Analyze effects of the flow on the vocalic reduction and the coarticulation in sequences CV of pharyngal Arabic

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Abstract

The degree of coarticulation and the vocalic reduction (RV) are indices related to a good engine control (Gay 1978). Fowler (1998) explains why locus equation (LE) is used to characterize, at the same time, the place of articulation and the degree of coarticulation between consonants and vowels: a strong slope (m = 1) indicates a maximum coarticulation between consonants and vowels (i.e. minimal resistance of the coarticulation), while a weak slope (m = 0) indicates absence of coarticulation between consonants and vowels (maximum resistance of the coarticulation).

The bond between the degree of coarticulation and the RV can be explained according to the linear relation between F2onset and F2milieu: the modifications of values of F2milieu will affect those of F2onset and consequently those of the slopes of. In this study, the analysis of the vocalic reduction and slopes of the equations of locus, carried out on CV (extracts starting from sentences) in standard Arabic pronounced by speakers having different mother tongues (near to Arabic standard and very far away from standard Arabic), and at speed of variable elocution, revealed a vocalic reduction and a variation of the slope of the locus equation, specific to each speaker, who seems to be related to his mother tongue.

1 Introduction

The bond between the degree of coarticulation and the RV can be explained according to the linear relation between F2onset and F2milieu: the modifications of values of F2milieu will affect those of F2onset and consequently those of the slopes
In this study, we analyzed of the CVC taken in sentences which are an expression of classical Arabic and not of dialectical Arabic so that there is no difference between the speakers on their origins (classical Arabic being a language learned for the three speakers).
Being given that Classical Arabic is not a mother tongue and considering that locus equation appears as of coarticulation emergence with first words appearance, around one year (Sussman et al... [1]), it is possible to detect differences of coarticulation by integrating speakers resulting from areas different from Arab speech. Our assumption is that Arabic-speaking speakers originating in different countries will present different locus equations
To highlight the degree of coarticulation and vocalic reduction, we used the constraint of flow. Indeed, the studies disturbing word constitute major elements in comprehension of engine control [7]. The goal of speech disturbance is to highlight compensatory phenomena which emerge in condition of constraint on articulatory and acoustic level for speech production
It is then a question of analyzing on the one hand:
Variation of vowels formantic values (F1 and F2) of Arabic /a /, /i /, /u/ according to consonant context and of flow to highlight vocalic reduction related on elocution flow and consonant context for each speaker,
In addition, to plot the straight lines of locus, to analyze impact of flow on slope and ordinate in beginning, in order to emphasize coarticulation degree for each speaker in constraint of flow and consonant context.

2 Methodology

We use flow as research paradigm, applied to a corpus of Arabic sentences.
Corpus sentences are an expression of classical Arabic and not in dialectical Arabic so that there is no difference between speakers on plan of his origins (classical Arabic being a language learned for the three speakers, let us note that for CH classical Arabic is very close to his mother tongue). All three speakers are students.

These different speakers by their mother tongue are:

- CH is Lebanese, witch Arab mother tongue approaching much classical Arabic, alive in Lebanon.

- FE is coming from Algiers, witch mother tongue: of Algiers dialect not very close to classical Arabic, alive in Algiers
- SA is Kabyle; witch mother tongue is Kabyle and living in Tizi Ouzou. He learned Arabic language at school for the first time.

2.1 Characteristic of corpus sentences

The sentence are interrogative, so that speaker keeps a certain naturalness while speaking and especially by changing flow.
Sentences contain specific fricative one to Arabic: /ʕ / (/ع/); in order to put the speaker in consonant context of Arab language. Also let us note that this fricative formed part of the of Algiers alphabet Kabyle and dialect

For more facility in writing, we will represent:

/ʕ / (/ع/ by **/a_/;**
The sentences are 3. Sentence containing the fricative one combined at three different times:

/ men saa_ala ? / ; / men saa_ila ? / ; / men saa_ula ? /

2.2 corpus sentences

It is consisted of the 3 preceding sentences(in three vocalic context) called with 10 repetitions by each speaker, in three different flows: flows: normal, fast, slow.

