Acoustics of Emphatics and Uvulars in Bedouin Hijazi Arabic

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Abstract

The current study examines the effects of emphatics /ðˤ sˤ tˤ/ and uvulars /ʁ χ/ on following vowels in Bedouin Hijazi Arabic. The main goal is to observe F1 and F2 of vowels /i æ u/ next to the aforementioned sounds. The outcome of this study shows that F1 and F2 values next to emphatics and uvulars are reliable acoustic correlates. Emphatics and uvulars next to vowels increase F1 values, a pattern not noticeable in vowels next to plain sounds /ð s t/. Both groups also show lower F2 values compared to plain coronals. The size of F2 decrease, however, is lower in vowels following emphatics than vowels following uvulars. Differences in F2 values between these sound groups suggest differences in their articulatory mechanisms.

Keywords: emphatics, uvulars, acoustics, F1, F2

1. Introduction

Arabic dialects are well known for their emphatic sounds. Emphatic sounds in Arabic are a group of sounds that have a main primary place of articulation that involves the tip/blade of the tongue and a lesser point of constriction that involves pushing the tongue dorsum against the upper area of the oro-pharynx (Kahn 1975; McCarthy 1994; Ghazeli 1977). Emphatics /ðˤ, sˤ, tˤ, dˤ/[1] have non-emphatic counterparts /ð, s, t, d/ which have a similar coronal articulation point but lack the secondary constriction point.

Studies on emphatic sounds agree that there is a lesser point of articulation involving the dorsum of the tongue. Ghazeli (1977) reported a depressed tongue during the articulation of emphatics as opposed to non-emphatic consonants. In addition to depressed shape of the tongue dorsum, Ali and Danilof (1972) suggested that the tongue dorsum is retracted further back towards the posterior wall of the pharynx during the production of emphatic consonants.

Despite the agreement between studies regarding the occurrence of a secondary articulation in emphatic sounds, its exact nature is a point of debate. This debate is manifested in referring to emphatic sounds as pharyngealized in (Ali and Daniloff 1972; Gianni and Pettorino 1982), uvularized in (Zawaydeh 1999) and velarized in (Obrecht 1968)[2].

Uvulars /ʁ χ q/ were reported by Delattre (1971) to involve a constriction in the uppermost part of the pharynx. Similar results were reported by Ghazeli (1977) with the constriction being the narrowest during the articulation of /q/ because of the difference in the manners of articulation between the three phonemes.

Acoustically, emphatics and uvulars are reported to influence the formants of neighboring vowels. The salient effect of emphatics is a lower F2 value in vowels following emphatics compared to plain sounds (Obrecht 1968; Giannini and Pettorino 1982; Khattab et al. 2006; Bin-Muqbil 2006). F1 values have been reported to be raised by neighboring emphatic sounds, but not in all studies, see for example (Bin-Muqbil 2006).

Uvulars show a similar pattern of lowering F2 values in vowels. The main difference from emphatics is that F2 values drop lower in vowels in the context of a preceding emphatic compared to a preceding uvular. F1 values in vowels after uvular consonants show higher values compared to vowels after plain consonants (Ghazeli 1977; Obrecht 1968; Bin-Muqbil 2006).

The current acoustic study investigates the influence of Arabic emphatic and uvular consonants on following short vowels /i æ u/ in word initial position. This context is compared with formant values in vowels following plain coronal consonants in Bedouin Hijazi dialect. The analysis focuses on Bedouin Hijazi dialect spoken in the Hijaz in Saudi

[1] Arabic dialects differ in the number of emphatics they have in their phonemic systems.

[2] I use pharyngealization as the secondary articulation in emphatics in this study for simplicity.

Arabia. The study attempts to see if the effects of emphatics and uvulars on following vowels are consistent and can characterize the acoustic cues for emphatics and uvulars.

This study is triggered by the scarcity of works in Arabic phonetic studies that examine the acoustics of Bedouin dialects. Given the unique phonology of these sounds in Bedouin dialects, (see McCarthy 1994; Al Solami 2013), this study provides new insights into the mechanism of the retracted tongue during the articulation of emphatics compared to uvulars in Bedouin dialects.

