On the Acoustic and Articulatory Characterization of the Effects of Arabic Pharyngealized Consonant on Adjacent Vowel

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Introduction

- During speech production, a series of articulatory gestures are realized by means of the phonatory organs movement in the vocal tract.
- The passage from the production of isolate phonemes to continuous speech involved an enormous articulatory and acoustic variability.
- technological developments in medical imaging, progress in the observation of organs and muscles facilitated by new tools, have produced significant advances in the understanding of the mechanisms involved in speech production.
- Close attention to the movement of the phonatory articulators involved in speech production can shed light on the consequences of certain actions on other organs.

Introduction

- The pharynx serves as the first resonator for laryngeal sound. the raising or lowering of the larynx alters the length of the pharyngeal cavity which leads to acoustic consequences due to the change in the vertical dimension of the pharynx.
- In this study, we deal with the Arabic sound which occurs in the pharyngeal zone of the vocal tract, the pharyngealized consonant /tˤ/ which shows the highest degree of emphaticness.
- our main aim in this paper is to study the production of the Moroccan Arabic pharyngealized sound /tˤ/, its effects on adjacent vowel /a/ and we compare them with the pharyngeal consonants /ʕ/.
- we refer to the acoustic and radiographic data to examine this issue.

Methods and Tools

- Type of data: x-ray images, taken from a data base DOCVACIM (Sock et al., 2011)
- Delineation of the articulators contour by automatic, semi automatic and manual methods
- Treatment of the acoustic data: the software Praat used for the segmentation and for the annotation of the phonemes
- Synchronisation of each phone with the corresponding x-ray images

Methods and Tools

- ***Measurment of the phonatory organs displacements***

- The method of semi-polar coordinates is used, an adapted grid for our subject is made. The measurements are carried out relative to the reference point(the upper incisor).

- The measurements are made for the effective gestures involved in the production of the pharyngealized consonant which are:

  - the larynx

  - the hyoid bone

  - the constriction oppening

  - the constriction location

Results

- Table 1. Measures regarding the hyoid bone position, the larynx center position, the construction opening and Construction location: in the rest position, during the production of the pharyngeal /ʕ/ , during the pharyngealized consonant /tˤ / and for the adjacent vowel /a/.

	Hyoid Bone position (y) cm	Larynx Center position (y) cm	Construction opening	Construction location
Rest position	4.2266	6.1732	-	-
/ʕ/ in /ʕtˤah /	2.8111	4.6995	0.9872	14.6384
/tˤ/in /ʕtˤah/	3.0527	4.6535	0.0583	1.4485
/tˤ/in /tsutˤina/	3.3362	5.5298	0.0878	1.7827
/tˤ/in/tˤwaʒen/	3.3649	5.9345	0.0877	1.9483
AV of /tˤ/ in plain cotexts	3.3505 /SD(0.17)	5.7321/ SD(0.654)	0.0877	1.8655
/a/ in /ʕtˤah/	3.2391	5.1861	0.5847	1.1145
/a_1/in /$ma_1t^ʕa_2ruʃ$/	4.1298	5.9788	1.1006	12.9673
/a_2/ in /$ma_1t^ʕa_2ruʃ$/	3.4968	5.8149	0.5756	1.4485
/a_1/ in /$ba_1t^ʕa_2t^ʕa_3$/	3.7440	5.8270	0.9887	13.3014
/a_2/ in /$ba_1t^ʕa_2t^ʕa_3$/	3.4715	5.61	1.0605	0.8338
/a_3/ in /$ba_1t^ʕa_2t^ʕa_3$/	3.7609	5.6995	0.9559	13.1343
AVfor /a/ in /tˤ/ contexts	3.6123/ SD(0.2909)	5.6717/ SD(0.2538)	0.8163/ SD (0.2697)	1.1322
/a/ in plain contexts	3.9359/SD(0.336)	5.8118/ SD(0.271)	1.2164	0.9474

Results

- For the pharyngealized /tˤ /, the larynx center rises by 0.8 cm relative to the rest position. The hyoid bone rises by 0.87 cm. The constriction location is at 1.87cm and the constriction opening is about 0.09cm.
- We can conclude from the obtained results that the primary articulation for / tˤ / is located at 1.45 to 1.87 cm relative to the upper incisor and the constriction opening is about 0.06 to 0.09 cm. the secondary constriction is located at 12.96 to 13.3 cm and the constriction opening is 0.98 to 1.1 cm. we noticed that the primary constriction is more constricted than the secondary one and the location of the secondary constriction for the pharyngealized /tˤ/ is close to that of the pharyngeal /ʕ, ħ/ which are at about 13.76 to 14.63 cm. the difference is 0.8 cm to 2.16 cm.