3*10*3=90 sentences for one speaker

Recording Conditions

Sentences corpus were recorded in soundproof room of acoustics laboratory of our electronics faculty, on a PC (P4), provided with a chart its of type sound Blaster, using professional microphone.
One period of training was allocated with each speaker in order to roughly obtain the same flow for the three speakers.

2.3 Speech analyzed units

It acts of units /CjVil /, VI are three vowels of Arabic speech

(i=/a/, /i/, /u/) , in consonant context

/Cj/: j=/a_/ for itch speaker

/a_al/, /a_il/,/a_ul/.

To obtain these various units, we manually segmented corpus sentences, while basing ourselves on the acoustic signal and the spectrogram, using Praat software.

3 Acoustic analyses of Arabic vowels Vi (i=/a /, /i/,/u/) of units /CjVil /, in flow constraint.

Perkell et al.. (2000)[2] add in their theory of speech production on auditive basis goal, they mention that articulatory dimension is governed unconsciously by speaker: Degree of speaker articulation given under a condition of speech given varies between its desire to obtain best possible acoustic contrasts, and thus best possible articulatory contrasts, and its will to minimize its articulatory owners from point of view of saving in efforts (figure1 perkell 2000[2]). It is on this axis that flow plays a very important part.

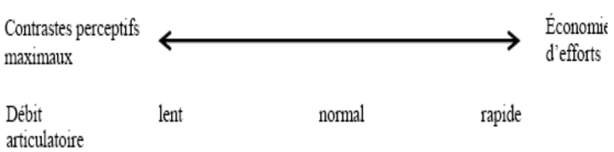


Fig 1.Speech production axis with flow constraint

That wants to say that in vocalic constraint situation, space varies compared to occupied vocalic space in normal flow. The goal is to know if all speakers make the same vocalic reduction or then, each speaker will have his own strategy of vocalic reduction, which will be related to its way of spoken. This way of speaking is without any doubt related to its training of speech, therefore of its mother tongue. What will have in theory an influence on locus equation being given that latter is built starting from second formant values in transition between vowel and consonant for what concerns us

3.1 Method principle

3.1.1 Methodology used for vocalic reduction study

We traced dispersion ellipses in plan (F1, F2) for three Arabic vowels, for each speaker, and each elocution flow, and then we analyzed ellipses variation under each condition.

3.1.2 Layout of dispersion ellipses

We traced dispersion ellipses in (F1, F2) plan for vowels /a /, /i /, /u /, for speech units considered, according to context consonant /a _ /, which gives: /a_al /, /a_il/, /a_ul/; for three elocution flows, for each speaker.
Results obtained are illustrated by figures hereafter. For each vowel, we have three ellipses corresponding to three flows: in blue: normal flow; in red: slow flow and in black: fast flow

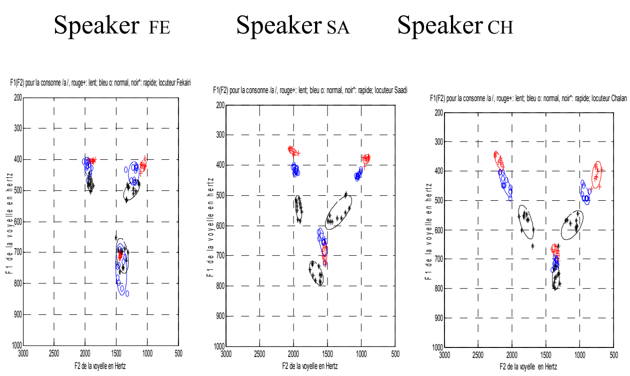


Fig 2. Dispersion ellipses variation to each speaker, and each flow. In blue: normal flow; in red: slow flow and in black: fast flow

- By looking at dispersion ellipses, we notice indeed that they all are almost superimposed for same vowel according to flow. So, there is no variation with flow for vocalic space for FE. What joined Gay theory

