn.'qa:dˤ/ – أحفاد 'grandchildren' /ʔɐħ.'fa:d/

/a:/ in /dˤa:/ are lower than those in /da:/. This indicates that the vowel height is slightly raised and the vowel is retracted to the back since F2 has decreased by ~298Hz. Similarly, in the 'following' contexts F1 and (more so) F2 values are lowered in /a:dˤ/ in comparison to those in /a:d/; F2 has decreased by ~264 Hz.

In both the 'preceding' and 'following' contexts of /dˤa:/ and /a:dˤ/, the low long vowel /a:/ is slightly raised and clearly retracted to the back of the vowel space. This indicates that the emphatic /dˤ/ maintains its influence on the quality of /a:/ in a similar manner in both 'preceding' and 'following' contexts.

5.2. The vowel /ɐ/

Figure 3 shows the averaged F1 and F2 values of the short vowel /ɐ/ across all ten informants in contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤɐ/ – /dɐ/ in the words ضَبْع 'hyena' /'dˤɐbʕ/ – دَبْغ 'leather tanning' /'dɐbʁ/ and in 'following' contexts; /ɐdˤ/ – /ɐd/ in the words فَضْل 'grace/favor' /'fɐdˤl/ – عَدْل 'justice' /'ʕɐdl/.

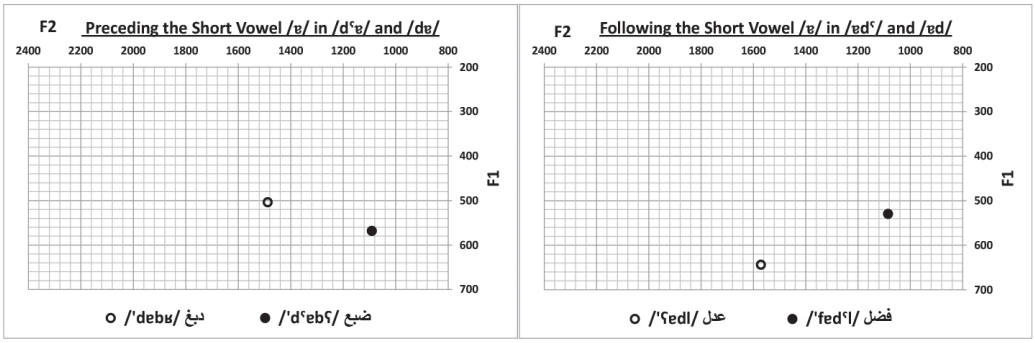

Figure 3. Averaged F1 and F2 values of the short vowel /ɐ/ across all ten informants in contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤɐ/ – /dɐ/ in the words عبْضَ 'hyena' /'dˤɐbʕ/ – غبْدَ 'leather tanning' /'dɐbʁ/ and in 'following' contexts; /ɐdˤ/ – /ɐd/ in the words لضْفَ 'grace/favor' /'fɐdˤl/ – لدْ-عَ 'justice' /'ʕɐdl/

In the 'preceding' context, it is noted that the F1 value of /ɐ/ has increased whereas its F2 value has clearly decreased in /dˤɐ/ compared to its value in /dɐ/. This indicates that the vowel height is slightly lowered but the vowel is retracted to the back as F2 has decreased by ~396 Hz. However, in the 'following' contexts F1 of /ɐ/ is decreased by ~114Hz indicating that the vowel is raised and F2 value is decreased by ~486Hz in /ɐdˤ/ in comparison to those values in /ɐd/.

In both 'preceding' and 'following' contexts of /dˤɐ/ and /ɐdˤ/ the low short vowel /ɐ/ is clearly retracted to the back of the vowel space. However, in the /dˤɐ/ context the vowel is lower than that in the /ɐdˤ/ context, indicated by the F1 values.

5.3. The vowel /i:/

Figure 4 shows the averaged F1 and F2 values of the long vowel /i:/ across all ten informants in contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤi:/ – /di:/ in the words رَضيْع 'infant' /ɾɐ.'dˤi:ʕ/ – رَديء 'bad' /ɾɐ.'di:ʔ/ and in 'following' contexts; /i:dˤ/ – /i:d/ in the words مَخيْض 'buttermilk' /mɐ.'χi:dˤ/ – حَفيْد 'grandson' /ħɐ.'fi:d/.