2. Method

2.1 Stimuli

The target sounds occurred in CVC syllable, in which V is vowel /i æ u/, and the initial consonant belonged to one of emphatic sounds /tˤ, ðˤ, sˤ/, non-emphatic coronals /t, ð, s/ and uvulars /χ, ʁ/[1], as in Table 1. Every word of the stimuli was recorded in the carrier phrase [gil li _____ marrah θa:nijah] 'say to me ____ a second time' to avoid list effect. Each consonant is found word-initially. Each participant said every word three times. The total number of tokens was 72 for every participant (8 consonants x 3 vowels x 3 repetitions).

Table 1. Test words with vowels following emphatics, plain coronals, and uvulars

Vowel	Emphatic	Gloss	Plain coronal	Gloss
i	/tˤib/	'medicine'	/tib.nah/	'a hay'
æ	/tˤab/	'jumped'	/tæb.laʔ/	'you swallow'
u	/tˤʊb/	'jump!'	/tʊr.kija/	'Turkey'
i	/ðˤilf/	'hoof'	/ðib.na/	'we melted'
æ	/ðˤab/	'lizard'	/ðæb/	'ridiculed'
u	/ðˤulm/	'injustice'	/ðub.ba:n/	'flies'
i	/sˤim.na/	'we fasted'	/sib/	'curse!'
æ	/sˤab/	'he poured'	/sæb/	'cursed'
u	/sˤub/	'pour!'	/suk.kar/	'sugar'
		Uvulars		
	χ	**Gloss**	**ʁ**	**Gloss**
i	/χib.rah/	'experience'	/ʁit.rah/	'head cover'
æ	/χæm.ʃah/	'a scratch'	/ʁæb.nah/	'frustration'
u	/χuʃ.mi/	'my nose'	/ʁub.ʃah/	'early morning'

2.2 Participants

Data were gathered from 4 male speakers who speak Bedouin Hijazi Arabic. All participants are native speakers of the dialect and had no speech or hearing problems.

2.3 Recordings

All the recordings were made in a quiet room. Each participant spoke into a condenser microphone. The distance between the participant and the microphone was constant throughout the recording session. The sampling rate was 48 kHz with 16-bit quantization.

2.4 Measurements

The sound files from the recording sessions were imported into Praat (Boersma and Weenink 2022). Waveforms and wide-band spectrograms were used in the analysis. The measurements focused on F1 and F2 by generating LPC, linear predictive coding, as presented by Praat over an 18-ms Hamming window at the beginning of each vowel. Vowel onset was tied to the beginning of F1, and vowel offset by the weakening of formants in general, see Figure 1. The average of the repetitions of each participant is used in the data analysis.

[1] The emphatic /dˤ/ and the uvular /q/ are not found in Bedouin Hijazi.

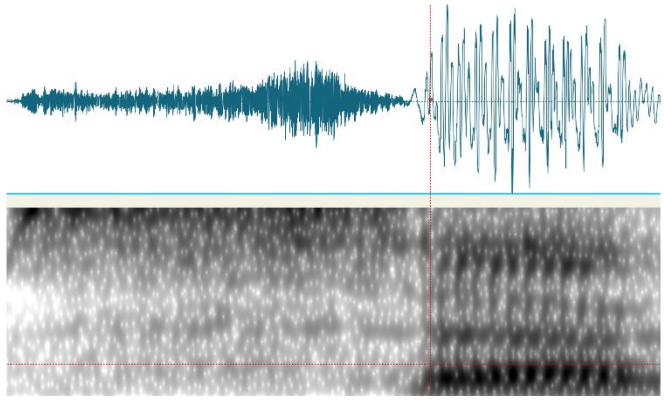

Figure 1. Cursor location at the vowel onset transition edge of token /sab/

3. Results

A two-way Repeated Measures Analyses of Variance (ANOVA) were conducted with Consonant Category and Vowel quality as independent variables for F1 and F2 values at the onset of each vowel in word-initial position.