Results

- we explore the articulatory effects of /tˤ/ on the adjacent vowel /a/, the larynx center rises by 0.50 cm relative to the rest position, and the hyoid bone rises by 0.61 cm. knowing that the acoustic output varies according to the behavior of the active gestures, the obtained results from the articulatory study lead to additional questions about the acoustic consequences of change in the vertical position of the larynx on /a/ adjacent to /tˤ/. An acoustic study of the vowel quality was conducted in order to determine the extent to which vowels could be affected by that environment.

Results

- The software Praat is used for the measurement of the formants values. The table II summarizes the formants values of the vowel /a/ in pharyngealized neighboring, in plain coronal contexts and in the voiced pharyngeal neighboring.

Results

- FORMANTS VALUES OF THE SHORT VOWEL/A/ IN DIFFERENT CONTEXTS: (/ʕ / AND /tˤ/) NEIGHBORING AND IN PLAIN CONTEXTS

Formants / /a/ in /ʕ/and /tˤ/ neighboring	F1(Hz)	F2 (Hz)	F3 (Hz)	F4 (Hz)
/a/ in /ʕtˤah/	718.58	1340.96	2487.67	3800.35
/a_1/ in/ma$_1$tˤa$_2$ruʃ/	659.81	1278.10	2601.01	3643.81
/a_1/in/ba$_1$tˤa$_2$ tˤa$_3$ /	674.1	1275.05	2471.15	3658.03
/a_2/in /ma$_1$tˤa$_2$ruʃ/	649.26	1256.64	2489.54	3674.53
/a_2/in/ba$_1$tˤa$_2$ tˤa$_3$ /	652.2	1359.74	2548.24	3805.53
/a_3/in/ba$_1$tˤa$_2$ tˤa$_3$ /	655.24	1126.95	2580.75	3718.96
Average value of /a/ formants in /tˤ/ neighboring	658.12	1259.29	2538.13	3700.17
/a/ in /ʕ/ neighboring	654.39	1706.22	1051.83	2539.67
/a/ in plain neighboring	440.50	1418.58	2566.69	3794.06
/a/ in / tˤ/ (%)	39.49%	-11.22%	-1.1%	-2.47%
/a/ in /ʕ/ (%)	48.55%	20.27%	-59%	-33%
/a/ in /ʕtˤah/ (%)	63.13 %	-7.47%	-3.07%	0.16%

Results

- In /tˤ/ neighboring, F1 increases by 138.52 Hz, F2 decreases by -314.15 Hz, F3 and F4 undergo a moderate increase of 52.33 Hz and 23.88 Hz respectively. In the case of /ʕtˤa/, F1 increases by 198.98 Hz, F2 decreases by -232.48 Hz, F3 remain stable, and F4 increases by 123.72 Hz.
- The effects of /tˤ / and /ʕ/on the formants values of /a / are: F1 increases by about 134.79Hz in /ʕ/ environment, and by 138.52 Hz in /tˤ/ environment, the effect of /ʕ/ is similar to that of the /tˤ/and in the context of /ʕtˤah/, F1 increases by about 198.98 Hz. F2 in the environment of /ʕ/ increases by about 132.78 Hz, in the environment of /tˤ /, it decreases by about -314.15 Hz. In the word /ʕtˤah/, it decreases by -232.48 Hz. We noticed that /ʕ/ decreases the effect of /tˤ/ by about 81.67 Hz.

Results

- F3 is less influenced by both /tˤ/ and / ʕ/
- F4 is less influenced by /tˤ/ and a little more by /ʕ/, so in /ʕtˤah/, the effects of /ʕ/ and /tˤ/ are superimposed.
- Comparing the articulatory and the acoustic results, we noticed a correlation between the degrees of the articulatory gestures spreading on the adjacent vowel /a/with the acoustic consequences.

Conclusions

- The effects of the pharyngeal consonant with the pharyngealized one as in the word /ʕtˤah/ on the adjacent vowel /a/are investigated.
- We noticed that the raising of the larynx center and the hyoid bone is in the same range during the production of both /ʕ/ and /tˤ/ (about 0.8 cm), and F1 increases by 48.5% in /ʕ/ neighboring and by about 39.49% in /tˤ/ neighboring. The production of the two consonants successively /ʕtˤ/ in the word /ʕtˤah/ the larynx center and the hyoid bone rise doubly by about 1.5 cm. So, we observe that the gesture is superimposed and the acoustic effect on F1 also is raised, we noticed a correlation between the articulatory effect and the value of the first formant F1.

End of the presentation

Q & A ?

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