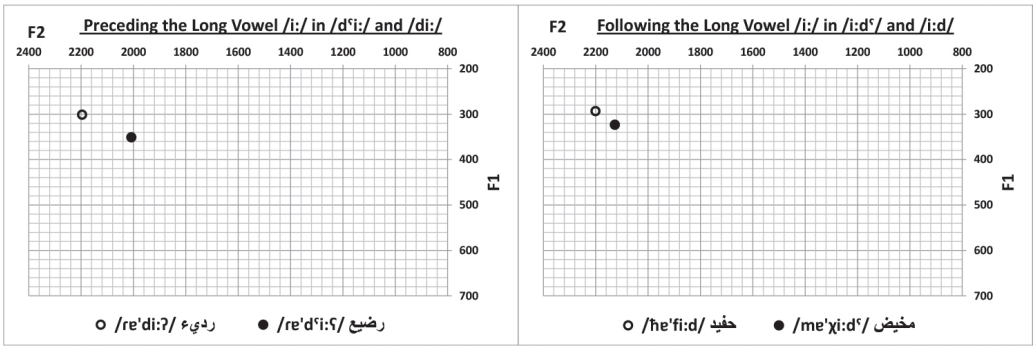

Figure 4. Averaged F1 and F2 values of the long vowel /i:/ across all ten informants in contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤi:/ – /di:/ in the words رَضيْع 'infant' /rɐ.'dˤi:ʕ/ – رَديء 'bad' /rɐ.'di:ʔ/ and in 'following' contexts; /i:dˤ/ – /i:d/ in the words مَخيْض 'buttermilk' /mɐ.'χi:dˤ/ – حَفيْد 'grandson' /ħɐ.'fi:d/

In the 'preceding' context, it is noted that the F1 value of /i:/ is increased whereas its F2 value is decreased in /dˤi:/ compared to that in /di:/. This indicates that the vowel height is slightly lowered and the vowel is retracted to the back as F2 is decreased by ~188 Hz. Similarly, in the 'following' contexts F1 value of /i:/ is increased whereas its F2 value is decreased in /i:dˤ/ compared to that in /i:d/, F2 is decreased by ~74 Hz.

In both 'preceding' and 'following' contexts, the change of vowel quality is very similar. The high front long vowel /i:/ is slightly lowered and slightly retracted in the vicinity (preceding/following) of emphatic /dˤ/.

5.4. The vowel /ɪ/

Figure 5 shows the averaged F1 and F2 values of the short vowel /ɪ/ across all ten informants in contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤɪ/ – /dɪ/ in the words مُضِرٌّ 'harmful' /mʊ.'dˤɪrr/ – مُدِرٌّ 'diuretic' /mʊ.'dɪrr/ and in 'following' contexts; /ɪdˤ/ – /ɪd/ in the words بِضْع 'a few' /'bɪdˤʕ/ – بِدْء 'starting' /'bɪdʔ/.

In the 'preceding' context, it is noted that the F1 value of /ɪ/ is slightly increased whereas its F2 value is decreased in /dˤɪ/ compared to that in /dɪ/. This indicates that the vowel height is slightly lowered and the vowel is retracted to the back as F2 is decreased by ~335 Hz. Similarly, in the 'following' contexts F1 value of /ɪ/ is slightly increased whereas its F2 value is decreased in /ɪdˤ/ compared to that in /ɪd/; F2 is decreased by ~381 Hz.

In both 'preceding' and 'following' contexts, the change of vowel quality is very similar. The front high short vowel /ɪ/ is slightly lowered in height and clearly retracted in the vicinity (preceding/following) of emphatic /dˤ/.