3.1 Emphatics

As indicated by Figures 2 and 3, vowels following emphatics had higher F1 and lower F2 values compared to vowels following plain consonants. Statistically, F1 value in vowel onset in vowels adjacent to emphatics was significantly higher [$F(2, 6) = 63.8$, $p < 0.001$]. F2, on the other hand, was significantly lower coming after an emphatic sound [$F(2, 6) = 63.4$, $p < 0.001$]. As shown in Figure 2, F1 values were highest for vowel /æ/, while F2 drop was more salient in vowels /æ/ and /i/ than /u/.

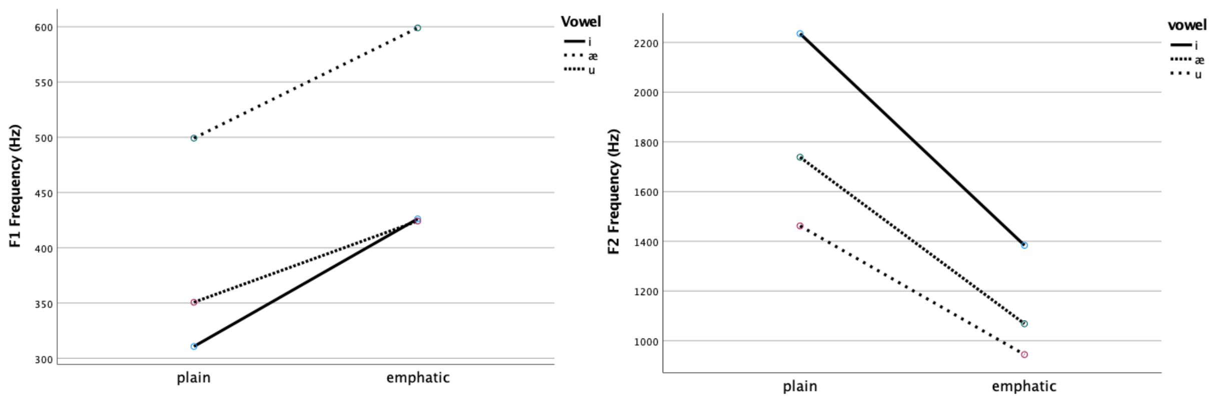

Figure 2. Formant frequency values measured at the onset of the vowel following a plain consonant and an emphatic

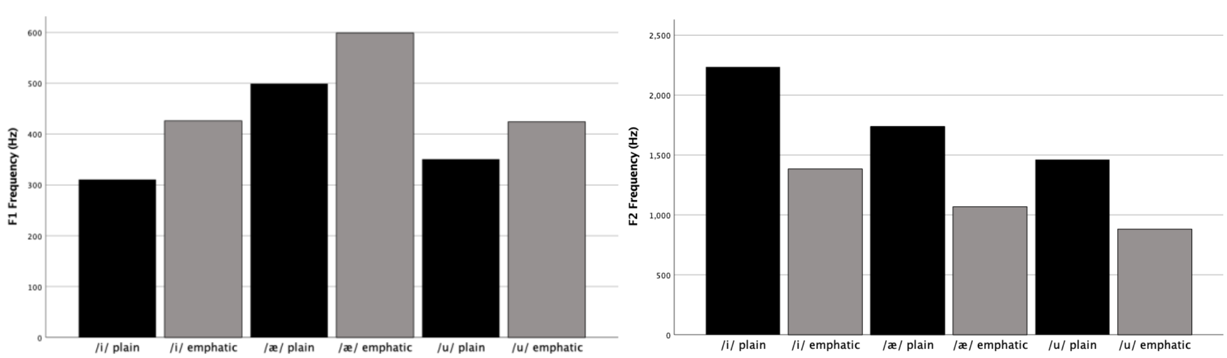

Figure 3. Differences in F1 (left) and F2 (right) for each vowel measured at the onset of the vowel after a plain consonant and an emphatic consonant

3.2 Uvulars

As indicated by Figures 4 and 5, vowels following a word initial uvular consonant had an increased value of F1 and a decreased value of F2 compared to vowels following non-emphatic consonants. Statistically, F1 in vowels adjacent to uvulars was significantly higher [F(2, 4) = 20.9, p=.008]. F2 was notably lower coming after a uvular sound [F(2, 4) = 45.6, p=.002].

