The status of vowels in Jordanian and Moroccan Arabic: Insights from production and perception.

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Introduction

- Vowels in isolation are often considered as the canonical form of a vowel. (Joos 1948, Ladefoged 1967 & Daniloff & Hammerberg 1973),
- But some researchers considered them as *'laboratory artefacts'* (Liberman & al. 1967 & Liberman 1970): a) generally, they 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,
- So, in different perceptual experiments, isolated vowels were discarded, and dynamic information was considered useful to have more natural stimuli and to help auditors in identification ~ discrimination tests.
- Different authors described isolated vowels as completely different from those produced in context, so they concluded that indices used by auditors to identify vowels (in isolation and in context) are different. (Fairbanks & Grubb 1961, Fujimura & Ochiai 1963, Lehiste & Meltzer 1973, Strange & al. 1976, 1983, 1989, etc.).

What about vowels in Arabic?

- Arabic grammarians described vowels as: a) sounds included in consonants and/or b) a facilitator of consonant production, so…
- Vowels never occur in isolation, they must be associated to consonantal environment to be produced, this can be explained by the morphological structure of Arabic, (A nonconcatenative language with a triconsonantal root, that exhibits direct consonant~consonant relation),
- Some verb categories are marked by a systematic alteration of vowel qualities, without any modification in the consonantal root. Ex. '***K T B'*** → [kaːtib] 'writer', [kitaːb] 'book', [maktaba] 'library',

(Sibawayh VIIIth century, Ibn Jinni Xth century, Cantineau 1960, Mehiri 1973, BenKiran 1982, McCarthy 1982, Ibrahim 1997, among others).

Goals of this research

1. The characterization of the variation, in both production and perception of speech in (and within) 2 Arabic dialects: Jordanian Arabic (JA) and Moroccan Arabic (MA),
2. The characterization of static and dynamic cues in production and perception of Arabic vowels,
3. To study the status of vowels in Arabic dialects.

Discussion & conclusion

In this work, we studied the variability in both production and perception of speech in JA and MA dialects. Results show that:

- Both in JA and MA, there is no significant difference between the production of vowels in Word and in Syllable, but a very significant one when compared with Isolated vowels,
- Both in JA and MA there is more variability in the production of vowels in Isolation, than when produced in Word or Syllable,
- In production, JA long vowels are more peripheral than those of MA (figures from 1 to 4), but no difference in perception (figures 5 & 6)
- In both production and perception, MA /ɔ u/ merge (figures 2, 4 & 6),
- JA and MA auditors found the perceptual experiment (figures 5 & 6) very difficult and caused a high degree of variability in the acoustic plan (that can be explained by the fact that isolated vowels *may* not exist in Arabic).

To characterize the importance of dynamic cues (in comparison with static ones), a new perceptual task was elaborated. The results displayed in figures 7 to 10 show less variability in the dynamic task than in static one, and auditors found the new task easier.

In production, a Delta Average calculation served to characterize the formant trajectories. Graphics (from 11 to 14) show that even in isolated vowels, formant trajectories do change over time.

Theses results indicates that dynamic cues (in both production and perception) may be taken into consideration to describe Arabic vowels, but experimentations with more consonantal context and more speakers are needed to characterize the vowel status in Arabic.

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Results

1.Production

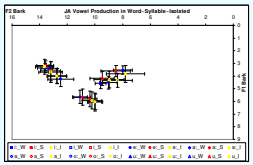

Figure 1: JA vowel production.

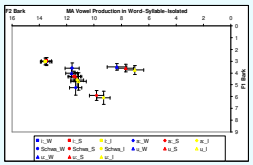

Figure 2: MA vowel production.

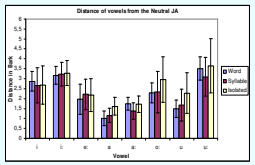

Figure 3: Distance of JA vowels in production to characterize the variation.

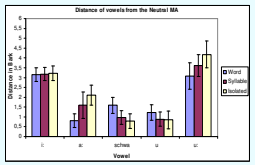

Figure 4: Distance of MA vowels in production to characterize the variation.

