LARYNGOSCOPIC (ARTICULATORY) AND ACOUSTIC EVIDENCE OF A PREVAILING EMPHATIC FEATURE OVER THE WORD IN ARABIC

Zeki Majeed Hassan [1] and John H. Esling [2]

[1] University of Göteborg, [2] University of Victoria
zekihassan_50@hotmail.com, esling@uvic.ca

ABSTRACT

The secondary place of articulation for Arabic 'emphatic' consonants varies across dialects. This study examines two speakers of Iraqi Arabic, using acoustic evidence, and one speaker of Iraqi Arabic, using direct visual laryngoscopic (articulatory) evidence, to determine the phonetic nature of the secondary feature and the prosodic effect of an emphatic consonant over multisyllabic words.

The acoustic and laryngoscopic evidence indicates that the prevailing nature of emphatics in Iraqi Arabic is pharyngealization. Furthermore, the effect of an emphatic spreads to all syllables, forwards or backwards, regardless of its position in the word, although the effect is modified or blocked in certain phonotactic conditions.

Keywords: Arabic, emphatics, pharyngealization, Iraqi, laryngoscopy.

1. INTRODUCTION

Although the phonetics and phonology of emphasis in Arabic have gained much attention in recent years, the earliest definitions of Arabic emphatic sounds go back to early Arab grammarians of the middle ages. In the 8th century Sibawayh classified them in his 'Al-Kitab' as 'al-huroof al-almutbaqa' which share the feature of 'itbaq'. Itbaq, according to Sibawayh, is the contact of the front part of the tongue with the front part of the palate while the back part of the tongue is raised towards the 'upper' part of the palate. This means that he recognized two articulations but did not specify their type [5]. More recently, Arab linguists have used the term 'al-huruuf al mufaxxama,' meaning 'heavy' or 'thick' sounds, a term which is acoustically and auditorily based [6]. It has been referred to by modern linguists as 'emphatic', 'velarized', 'uvularized' or 'pharyngealized' [11].

Abercrombie [1] specifies Arabic emphatic consonants as having a primary and a secondary articulation, e.g. in /seef/ 'sword' and /seef/ 'summer,' /s/ and /s/ share the same primary alveolar articulation, but /s/ is secondarily backed. Researchers have posited that emphatics are velarized [16]; uvularized in Jordanian Arabic [17]; or pharyngealized in Iraqi Arabic [3, 9]. It has also been unclear whether the coarticulatory effect of an emphatic consonant spreads beyond the emphatic and, if it does, what direction it takes, forwards or backwards. Another issue to resolve is whether the vowel or the consonant is the exponent of the emphatic feature, whether it is confined to either of them or if it stretches over the whole word. These issues are addressed in this research.

2. PHONETIC CUES TO EMPHATICS

2.1. Acoustic exponents of emphatics

Lowering of F2 is the most consistent acoustic exponent of emphatics reported for different Arabic varieties [8, 10, 4, 2, 14, 9, 6, 13]. But it has also been found that F1 and F2 may be closer to each other in vowels preceding or following emphatics rather than non-emphatics.

A raised F1 suggests a constriction in the post-uvular pharyngeal area, while an unchanged F1 suggests uvular constriction, and velar constriction would cause F1 to go down. However, this cannot be taken for granted because additional articulatory adjustments in the production of emphatics such as lip protrusion and tongue sulcalization [3] would enlarge the volume of the resonating chamber between the point of the secondary articulation and the lips, causing a lowering of all resonant frequencies. It is therefore unreliable to generalize formant patterns unless the vowels investigated are unrounded vowels with no tongue sulcalization for adjacent consonants.

As for F3, no conclusive findings have been reported to isolate the location of the secondary articulation or its coarticulatory effect on adjacent vowels. However, F3 lowering has been reported for pharyngealized vowels in some Caucasian

languages, which could be attributed to articulatory gestures other than in the pharynx [3, 9].

2.2. Articulatory exponents of emphatics

The articulatory exponents of the secondary articulation are more complicated to pinpoint, and it is possible that there is no consistent single articulatory exponent of emphasis but that speakers have a range of articulatory strategies at their disposal, including degree of constriction and larynx height. Each strategy will depend on several factors such as native dialect, phonological context, gender and social background.