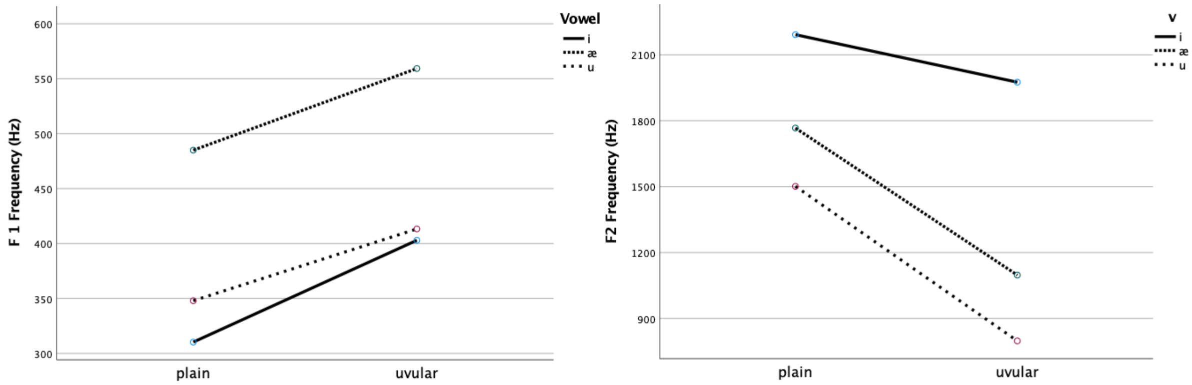

Figure 4. Formant frequency values measured at onset of the vowel following a plain consonant and a uvular

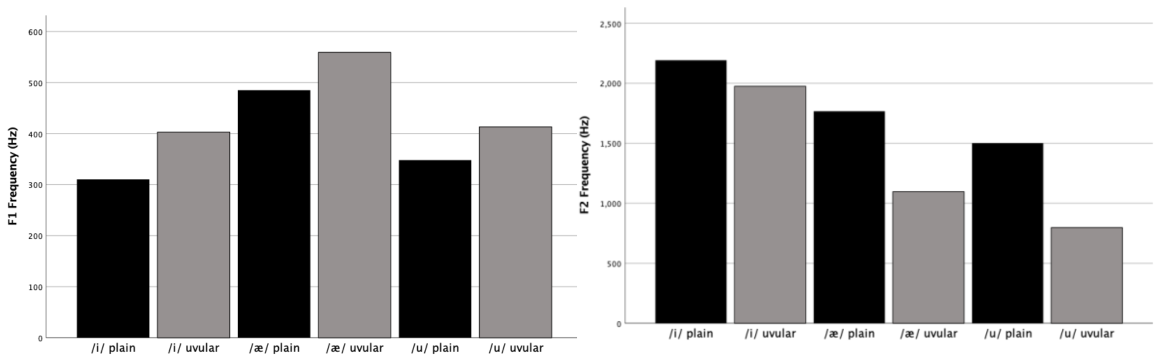

Figure 5. Differences in F1 (left) and F2 (right) for each vowel measured at onset of the vowel after a plain consonant and a uvular sound

As shown in Figure 6, the rise in F1 values is very similar in emphatic and uvular consonants. However, as indicated by Figure 7, the drop in F2 values is more salient in emphatics than in uvulars, except for vowel /u/ where uvulars showed the lowest F2 values.