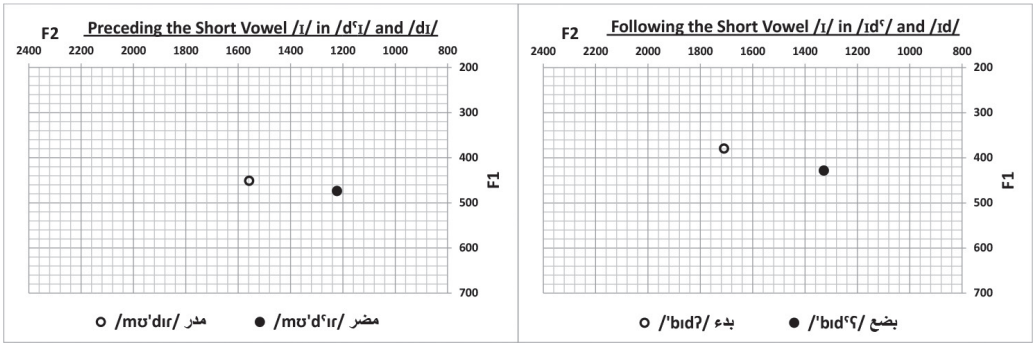

Figure 5. Averaged F1 and F2 values of the short vowel /ɪ/ across all ten informants in contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤɪ/ – /dɪ/ in the words مُضِرٌّ 'harmful' /mʊ.'dˤɪrr/ –مُدِرٌّ 'diuretic' /mʊ.'dɪrr/ and in 'following' contexts; /ɪdˤ/ – /ɪd/ in the words بِضْع 'a few' /'bɪdˤʔ/ – بِدْء 'starting' /'bɪdʔ/

5.5. The vowel /u:/

Figure 6 shows the averaged F1 and F2 values of the long vowel /u:/ across all ten informants in contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤu:/ – /du:/ in the words ضُوء 'light' /'dˤu:ʔ/ – هدُوء 'calmness' /hʊ.'du:ʔ/ and in 'following' contexts; /u:dˤ/ – /u:d/ in the words مَقبُوض 'caught' /mɐq.'bu:dˤ/ – مَعبُود 'worshipped' /mɐʕ.'bu:d/.

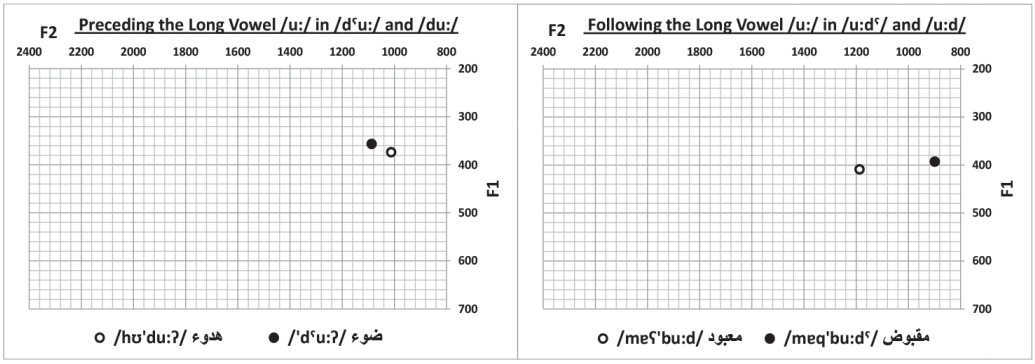

Figure 6. Averaged F1 and F2 values of the long vowel /u:/ across all ten informants in contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤu:/ – /du:/ in the words ضُوء 'light' /'dˤu:ʔ/ – هدُوء 'calmness' /hʊ.'du:ʔ/ and in 'following' contexts; /u:dˤ/ – /u:d/ in the words مَقبُوض 'caught' /mɐq.'bu:dˤ/ – مَعبُود 'worshipped' /mɐʕ.'bu:d/

In the 'preceding' context, it is noted that the F1 value is slightly decreased making the vowel slightly raised in /dˤu:/ than in /du:/. The F2 value of /u;/ is slightly increased in /dˤu:/ compared to that in /du:/. This increase of F2 value, however, is almost insignificant. The position of the vowel /u:/ in both /dˤu:/ and /du:/ is clearly very similar. In the 'following' context F1 is almost unaltered in /u:dˤ/ and /u:d/. The F2 value, however, has decreased by ~289 Hz, indicating a clear retraction of the vowel in /u:dˤ/ compared to its position in /u:d/.

The influence of the emphatic /dˤ/ on the back high long vowel /u:/ seems to be prominent in the 'following' context /u:dˤ/, where the vowel is clearly retracted to the back of the vowel space. In 'preceding' contexts /dˤ/ does not seem to alter the realization of /u:/.

5.6. The vowel /ʊ/

Figure 7 shows the averaged F1 and F2 values of the short vowel /ʊ/ across all ten informants in contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤʊ/ – /dʊ/ in the words يَضُخُّ 'he pumps' /jɐ.'dˤʊχχ/ – يَدُقُّ 'he knocks' /jɐ.'dʊqq/ and in 'following' contexts; /ʊdˤ/ – /ʊd/ in the words تُضْرب الأمثال 'proverbs are provided' /'tʊdˤ.ɾɐb/ – تُدْرج الأوقات 'times are scheduled' /'tʊd.ɾɐʤ/ (in these phrases, transcription is provided for the underlined target words only).