- Dispersion ellipses of CH on other hand almost all are disjoined and move towards center of space (F1, F2). That wants to say that vocalic space changes with flow. This joined Gay theory taken in assumption.
- SA , on the other hand, is between the two speakers.
There are disjoined ellipses and others not. Thus for moment we cannot allot a strategy to him. To arrive at more quantitative results thus more concrete, it would be interesting to compare surfaces of vocalic triangles according to flow in order to see whether there is variation of vocalic space with flow and this for each speaker.
From the preceding dispersion ellipses, we traced for each flow, the lines joining centers of dispersion ellipses (correspondents to formants averages F1 and F2). We obtained three vocalic triangles thus corresponding to each elocution flow. Results obtained are illustrated by the following figures:

For fricative /a_ /

Speaker FE Speaker SA Speaker CH

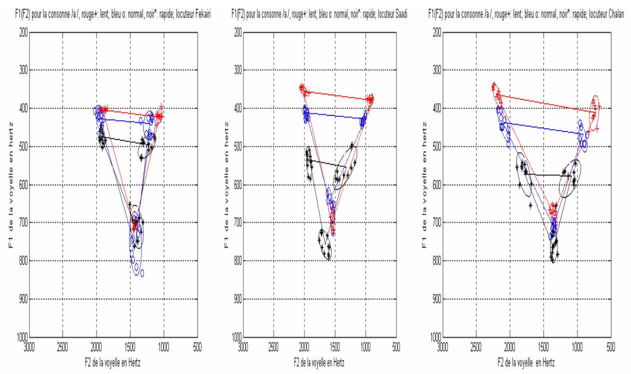


Fig 3. Vocalic triangles layout starting from dispersion ellipses, flow for each speaker. In blue: normal flow; in red: slow flow and in black: fast flow

Résultats obtenus pour les surfaces des triangles vocaliques

NORMAL FLOW

For mants	F1a	F2a	F1i	F2i	F1u	F2u	Aire en Hz2
speaker	**consonat /a_/**						
FE	754,5	1420,7	424,8	1956,2	444,9	1216,5	**1.1656e+005**
CH	715,2	1354,9	443,2	2096,3	480,5	915,1	**1.4699e+005**
SA	652,9	1571,5	415,6	1971,2	432,1	1040,8	**1.0709e+005**

FAST FLOW

	Fast flow						
Form ants	**F1a**	**F2a**	**F1i**	**F2i**	**F1u**	**F2u**	**Aire en Hz2**
speaker	**Consonant /a_/**						
FE	710,9	1402,1	476,9	1919	498,7	1250,5	**7.2580e+004**
CH	763,6	1350,4	573,6	1791,6	584,6	1110,3	**6.2297e+004**
SA	736,363	1600,81	540	1839,9	554,09	1304,182	**5.0913e+004**

SLOW FLOW

	Slow flow						
For mants	**F1a**	**F2a**	**F1i**	**F2i**	**F1u**	**F2u**	**Aire en Hz2**
speaker	**consonant /a_/**						
FE	707,4	1433,8	400,4	1889	420,7	1066,1	**1.2169e+005**
CH	674,4	1353,8	365,9	2193,4	413,2	748,1	**2.0308e+005**
SA	691,9	1537,2	353,5	2010,6	379,9	923,4	**1.4686e+005**

Table 1. Vocalic triangles areas calculation according to consonant context and speaker and flow

For speakers CH and SA : Vocalic triangles areas decrease with elocution speed, however CH present of greater vocalic triangles areas variations than SA and has area more important.

For speaker FE : According to these results, roughly the three speakers vary their vocalic spaces with flow. What let us can conclude itself from it?

Lane et al... [4] and more other authors noticed that size of vocalic spaces was reduced in event of speech disturbance. However, a study concerning the influence of flow on vocalic triangle in neutral word [5], shows that formants tend towards a central vowel for segments of short duration. A major difference exists between neutral case and other expressivities: The degree of articulation is not only any more depend on the variable flow.

