



## TOWARDS AN ACOUSTIC-PHONETIC CLASSIFICATION OF MODERN STANDARD ARABIC VOWELS

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### ABSTRACT

As part of an investigation of the coarticulatory influence of "lingual" consonants on the quality of adjacent vowels in MSA, measurements were made of F1 & F2 of all the vowels in CV-structure real words pronounced by native Arabic speakers from different countries. It was found that F1 in vowels preceded by interdental, dentals, palatals and post-palatals was lower than that in vowels preceded by emphatics, velars, uvulars and pharyngeals. F2, however was found to be higher in vowels following interdental, dentals, palatals and postpalatals than in those following emphatics, uvulars and pharyngeals. Based on these findings, a binary classification of MSA vowels is proposed in terms of the correlation between tongue movements and acoustic-phonetic variance.

**Keywords:** Fronted, Backed, Acoustic-phonetic Binary classification.

### 1. INTRODUCTION

The vocalic system of MSA is an interesting field of research from the point of view coarticulation given the high number of consonants it contains (28 consonant phonemes). The fact remains however, that only few analysts have studied this issue [1,2,3,4, 5]. The lack of systematic studies in this domain is probably due to the once overwhelming influence of the phonological approach which has it that the system of MSA contains only 3 short vowels /a, i, u/ and 3 long vowels /a:, i:, u:/. In the present study, we aimed at establishing an acoustic-phonetic classification of the MSA vocalic system on the basis of acoustic invariants, mainly F1 and F2 of all the vowels in CV-structure real words.

### 2. PROBLEM

A difficult choice to make for anyone wanting to study acoustic vowel data is whether to proceed from acoustics to articulation [6, 7, 8] or from articulation to acoustics [9, 10, 11, 12].

More considerable attention has been devoted, however to the study of the vocal tract configuration as the primary factor determining the identity of speech sounds [13,14].

It has been claimed that the tongue is the most important articulator in speech production, as it seems this organ is neuro-motorically coordinated in its backward and forward movements [11,12,13,14].

Based on the movement of the tongue in consonant production, we investigated some acoustic-phonetic properties of Arabic vowels in contact with each of the coronal and velo-pharyngeal consonants of MSA. Vowel quality in a glottal environment was taken as a reference because the glottals /h/ and /ʔ/ have no significant impact upon vowels (15, 16). It may be argued however, that the reference should be the vowel quality in an isolated context. We did not choose to do this solution because in MSA, vowels alone have no psychological reality as they cannot occur in isolation [17]. We hoped, moreover that these results would provide the basis for a more general account of the diverse findings obtained with other languages.

### 3. EXPERIMENT

**Methods:** Each of the 6 MSA vowels /a, i, u, a:, i:, u:/ was combined with all the lingual consonants in CVCV:CVC structure real words, where the onset of the second syllable was a labial or a dental. The test words were inserted in a frame sentence /qa:la [CVCV:C] marratan/ (He said [...] once).

A pseudo-random list was prepared containing other words which were inserted in the same frame sentence to distract attention from test items. Three native Arabic speakers from Algeria, Morocco and Tunisia were asked to read the data at a comfortable rate and loudness.

The subjects were asked to repeat the sentence if they judged it necessary. The recordings were made in a quiet

booth on a Revox 72 via a professional microphone set at 40 cm from the subject. Wide-band spectrograms were made of each test item on a MacSpeech Lab program (Laboratory of Phonetics Paris VII). The sampling frequency was set at 10 KHz and the measurements were done at the steady part of the vowel formant.

#### 4. RESULTS AND DISCUSSION

As can be seen from figure 1 and figure 2, interdental, dentals, palatals, postpalatals exhibit a lowering effect on the F1 of all the vowels (henceforth G1); emphatics, velars, uvulars, and pharyngeals have a rising effect on the F1 of all the vowels (G2). By contrast, the second formant of all the vowels were found to be higher in vowels preceded by interdentals, dentals, palatals and postpalatals (G1) than in vowels preceded by emphatics, velars, uvulars, and pharyngeals (G2).

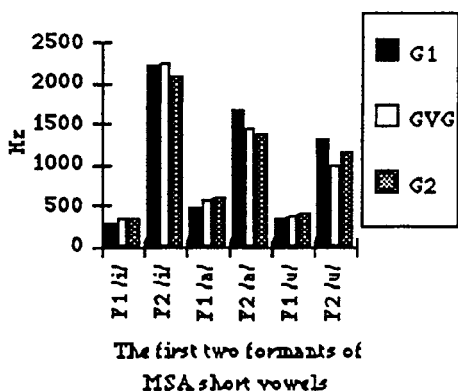


Figure (1). Means of F1 & F2 of the /i, a, u/ in contact with interdentals, dentals, palatals and postpalatals (G1), velars, uvulars, pharyngeals and emphatics (G2) and glottals (GVG).

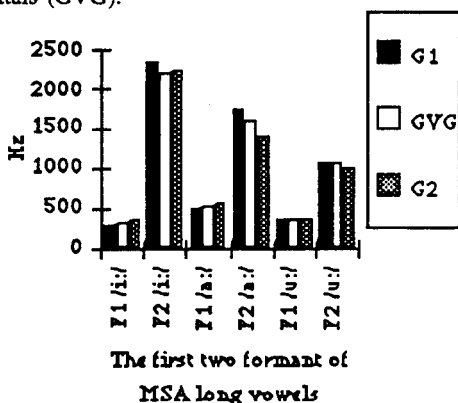


Figure (2). Means of F1 & F2 of /i:, a:, u:/ in contact with interdentals, dentals, palatals and postpalatals (G1), velars, uvulars, pharyngeals and emphatics (G2) and glottals (GVG).

In order to assess whether the difference between G1 and G2 was significant or not, means of F1 and F2 values of the three subjects were calculated and submitted to a two-tailed t-test. It turned out that the

two groups differed significantly ( $t(2) = 6,94; p < .001$  for F1 and  $t(2) = 2,06 p < .05$  for F2).

The results of this study should allow us to draw certain conclusions regarding the influence of consonants on vowel timbres. The main finding may be stated as follows: MSA vowels are better apprehended within the framework of a binary classification with G1 vowels labelled as *fronted vowels* and G2 vowels as *backed vowels*. Vowel fronting and backing are of course, relative to the vowel formant values in a glottalic environment which has no influence on vowel quality. In the Table1, the two groups of vowels are shown as function of permeability to environning consonant effects.

	vowels	Nature of the environning consonant	Effect on vowel quality
G1	i: a: u:	Interdentals dentals palatals post-palatals	F2 higher / Fronted F1 lower / vowels F1 is less close to F2
	i a u		
G2	i: a: u:	velars-uvulars pharyngeals emphatics	F2 lower / Backed F1 higher / vowels F1 is closer to F2
	i a u		

Table1: The acoustic-phonetic classification of MSA vowels

#### 5. CONCLUSION

In this paper a new binary classification of MSA vowels has been introduced. It appears that in MSA, vowels in contact with lingual consonants are either fronted or backed depending on the place of articulation of the environning consonant. Added to what we already know about coarticulation in speech production (18, 19, 20, 21, 22, 23, 24, 25, 26, 27), our preliminary results should allow us to draw certain conclusions as to the universal and language dependent lingual coarticulatory patterns concerning the influence of consonants on vowel timbres. Neural commands for the vowel and the following consonant may be consecutive but the overlap in adjacent segment is inevitable since the articulators cannot move instantaneously from one configuration to another. (28]

Further study is planned, in which the perceptive relevance of the binary classification proposed here will be investigated.

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