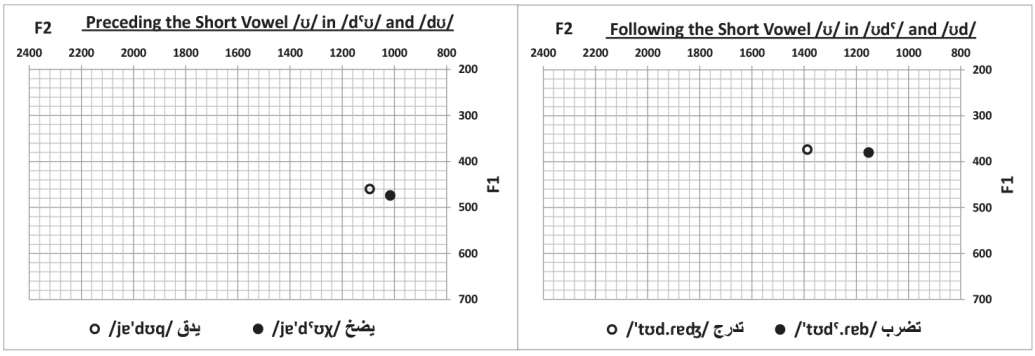

Figure 7. Averaged F1 and F2 values of the short vowel /ʊ/ across all ten informants in contexts of emphatic /dˤ/ and non-emphatic /d/ in 'preceding' contexts; /dˤʊ/ – /dʊ/ in the words يَضُخُّ 'he pumps' /jɐ.'dˤʊχχ/ – يَدُقُّ 'he knocks' /jɐ.'dʊqq/ and in 'following' contexts; /ʊdˤ/ – /ʊd/ in the words تُضْرب الأمثال 'proverbs are provided' /'tʊdˤ.ɾɐb/ – تُدْرج الأوقات 'times are scheduled' /'tʊd.ɾɐʤ/

In the 'preceding' context, it is noted that the F1 value is slightly increased making the vowel slightly lowered in /dˤʊ/ than in /dʊ/. The F2 value of /ʊ/ is slightly decreased in /dˤʊ/ compared to its value in /dʊ/, making the vowel slightly retracted. Nonetheless, the position of the vowel /ʊ/ in both /dˤʊ/ and /dʊ/ is clearly very similar. In the 'following'

context F1 is almost unaltered in /ʊdˤ/ and /ʊd/. The F2 value, however, has decreased by ~235 Hz, indicating a clear retraction of the vowel in /ʊdˤ/ compared to its position in /ʊd/.

Similar to the case of the long vowel /u:/, the influence of the emphatic /dˤ/ on the back high short vowel /ʊ/ seems to be more prominent in the 'following' context /ʊdˤ/, where the vowel is clearly retracted to the back of the vowel space. In 'preceding' contexts, /dˤ/ does not seem to alter the realization of /ʊ/.

Table 2 shows the averaged first four formant values (in Hz) and averaged durations (in ms) of all six MSA monophthongs across all ten informants in empathic 'preceding' /dˤV/ and 'following' /Vdˤ/ contexts and non-emphatic 'preceding' /dV/ and 'following' /Vd/ contexts.

Table 2: Averaged first four formant values (in Hz) and averaged durations (in ms) of all six MSA monophthongs across all ten informants in empathic 'preceding' /dˤV/ and 'following' /Vdˤ/ contexts and non-emphatic 'preceding' /dV/ and 'following' /Vd/ contexts