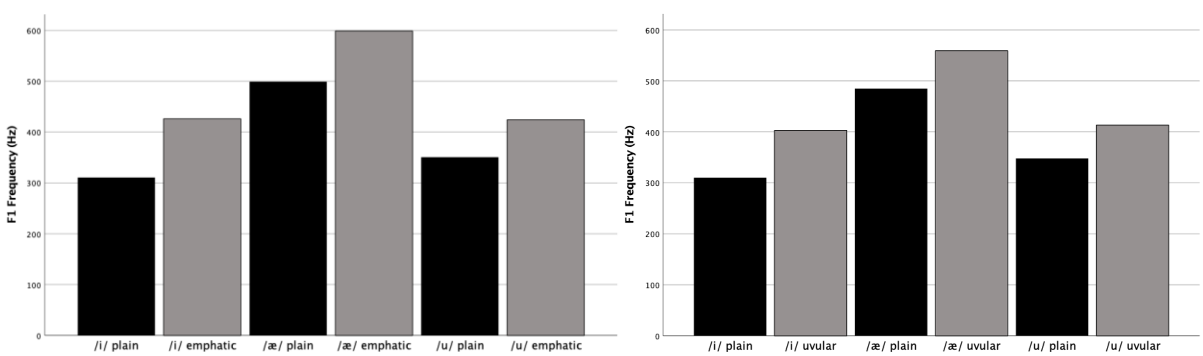

Figure 6. F1 values in emphatics (left) and uvulars (right)

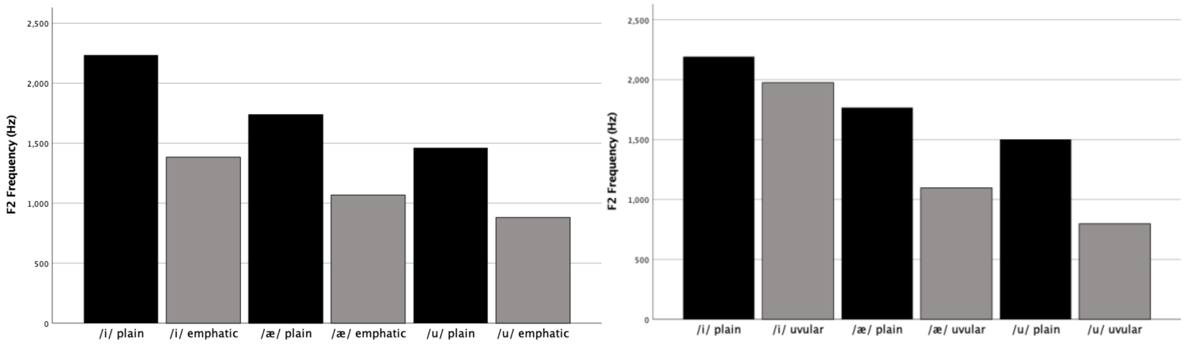

Figure 7. F2 values in emphatics (left) and uvulars (right)

4. Discussion

The results in Figures 2-7 show that F1 values in vowels after emphatics and uvulars are increased. Compared to plain coronals /ð, s, t/, emphatic sounds /ðˤ, sˤ, tˤ/ have low F2 values in following vowels. Al-Ani (1970) reported that emphatics cause F2 to drastically drop in following vowels. Obrecht (1968) indicated similar results in Lebanese Arabic. Similarly, uvulars /χ, ʁ/ have similar acoustic effect on vowels where low F2 values are observed. However, the drop of F2 values in vowels following uvulars is less than that in vowels following emphatics.

It is possible to explain high F1 values and low F2 values caused by emphatics and uvulars based on the resonance model of formants (Fant 1960; Pickett 1999; Stevens 1999). Based on this model, tongue height and root retraction influence F1 values. F1 values are higher when the tongue is lowered, and the pharyngeal area is decreased. Both emphatics and uvulars involve tongue retraction and tongue body lowering which explains the higher F1 values compared to plain consonants.

F2 values, on the other hand, are influenced by the point of constriction and the resulting vocal tract length from the constriction point to the lips. Accordingly, the shorter the tube in front of the point of constriction, the higher F2 values. It seems that the constriction point of emphatics is more backed in the vocal tract than uvulars, since F2 values in emphatics are lower than F2 values in uvulars.

Perturbation theory, (Chiba and Kajiyama 1958), provides a possible explanation to the patterns of F1 F2 values mentioned above. In this theory, nodes and antinodes influence formant values differently. A constriction point of a formant near an antinode lowers that formant, while a constriction near a formant node causes it to increase. Emphatics seem to have a lower constriction point compared to uvulars. This point of constriction is closer to F2 antinode, which causes a drastic decrease in F2 values in emphatics. Uvulars, on the contrary, have a constriction point higher than emphatics and not as close to the antinode of F2, which causes a limited decrease in F2 values in uvulars.