Ali and Daniloff's [3] cinefluorographic study of Iraqi Arabic found emphatics to exhibit simultaneous slight depression of the palatine dorsum, a rearward movement of the pharyngeal dorsum towards the posterior pharyngeal wall, and a lowering velum towards a rising tongue dorsum. Although the data suggest pharyngealization, they do not exclude uvularization. Similar results are reported in Ghazeli's [8] cinefluorographic study of Tunisian. Al-Nassir's [5] x-ray study of Iraqi, Laradi's [12] videofluorographic and endoscopic study of Libyan, and Laufer and Baer's [13] endoscopic study have only been able to observe a rearward movement of the tongue root towards the back wall of the upper pharynx and a depression in the tongue dorsum. It has been claimed, however, that significant articulatory activity takes place beneath this point of upper stricture, so that the tongue is not the primary articulator responsible for the pharyngeal articulation but rather the laryngeal constrictor mechanism, which is responsible for raising the larynx and retracting the tongue and thus changing the volumes of the pharyngeal cavity [7]. One goal of the present study is to determine if this lower articulator is in fact active when vowels are in the vicinity of Iraqi Arabic emphatic consonants, which would account for the narrowed F1 and F2 observed acoustically.

2.3. Spreading domain of emphatics

As to the extent to which the emphatic feature prevails over the word, some studies have shown that it might prevail over several syllables. In Firth's prosodic analysis terms, the emphatic feature is considered a prosody which is best seen as extending over units which can encompass more than one segment. It is also necessary to determine whether the primary or the secondary articulation is assumed first (whether coarticulatory effect is progressive or regressive). Longer vowel durations before emphatics than non-emphatics is a suspected quantitative effect, which could possibly be attributed to the anticipated execution of the secondary articulation.

3. EXPERIMENTAL PROCEDURE

In this study, we reinvestigate the acoustic and articulatory exponents of the emphatic feature in Iraqi spoken Arabic (ISA) to confirm to what extent its effect prevails over a multisyllabic word containing only one emphatic consonant. Monosyllabic, bisyllabic and trisyllabic words were recorded by two native speakers of ISA to a PC using Speech Station 2 software with noise reduction. Each minimal pair has only one emphatic vs. non-emphatic consonant with front unrounded vowels. Rounded and back vowels are excluded to avoid interference with the back coarticulatory gesture of emphasis on the formants of neighbouring vowels. The words were spoken in the frame: /ikitbu __ sit mar'rat/ 'Write __ six times.' The minimal pairs were repeated six times in a continuous recording session. The two informants (male and female) are in their twenties, represent educated ISA, and have no history of speech disorders. The file was then transferred to Praat 4.2.2.1 (2004) for formant measurements.

Formant measurements are based on vocoid duration criteria and segmentation criteria [15]. Vocoid segments were identified by positioning a cursor at time points in the waveform as well as at onset and offset points of formant resonance frequencies on spectrograms. Both aspiration and affrication are excluded from the segment domain. After identifying the vocoid duration domain, values of F1 & F2 for each vocoid (e.g. V1, V2…) were calculated for six tokens; then F1 values were subtracted from F2 values for each token. Resultant values, indicative of the distance between F1 & F2 for the six tokens of the word, were then computed with the six tokens of its counterpart using a Mann-Whitney U test of significance. Average values of F2-F1 for each vocoid with their probabilities are tabulated in tables 1, 2 and 3. All the values are average values of the tokens of both informants (male and female). No measurements have been made for F3 as no conclusive findings have been seen in the literature to relate velo-pharyngeal constriction to F3 lowering.

To verify visually the place of articulation of the secondary feature, the same set of emphatics and

pharyngeals was observed and filmed using an Olympus ENF-P3 fibreoptic nasal laryngoscope attached to a Kay RLS9100 light source and three-chip Panasonic GP-US522 camera with a 28mm lens for optimal wide-angle framing of laryngeal mechanisms during varying prosodic conditions. Video recordings were captured directly to a Sony DCRTRV17 Mini-DV Digital Camcorder and postprocessed with Adobe Premiere 6.5 (30 frames/sec). In total, 72 words with emphatics and pharyngeals in strategically varying test positions were recorded laryngoscopically, synchronized with the acoustic signal for each word.

4. EXPERIMENTAL RESULTS

4.1. Acoustic data

Acoustic results for the emphatic/non-emphatic comparison show a consistently smaller difference between F1 and F2 for all vowels of words containing one emphatic consonant in any position, whether monosyllabic (table 1), bisyllabic (table 2) or trisyllabic (table 3). The only exception is a long final /ii/ vowel two syllables away from the emphatic. These findings indicate that not only does the syllable containing the emphatic have a greater degree of pharyngealization, but that the effect of the emphatic is spread over other syllables of the word progressively and, even more strikingly, regressively.

Table 1: Average values of measurements in Hz of F2-F1 of vowels in monosyllabic words with emphatic vs. non-emphatic consonants with *p* values (Mann-Whitney U test).