'Preceding' Contexts												
Vow.	/dV/	F1	F2	F3	F4	Dur.	/dˤV/	F1	F2	F3	F4	Dur.
a:	/ʔɐh›da:b/ أهداب	624	1416	2722	3838	132	/hi'dˤa:b/ هضاب	626	1119	2808	3684	142
ɐ	/'dɐbʁ/ دبغ	504	1488	2745	3824	61	/'dˤɐbʕ/ ضبع	568	1091	2882	3748	58
i:	/ɾɐ›di:ʔ/ رديء	301	2196	2746	3799	113	/ɾɐ›dˤi:ʕ/ رضيع	351	2008	2608	3783	130
ɪ	/mʊ'dɪɾɾ/ مدر	451	1558	2651	3760	59	/mʊ'dˤɪɾɾ/ مضر	474	1223	2788	3705	60
u:	/hʊ'du:ʔ/ هدوء	374	1013	2802	3673	115	/'dˤu:ʔ/ ضوء	357	1087	2909	3641	132
ʊ	/jɐ'dʊqq/ يدق	460	1094	2795	3598	52	/jɐ'dˤʊχχ/ يضخ	466	1016	2920	3617	45
'Following' Contexts												
Vow.	/Vd/	F1	F2	F3	F4	Dur.	/Vdˤ/	F1	F2	F3	F4	Dur.
a:	/ʔɐh›fa:d/ أحفاد	644	1358	2672	3746	141	/ɐn›qa:dˤ/ أنقاض	620	1094	2810	3666	152
ɐ	/'ʕɐdl/ عدل	644	1571	2573	3861	53	/'fɐdˤl/ فضل	530	1085	2808	3761	51
i:	/ħɐ›fi:d/ حفيد	293	2201	2770	3725	119	/mɐ'χi:dˤ/ مخيض	323	2127	2569	3598	124
ɪ	/'bɪdʔ/ بدء	379	1710	2617	3771	47	/'bɪdˤʕ/ بضع	428	1329	2794	3695	57

u:	/mɐʕ'bu:d/ معبود	409	1187	2993	3748	118	/mɐq'bu:dˤ/ مقبوض	393	899	2942	3652	140
ʊ	/'tʊd.ɾɐʤ/ تدرج	373	1388	2738	3696	49	/'tʊdˤ.ɾɐb/ تضرب	380	1153	2768	3639	44

6. Discussion

This paper is set out to answer the following research questions:

1. Does the influence of /dˤ/ on the vowels vary according to vowel quality?
2. Does the influence of /dˤ/ on the vowels vary according to vowel duration?
3. Is the /dˤ/ influence on MSA vowels more prominent preceding or following the vowel?

The first question relates to whether the influence of /dˤ/ differs among the three vowel groups; the low and central-back/central pair /a: – ɐ/ (Figures 2 and 3) the high front pair /i: – ɪ/ (Figures 4 and 5) and the back high pair /u: – ʊ/ (Figures 6 and 7). Comparing the figures reveals that the vowel change in the emphatic and non-emphatic contexts (represented by the black and empty dots in each figure, respectively) is clearest in the pair /a: – ɐ/ (Figures 2 and 3), followed by the pair /i: – ɪ/ (Figures 4 and 5) and finally the least change is noted in the pair /u: – ʊ/ (Figures 6 and 7).

This indicates that the low and central-back vowels /a: – ɐ/ are the most influenced by /dˤ/ where they are slightly raised and largely retracted in the vowel space. The high front vowels /i: – ɪ/ are both slightly lowered and retracted in the vowel space, although less in /i:/ than in /ɪ/ as will be discussed below. The back high vowels /u: – ʊ/ are only retracted in the vowel space in contexts of a 'following' /dˤ/ and the vowel height remains almost unchanged.

The second question relates to whether the influence of /dˤ/ differs with the duration of vowels. To look at the impact of vowel duration on the extent of the emphasis, each vowel pair figures are compared (Figure 2-3, Figures 4-5 and Figures 6-7).

In the pair /a: – ɐ/ the extent of vowel change is larger in the short vowel /ɐ/ than in its longer counterpart /a:/. The retraction of /ɐ/ in 'preceding' /dˤ/ contexts is 100 Hz more than that of /a:/ (~298 Hz for /a:/ and ~396 Hz for /ɐ/). In the 'following' /dˤ/ contexts the retraction of /ɐ/ is almost double that of /a:/ (~264 Hz for /a:/ and ~486 Hz for /ɐ/) (cf. Figures 2-3). The clearest difference between long and short vowel change is evident in the pair /i: – ɪ/. In 'preceding' /dˤ/ contexts, the retraction of the long vowel /i:/ is ~188 Hz but ~335 Hz for the short vowel /ɪ/ (over double the retraction of /i:/). In the 'following' /dˤ/ contexts, /i:/ is retracted by only ~74 Hz; whereas /ɪ/ is retracted by ~381 Hz (about triple the retraction of /i:/) (cf. Figures 4-5). In the pair /u: – ʊ/, the only significant difference in vowel retraction is evident in 'following' /dˤ/ contexts. However, the difference is not significant; the retraction of /u:/ is ~289 Hz and that of /ʊ/ is ~235 Hz (cf. Figures 6-7).