5. Conclusion

The paper aims to explore the phonetic properties of emphatic and uvular sounds in Bedouin Hijazi dialect by examining the onset transitions in vowels following these sounds and comparing them with vowels preceded by plain coronals.

Emphatics and uvulars show increased F1 values and decreased F2 values compared to plain coronals. Emphatics have lower F2 values than uvulars. This suggests that the tongue is retracted differently in these two groups. Emphatics seem to have a lower constriction point to uvulars.

This study could benefit from including speakers of different Arabic dialects. In addition, the analysis could include vowels preceding emphatics and uvulars and comparing the effect to vowels following these sounds. Gender is said to influence emphasis in some Arabic dialects, so it is another possible point that warrants more investigation (Wahba 1996, Khattab et al. 2006).

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No additional data are available.

References

Al-Ani, S. (1970). *Arabic phonology; an acoustical and physiological investigation*. The Hague: Mouton. https://doi.org/10.1515/9783110878769

Al Solami, M. (2013). Arabic emphatics: Phonetic and phonological remarks. *Open Journal of Modern Linguistics*, *3*(4), 314-318. https://doi.org/10.4236/ojml.2013.34040

Ali, L. H., & Daniloff, R. G. (1972). A contrastive cinefluorographic investigation of the articulation of emphatic-non emphatic cognate consonants. *Studia Linguistica*, *26*(2), 81-105. https://doi.org/10.1111/j.1467-9582.1972.tb00589.x

Bin-Muqbil, M. (2006). *Phonetic and phonological aspects of Arabic emphatics and gutturals*, Ph.D. Doctoral dissertation, University of Wisconsin.

Boersma, P., & Weenink, D. (2022). "PRAAT: doing phonetics by computer". Computer program, retrieved 27 November 2022, from http://www.praat.org

Chiba, T., & Kajiyama, M. (1958). *The vowel, its nature and structure*. Tokyo: Phonetic Society of Japan. (Originally published in 1941)

Delattre, P. (1971). Pharyngeal features in the consonants of Arabic, German, Spanish, French, and American English. *Phonetica*, *23*(1971), 129-155. https://doi.org/10.1159/000259336

Fant, G. (1960). *Acoustic Theory of Speech Production*, Mouton & Co., The Hague, The Netherlands.

Ghazeli, S. (1977). *Back consonants and backing coarticulation in Arabic*, Ph.D. Dissertation, University of Texas at Austin.

Giannini, A., & Pettorino, M. (1982). *The emphatic consonants in Arabic*: Speech laboratory report IV. Naples: Istituto Universitario Orientale.

Kahn, M. (1975). Arabic emphatics: the evidence for cultural determinants of phonetic sex-typing. *Phonetica*, *31*(1), 38-50. https://doi.org/10.1159/000259648

Khattab, G., Al-Tamimi, F., & Heselwood, B. (2006). Acoustic and auditory differences in the/t/-/t̲/opposition in male and female speakers of Jordanian Arabic. *Perspectives on Arabic Linguistics. Amsterdam, Benjamins*, 131-160. https://doi.org/10.1075/cilt.266.09kha

McCarthy, J. (1994). The phonetics and phonology of Semitic pharyngeals. In P. Keating (Ed.), *The phonetics and phonology of Semitic pharyngeals* (pp. 191–233). Cambridge University Press. https://doi.org/10.1017/CBO9780511659461.012

Obrecht, D. (1968). *Effects of the second formant in the perception of velarization in Lebanese Arabic*, Ph.D. Dissertation, University of Pennsylvania. https://doi.org/10.1515/9783111357393

Pickett, J. (1999). *The acoustics of speech communication: Fundamentals, speech perception theory, and technology*. Needham Heights, MA: Allyn and Bacon.

Stevens, K. N. (1999). *Acoustic Phonetics*, MIT Press, Cambridge, MA. https://doi.org/10.7551/mitpress/1072.001.0001

Wahba, K. M. (1996). *Linguistic variation in Alexandrian Arabic: the feature of emphasis* (pp. 103-125). Cairo: American University in Cairo Press.

Zawaydeh, B. A. (1999). *The phonetics and phonology of gutturals in Arabic,* Ph.D. dissertation, Indiana University.