4 Calculation of formants variations F1 and F2 according to elocution flow

The following tables illustrate average values of F1 and F2 of each vowel VI (i=/a /, /i /, /u/) , for each speaker, in unit /CjVil/: /a_al /, /a_il/, /a_ul/

Abbreviations were allotted for:

F1N, F2N : formants F1 and F2 in normal flow

F1L, F2L : formants F1 and F2 in slow flow

F1R, F2R : formants F1 and F2 in fast flow.

4.1 Results interpretation

We note that when flow is increased, speaker:

CH : Centralize much for vowels /i/ and /u/ But does not centralize for /a/

SA: always centralize in fast flow for /i/ and /u/ (but less than CH), but not for /u/.

In slow flow for /i/ and /u/ (but little),

But does not centralize for the /a/

FE: Don’t centralize for /a/.

Centralizes only for /u/ in slow flow

Centralise for /i/ and /u/ in fast flow (but very little, even less than SA)

SPEAKER FE						
/ a_ /						
	F1N	**F2N**	**F1R**	**F2R**	**F1L**	**F2L**
/a/	754,5	1420,7	710,9	1402,1	707,4	1433,8
/i/	424,8	1956,2	476,9	1919	400,4	1889
/u/	444,9	1216,5	498,7	1250,5	420,7	1066,1

SPEAKER SA						
/ a_ /						
	F1N	**F2N**	**F1R**	**F2R**	**F1L**	**F2L**
/a/	652,9	1571,5	736,3	1600,81	676,5	1487,18
/i/	415,6	1971,2	540	1839,9	368,9	1917,5
/u/	432,1	1040,8	554,09	1304,18	392,9	929,18

SPEAKER CH						
/ a _/						
	F1N	**F2N**	**F1R**	**F2R**	**F1L**	**F2L**
/a/	715,2	1354,9	763,6	1350,4	674,4	1353,8
/i/	443,2	2096,3	573,6	1791,6	365,9	2193,4
/u/	480,5	915,1	584,6	1110,3	413,2	748,1

Tables 2. Formants Variations F1 and F2 with flow, according to consonant context, for each speaker

5 Analyze slopes and ordinates at origin of locus equations

5.1 Methodology

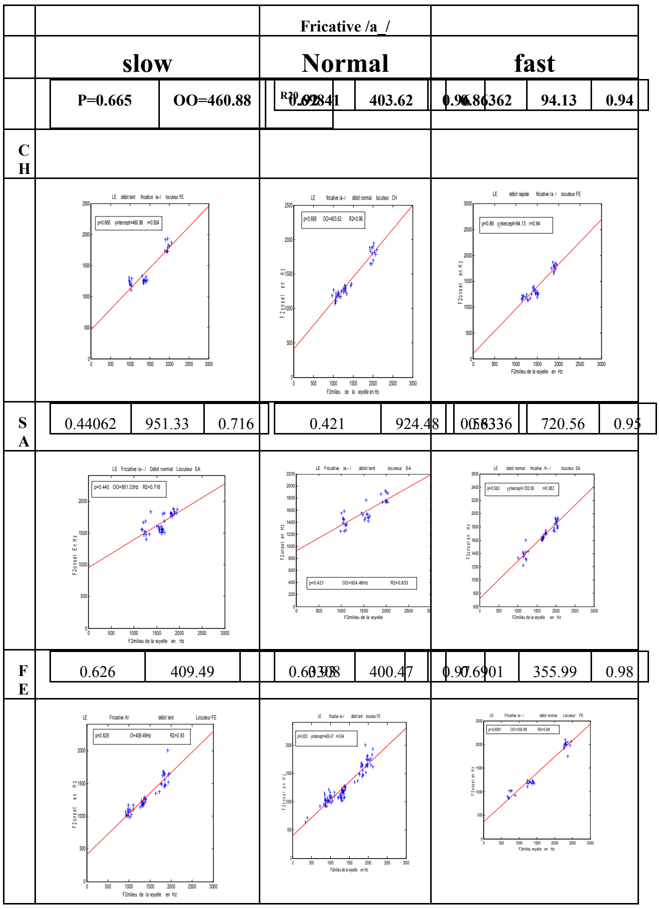
We took F2onset (at end of consonant) and F2 of medium vowel, on spectrogram and follow-up of formants traced with Praat software for each elocution flow.