Table 3 shows the extent of retraction and the extent of raising or lowering for the six MSA vowels in emphatic contexts. The extent of retraction is calculated as the difference in F2 values between the emphatic /dˤ/ and the non-emphatic /d/ contexts for each vowel. Similarly, and the extent of raising or lowering is calculated as the difference in F1 values for each vowel in emphatic /dˤ/ and the non-emphatic /d/ contexts. Therefore, the vowel that has the largest retraction in the emphatic /dˤ/ contexts is the short vowel /ɐ/ followed by the short vowel /ɪ/. The long vowel /a:/ has also a significant retraction. The long vowel /i:/ has the least retraction in emphatic /dˤ/ contexts. The high back vowels /u:/ and /ʊ/ show retraction in 'following' /dˤ/ contexts only.

Table 3: The extent of retraction and the extent of raising or lowering for the six MSA vowels in emphatic contexts, calculated as the difference in F2 values and the difference in F1 values, respectively, between the emphatic /dˤ/ and the non-emphatic /d/ contexts for each vowel

Context	Vowel	Extent of raising /lowering (Hz)	Extent of retraction (Hz)
		(F1 in /dˤ/ – F1 in /d/)	(F2 in /dˤ/ – F2 in /d/)
Short Vowels			
'Preceding'	ɐ	65	397
'Following'	ɐ	–114	486
'Preceding'	ɪ	23	335
'Following'	ɪ	49	381
'Preceding'	ʊ	6	78
'Following'	ʊ	6	235
Long Vowels			
'Preceding'	a:	2	298
'Following'	a:	-24	264
'Preceding'	i:	50	188
'Following'	i:	30	74
'Preceding'	u:	–17	–74
'Following'	u:	–16	288

To answer the third question, Figures 1 to 4 for the vowels /a:, ɐ, i:, ɪ/ clearly show that both 'preceding' and 'following' /dˤ/ contexts do not significantly differ for each of these four vowels. The change of the vowel quality is almost identical for each vowel after and before /dˤ/. The only exception is the front high long vowel /i:/ where the vowel retraction in 'preceding' /dˤ/ contexts is ~188Hz but in the 'following' /dˤ/ contexts is ~74Hz. However, in both contexts, the vowels /a:, ɐ, i:, ɪ/ are retracted towards the back of the vowel space.

Only in the case of the back vowels /u:/ and /ʊ/, is vowel retraction more prominent in the contexts of a 'following' /dˤ/ as shown in Figures 6 and 7. This could be justified

by the fact that back vowels share the articulatory space of /dˤ/; a velar articulation is closer to a back high vowel than to a front vowel. Therefore, when high back vowels are followed by a velarized consonant they are relatively in the same vocal space and are more accentuated in their back realization than front vowels are.

Figure 8 shows the averaged F1 and F2 values of the short monophthongs /ɐ, ɪ, ʊ/ produced by the ten informants in the stressed syllable /h-d/ in the words ردة /'hɐdɾ/ 'waste', انعِدْ /ʔɐ›hɪdna:/ 'we have entrusted' and دُدهُ /'hʊdhʊd/ 'hoopoe', respectively.

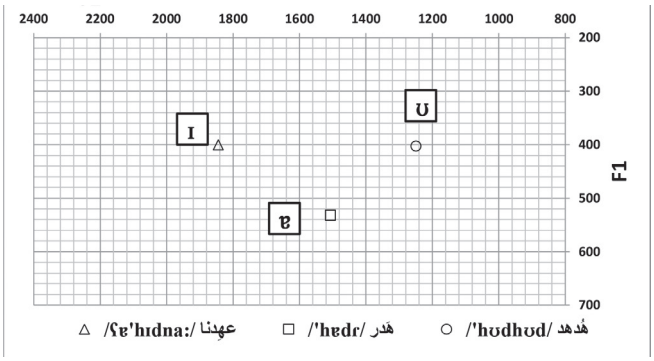

Figure 8: Averaged F1 and F2 values of the short monophthongs /ɐ, ɪ, ʊ/ produced by all informants in the stressed syllable /h-d/ in the words هَدر /'hɐdɾ/'waste', عهدنا /ʔɐ›hɪdna:/ 'we have entrusted' and هُدهد /'hʊdhʊd/ 'hoopoe', respectively