	Monosyllabic words	F2-F1	
		V	U-test (2t)
1	/seef/	1042	.002
	/seef/	1571	$p < .01$
2	/faad/	582	.002
	/faad/	896	$p < .01$

Further measurements in Hz were also made of vowels immediately following and preceding pharyngeals vs. emphatics. These results are not presented in detail here, but vowels surrounded by pharyngeals had higher F1 and lower F2 than those surrounded by emphatics. The implication is that pharyngeals as primary articulations demonstrate a stronger pharyngeal (laryngeal constrictor) effect than emphatics, which only employ the feature secondarily. It is still possible, however, taking the acoustic comparison with pharyngeals into account, that the emphatic consonants are showing a velarized or uvularized effect. To resolve this issue, visual laryngoscopic evidence is examined.

Table 2: Average values of measurements in Hz of F2-F1 of vowels in bisyllabic words with emphatic vs. non-emphatic consonants.

	Bisyllabic words	F2-F1	
		V1	V2
1	/ˈsaaʔib/	665	1492
	/saaʔib/	1492	1661
	U-test (2t)	.002	.04
		$p < .01$	$p < .05$
2	/ˈfaatir/	602	690
	/ˈfaatir/	840	1161
	U-test (2t)	.002	.002
		$p < .01$	$p < .01$
3	/ˈraakid/	747	898
	/ˈraakid/	824	1829
	U-test (2t)	.03	.001
		$p < .05$	$p < .01$

Table 3: Average values of measurements in Hz of F2-F1 of vowels in trisyllabic words with emphatic vs. non-emphatic consonants.

	Trisyllabic words	F2-F1		
		V1	V2	V3
1	/taˈbaaʃiir/	610	720	1818
	/taˈbaaʃiir/	988	850	1824
	U-test (2t)	.002	.009	.8
		$p < .01$	$p < .01$	$p > .05$
2	/faˈsaaʔil/	558	627	1643
	/faˈsaaʔil/	1008	931	1776
	U-test (2t)	.002	.002	.02
		$p < .01$	$p < .01$	$p < .05$
3	/faˈraaʔid/	536	500	806
	/faˈraaʔid/	695	683	1245
	U-test (2t)	.002	.002	.002
		$p < .01$	$p < .01$	$p < .01$

4.2. Articulatory (laryngoscopic) data

The laryngoscopic evidence shows a higher degree of stricture in the pharyngeal articulator throughout all syllables in words containing an emphatic, at points where F1 and F2 narrow acoustically as well as in other aspects of the articulation of the word, such as the propensity for other laryngeal sounds in a word (e.g. [ʔ]) to be more strongly articulated or for glottal stop to occur prosodically at the end of the word. An example of this word class is /faˈraaʔid/ ‘rituals’ (Fig. 2, video file 1), where the three classic components of laryngeal constriction (aryepiglottic sphinctering, tongue retraction, and larynx raising) are evident throughout the word, the medial /ʔ/ is more constricted than in the non-

emphatic context, and the final syllable is closed by [ʔ]. This contrasts with /fa'raaʔid/ 'valuables' (Fig. 3, video file 2), where the supraglottic space is more open, the tongue is not retracted into the pharynx, and the larynx is not raised, and /ʔ/ is less constricted. Certain segments (e.g. [i, ʃ) in the vicinity of emphatic consonants are observed to block or weaken the emphatic feature, consistent with findings of earlier studies [3, 6, 8].

Figure 1: Laryngoscopic orientation in the pharynx. P, posterior pharyngeal wall; A, arytenoids; C, cuneiform tubercles; VF, vocal folds; Ve, ventricular folds; AE, aryepiglottic folds; E, tubercle (base) of epiglottis.

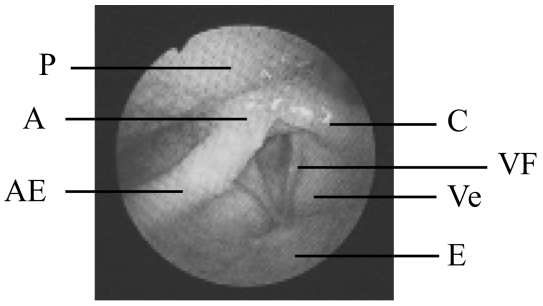


Figure 2: Laryngoscopic sequence of the pharyngeal gesture (start, middle, end) for the ISA word /fa'raaʔid/ 'rituals'.