Table 4 of values giving slopes, ordinates in beginning and coefficients regression is as follows:

		ch		**SA**			**FE**		
	slope	**OO**	**R^2**	**slope**	**OO**	**R^2**	**slope**	**OO**	**R^2**
a_l	0.665	460.88	0.92	0.44062	951.33	0.716	0.626	409.49	0.93
a_n	0.69841	403.62	0.96	0.421	924.48	0.833	0.63308	400.47	0.97
a_r	0.86362	**94.13**	**0.94**	0.56336	720.56	0.95	0.6901	355.99	0.98

Table 4. Values of slopes, ordinates in beginning "OO" and regression coefficients of R^2, obtained by speaker and by flow

The right-hands of locus corresponding to table 4 are showing in figures 9



Figures 9. Right-hands of locus, slopes and ordinates in beginning and coefficient regression, obtained

6 Discussions and conclusions

Fowler in 1994[8] mentions that values modifications of F2milieu will affect those of F2onset and consequently those of slopes of. Therefore, we should find a variation law of slopes as of which should follow that of variation of F2, which will thus approach variation of vocalic reduction According to obtained results by many researchers, by increasing flow, we have a vocalic reduction which results in a centralization of vowels into a schwa in plan (F1, F2). What will cause to increase F2 since centralization goes in positive direction of F2 (towards /a /, which has the lowest position in vocalic triangle). We should thus find a slope of locus equation which increases with flow for a speaker having a good engine control, therefore an increase in coarticulation with the flow.
Let us see now the results obtained:

For speaker CH: We indeed note an increase in slope of locus equation with flow. What joined vocalic reduction observed for this speaker who indeed presented a good centralization of vowels (see figure ellipses).

For speaker FE: Slopes obtained in slow and normal flow are practically whereas for fast flow we note a great increase in slope. What joined what we found for FE in vocalic reduction with dispersion ellipses.. We indeed noted for speaker FE almost a total absence of vowels centralization, therefore not of variation of F1 and F2.

For speaker SA: Slope**s** are overall increasing with flow. Which joined result of vocalic reduction observed for this speaker?

Thus it will be said that vocalic reduction variation is found on level of slopes variation of locus equations.
We thus see that each speaker has his own strategy for coarticulation and vocalic reduction. This difference can be indeed related to its training of language in beginning whose pronunciation of phonemes is very influenced by mother tongue of individual.
In addition, we note that the greatest slopes are observed for CH speaker and lowest for speaker SA, and this for fricative /a_/ and /h_/.

The slopes are of the same order of magnitude for the three speakers, and have practically same values for FE and CH: Let us note that these two individuals have Arab mother tongues (approaching much classical Arabic for CH, and little for FE).

This phenomenon must be related to fact that these two fricative takes place very close of articulation, therefore the slopes of their line of locus should be similar at the same individual. Also let us note that slopes of CH are raised, which testifies of more than coarticulation at CH than both other speaker, which could be related to the fact that its mother tongue is very close to the classical Arabic.

The slopes obtained, for speaker SA are relatively weak comparatively with those obtained for the two other speakers. What could be due to mother tongue of SA which is kabyle (very different from the Arab language). What testifies to much less coarticulation, therefore of a less engine control compared to the two other speakers who seem to have more ease to express itself in classical Arabic

According to all these results, we can say that speaker SA have results very different from those of the CH speakers and FE which them have relatively close results
This phenomenon in our opinion can be related only to the mother tongue since speaker SA has a mother tongue Kabyle which is very different from that of the two other speakers who them have mother tongues which are close (Arabic both).

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