Figure 9 shows the short monophthongs /ɐ, ɪ, ʊ/ in 'preceding' and 'following' emphatic /dˤ/ contexts superimposed on Figure 8. The short monophthongs are connected to show the MSA vowel triangle, the dotted triangle represents the short vowel space in the emphatic /dˤ/ contexts. The figure clearly shows extent of vowel change in the emphatic /dˤ/ contexts, where the dotted triangle indicates the large shift in vowel quality in terms of retraction and slight lowering. It is also noticed that in the 'preceding' /dˤ/ contexts, the vowel space shift is more lowered than that in the 'following' /dˤ/ contexts.

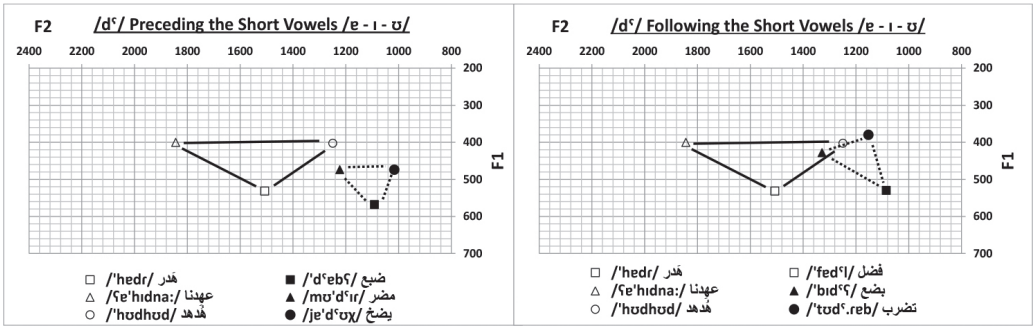

Figure 9. The short monophthongs /ɐ, ɪ, ʊ/ in 'preceding' and 'following' emphatic /dˤ/ contexts superimposed on Figure 8. The solid line triangle represents the MSA short vowel space and the dotted triangle represents the short vowel space in the emphatic /dˤ/ contexts

Figure 10 shows the averaged F1 and F2 values of the long monophthongs /a:, i:, u:/ produced by the ten informants in the stressed syllable /h-d/ in the words سهاد /sʊ'ha:d/ 'Suhad; a female name', زهيد /zɐ'hi:d/ 'low/small' and هود /hu:d/ 'Hud; a prophet's name', respectively.

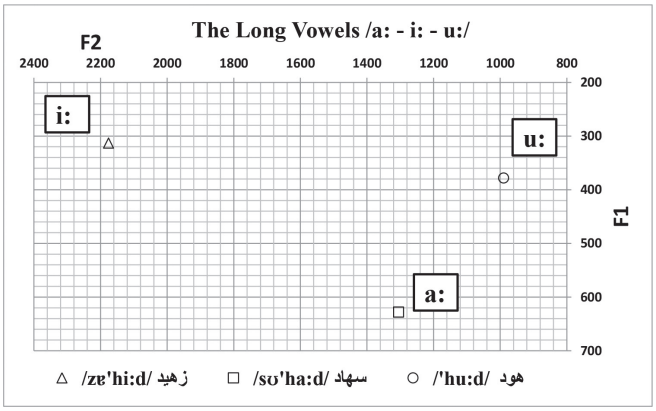

Figure 10. Averaged F1 and F2 values of the long monophthongs /a:, i:, u:/ by all informants in the stressed syllable /h-d/ in the words سهاد /sʊ'ha:d/ 'Suhad; a female name', زهيد /zɐ'hi:d/ 'low/small' and هود /hu:d/ 'Hud; a prophet's name', respectively

Figure 11 shows the long monophthongs /a:, i:, u:/ in 'preceding' and 'following' emphatic /dˤ/ contexts superimposed on Figure 10. The long monophthongs are connected to show the MSA vowel triangle, the dotted triangle represents the long vowel space in the emphatic /dˤ/ contexts. The shift in the vowel space in emphatic /dˤ/ contexts for long vowels is not as dramatic as that for the short vowels (cf. Figure 9). In Figure 11, the two triangles (the solid line and the dotted one) cover, more or less, a similar area in the vowel space. However, it is noticed that in 'following' /dˤ/ contexts, the long vowel triangle is shifted rightwards and downwards indicating more retraction and lowering than that in the 'preceding' /dˤ/ contexts where retraction is only evident for /a:/ and /i:/.