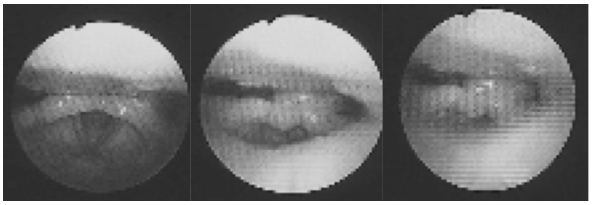
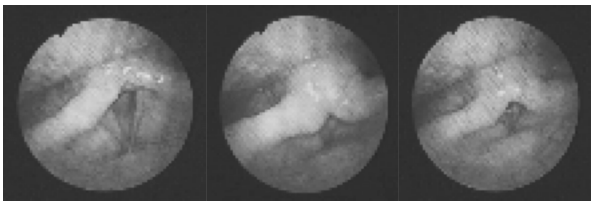


Figure 3: Laryngoscopic sequence of the pharyngeal gesture (start, middle, end) for the ISA word /fa'raaʔid/ 'valuables'.



5. FINDINGS

F1 and F2 show significant narrowing in vowels in the vicinity of emphatics, indicative of a retracting coarticulatory gesture. Laryngoscopic images showing aryepiglottic fold constriction, tongue retraction, and larynx raising (with resulting general pharyngeal narrowing) can be considered indicative of a pharyngeal coarticulatory gesture. There is a very good indication of a prevailing emphatic feature over bisyllabic and trisyllabic words in Iraqi Arabic, though in different levels of significance.

6. CONCLUSIONS

It is plausible to conclude that the phenomenon of 'emphatic feature' extends beyond the emphatic consonant and may well prevail over one, two, or three syllables, whether the emphatic is word-initial, word-medial or word-final. The articulatory, laryngoscopic evidence strongly suggests that the prevailing emphatic feature in Iraqi Arabic is pharyngealization rather than velarization or uvularization as reported by other researchers for dialects such as Jordanian or Moroccan Arabic. The findings also support the concept that anticipatory coarticulation is a language-specific phenomenon, implying that the secondary articulation is assumed prior to the primary one.

7. REFERENCES

[1] Abercrombie, D. 1967. *Elements of General Phonetics*. Edinburgh: Edinburgh University Press.
[2] Al-Ani, S. 1970. *Arabic Phonology*. The Hague: Mouton.
[3] Ali, L.H., Daniloff, R.E. 1972. A contrastive cine-fluorographic investigation of the articulation of emphatic-non-emphatic cognate consonants. *Studia Linguistica* 26, 81-105.
[4] Al-Masri, M., Jongman, A. 2004. Acoustic correlates of emphasis in Jordanian Arabic: preliminary results. *Proc. 2003 Texas Ling. Soc. Conf.*, 96-106.
[5] Al-Nassir, A. 1993. *Sibawayh the Phonologist*. London: Kegan Paul.
[6] Bukshaisha, F. 1985. *An Experimental Phonetic Study of Some Aspects of Qatari Arabic*. PhD, Univ. Edinburgh.
[7] Esling, J.H. 2005. There are no back vowels: the laryngeal articulator model. *Cdn. J. Ling.* 50, 13-44.
[8] Ghazeli, S. 1977. *Back Consonants and Backing Coarticulation in Arabic*. PhD, Univ. Texas at Austin.
[9] Giannini, A., Pettorino, M. 1982. The emphatic consonants in Arabic. *Speech Laboratory Report IV*, Istituto Universitario Orientale di Napoli.
[10] Heselwood, B. 2007. The 'tight approximant' variant of the Arabic 'ayn. *JIPA* 37, 1-32
[11] Jakobson, R. 1957. Mufaxxama – the emphatic phonemes in Arabic: synchronic and diachronic aspects. In: Pulgram, E. (ed), *Studies Presented to Joshua Whatmough*. The Hague: Mouton, 105-115.
[12] Laradi, W. 1983. *Pharyngealisation in Libyan (Tripoli) Arabic*. PhD, Univ. Edinburgh.
[13] Laufer, A., Baer, T. 1988. The emphatic and pharyngeal sounds in Hebrew and Arabic. *Lang. & Speech* 24, 39-61.
[14] Odisho, E. 1973. The role of the rear section of the vocal tract in Baghdadi Arabic. MPhil, Univ. of Leeds.
[15] Peterson, G., Lehiste, I. 1960. Duration of syllable nuclei in English. *JASA* 32, 693-703.
[16] Trubetzkoy, N. 1969. *Principles of Phonology*. Berkeley: University of California Press.
[17] Zawaydeh, B. 1998. Gradient uvularisation spread in Ammani-Jordanian Arabic. In: Benmamoun, A., Eid, M., Haeri, N. (eds), *Perspectives on Arabic Linguistics 11*. Amsterdam: John Benjamins, 117-141.