2.Perception

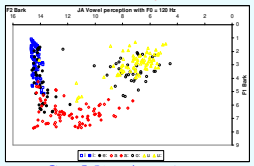

Figure 5: JA vowel perception.

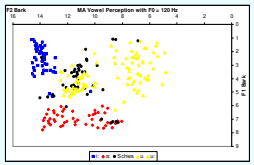

Figure 6: MA vowel perception.

We have applied different statistical analysis on the data. The table indicates when differences were significant. (-) indicates that statistical analysis were not conducted due to number of repetitions or speakers, or non comparable data.

Paradigms	experience	Variable	JA	MA
Paradigm A	Production	Word vs. Syllable	n.s	n.s
		Syllable vs Isolated	0,0001	0,001
		Word vs. Isolated	0,0002	0,0067
		JA vs. MA	0,0006	-
	Perception	Isolation	-	-
		JA vs. MA	n.s	-
Paradigm B	Perception	Static vs. Dynamic	n.s	n.s

Paradigme A

Paradigme B

1.Static

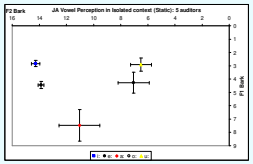

Figure 7: JA vowel perception (static task).

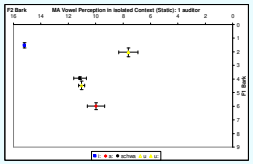

Figure 9: MA vowel perception (static task).

2.Dynamic

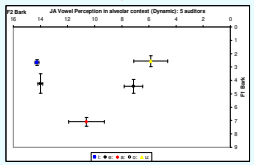

Figure 8: JA vowel perception (dynamic task).

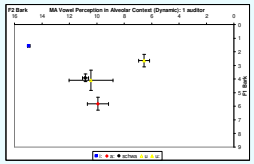

Figure 10: MA vowel perception (dynamic task).

Long-Term Average Variation in Production (Delta Average)

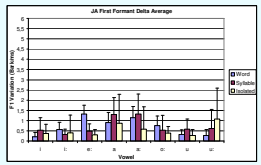

Figure 11: JA Delta Average for F1.

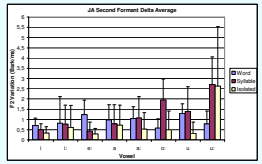

Figure 12: JA Delta Average for F2.

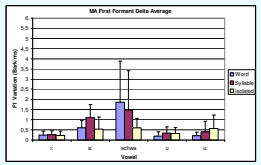

Figure 13: MA Delta Average for F1.

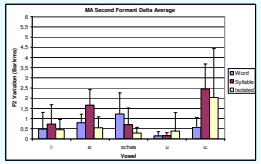

Figure 14: MA Delta Average for F2.

Methodology

- In paradigm A:
  - 10 speakers in both JA and MA were recorded in 2 experimental protocols, in production and perception of speech,
  - In production, speakers recorded vowels (/i iː eː a aː oː u uː/ in JA and /iː aː ə u uː/ in MA), as produced in word, syllable and in isolation, in alveolar context (non pharyngealised),
  - In perception, the same speakers categorized vowels in a F1/F2 synthetic plane, based on a MOA Model (Method of Adjustment, Johnson & al. 1993)
- In paradigm B:
  - 5 auditors from JA and 1 from MA, categorized vowels in a static (static formant values + F0) and dynamic (static values + F0 + Duration + Dynamic information = onset of alveolar consonant) F1/F2 synthetic plane.

Recording & Acoustical Analysis

- Speakers were recorded in an attenuated room, and vowels were digitized at 22 KHz, 16 Bits, Mono.
- Recording of 8 JA and 10 MA (2 JA speakers were discarded because of saturation in the signal), were analyzed using Praat and Akustyk.
- LPC acoustical analysis were conducted on vowels produced in word, syllable and in isolation, with a 25 ms Hamming window, 10 coefficients. Formant values were taken at the mid of the static portion of vowel. Onset and offset were taken at respectively the first and final pulses,