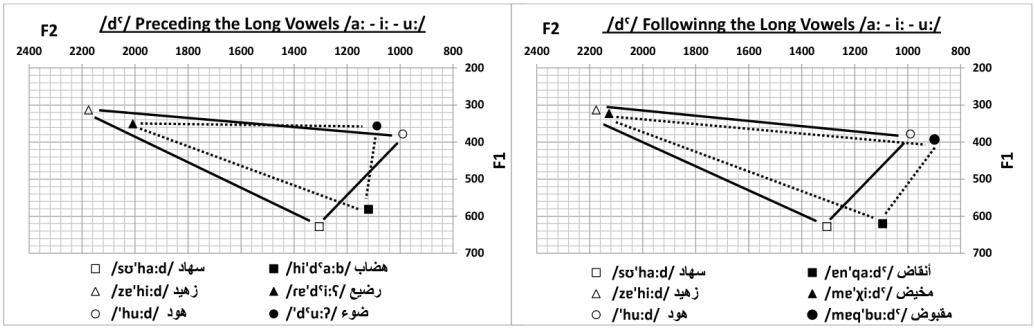

Figure 11. The long monophthongs /a:, i:, u:/ in 'preceding' and 'following' emphatic /dˤ/ contexts superimposed on Figure 10. The solid line triangle represents the MSA long vowel space and the dotted triangle represents the long vowel space in the emphatic /dˤ/ contexts

This study confirms the importance of F2 lowering more so than the F1 raising in the identification of the pharyngeal constriction. This finding has been corroborated by several previous studies on various Arabic dialects (e.g. Jongman et al. 2011; Khattab et al. 2006; Al-Masri & Jongman 2004; Watson 2002; Zawaydeh 1999; Watson 1999; Zawaydeh 1997 (only included the vowel /ɐ/ in her study); Davis 1995; Card 1983; Broselow 1976).

7. Conclusion

This study is part of a larger project on the influence of the four main emphatics in Arabic /tˤ, dˤ, ðˤ, sˤ/ on adjacent MSA vowels. Previous studies on the acoustics of emphasis have improved our understanding of the influence of emphatics. However, not all studies provide conclusive evidence; some studies investigated only one vowel (e.g. Zawaydeh 1997), others had a limited number of informants (e.g. Hassan (2005) had only two informants: a male and a female).

In the present study, the influence of /dˤ/ is investigated on the six MSA monophthongs. Many previous studies were concerned with the directionality of the spread of emphasis (as reported in Section 1). The present study investigates the vowel quality and vowel duration as factors on the extent of the emphatic consonant's influence. Additionally, the study looks at the directionality of emphasis on the tauto-syllabic vowel with the emphatic, namely, in contexts both 'preceding' and 'following' the vowels as produced by ten male speakers of Jordanian Arabic.

The findings here support previous studies that consider lowering of F2 of vowels adjacent to emphatics as the main acoustic correlate of emphasis (e.g. Jongman et al. 2011; Khattab et al. 2006; Al-Masri & Jongman 2004; Watson 2002; Zawaydeh 1999). Moreover, in terms of vowel quality, the clearest and most significant influence of retraction and lowering in the emphatic context was for the short vowel /ɐ/ followed by the short vowel /ɪ/. In terms of vowel duration, the long vowels showed retraction in the emphatic context but to a lesser extent than short vowels; mostly the long vowel /a:/ followed by the long vowel /i:/. Regarding the directionality of emphasis influence, the findings indicate that, in general, vowel retraction is evident in both 'preceding' and 'following' contexts. However, for the pair /u: – ʊ /, the retraction was only evident when /dˤ/ was 'following' these two high back vowels.

It is hoped that the present findings add to the increasing evidence from previous and current research on the phenomenon of emphatic consonants influence. Ongoing research will take into account the remaining three emphatics /tˤ, ðˤ, sˤ/ which will unfold a clearer understanding of the whole emphasis picture, particularly on the different MSA vowels. For future work, we aspire to add data from female Jordanian speakers in order to explore the gender sociolinguistic aspect of this phenomenon.

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