Friction Sources Characterization for Fricative Consonants of Arabic

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Abstract: The objective of this work is the acoustic characterization of the friction source for Arabic voiced consonants [v], [z], [ʒ], [h], [ς] and unvoiced ones [s], [f], [ʃ], [ħ], employing vocal tract transfer function obtained from a direct measurement by the Pseudo Random Excitation of the human vocal tract and the signal spectrum radiated at the lips. Assuming the separability of the source of the vocal tract considered as a linear filter, the sources spectrum is obtained by the ratio of the output signal spectrum of the vocal tract transfer function. The results are derived from data produced by two female and two male subjects.

1 INTRODUCTION

The fricatives are produced when a supra glottis constriction is formed in the vocal tract; the air flow through the constriction produces a jet (turbulence) in the region downstream of the constriction (near the walls of the vocal tract and / or the teeth that form an obstacle). In addition to the turbulence, the vocal cords vibrate in the case of voiced fricatives. To characterize the Arabic fricative consonants our study is divided in two parts: the first part is the acoustic characterization of the vocal tract by measuring the vocal tract transfer function using Pseudo Random Excitation method. The second part is determining the friction sources spectra involved in the production of the studied Consonants.

2 MEASUREMENT OF THE VOCAL TRACT TRANSFER FUNCTION

The excitation of the vocal tract by a pseudo-random binary sequence (PRE) is a technique for direct measurement of the vocal tract transfer function in human subjects developed by Djéradi et al. in 1991.

This method has several advantages over previous methods for providing in this case a very short measurement time (100ms), it is also compatible with phonation (Djéradi et al., 1992).

2.1 Data Acquisition

The recordings were made in an ambient environment. The fricative consonants [s, f, ʃ, v, ʒ, z, h, ħ, ς] were made by two female speakers of native language Kabyle for the subject KF and Algerian Arabic for the subject BS. The signal is digitized at sampling frequency of 16 KHz. The measuring time is about 100 ms, corresponding to a pseudo-random sequence of 1024 points. Each consonant is recorded ten times by each speaker

3 SOURCE SPECTRUMS

The pseudo random excitation method developed by (Djéradi et al., 1991). Allows the measuring of the vocal tract transfer function in phonation mode and also the obtaining of the signal spectrum radiated at the lips as shown in the diagram below:

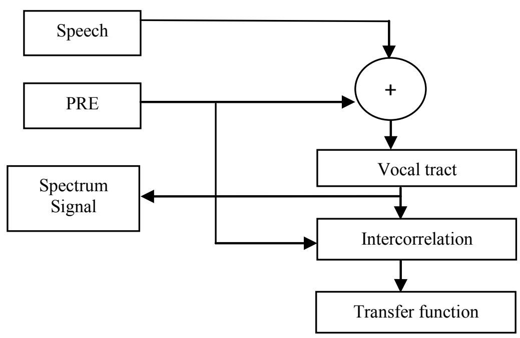

Figure 1: Block diagram of PRE method.

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The sources spectrum is obtained by the ratio of the output signal spectrum of the vocal tract transfer function. The ten source spectrums of each consonant are superposed in the same figure, and the voiced consonants are opposed with the unvoiced ones for the fourth speakers, in order to compare the results, figure 2.

3.1 Analysis and Interpretation of Results

The main observation is that the spectral curves overlap very well and the peaks values obtained are stable for the speakers in the corpus. For the dental voiced/ unvoiced fricatives [z, s], we see the emergence of two main peaks one at about 4500Hz and the other at 3200 Hz, these resonances are attributed to incisive that form the source of obstacle. According to previous studies in particular that of Shadle (Shadle, 1985). The value of these peaks depend both of the shape of the obstacle, the diameter of the constriction and the distance between the constriction and the obstacle which may explain the appearance of two peaks for the dental source. The amplitude of the peak (at 4500Hz) of the fricative [s] is 50dB and that of [z] is 35dB, the peak at 3200Hz [s] is 40 dB and that of [z] is 30 dB. Note that the amplitude spectrum for the dental voiced [z] falls relative to that of the unvoiced [s], this is due to the drop in pressure at the glottis. Note also that the amplitude and slope of the spectrum differs between subjects that are due to the pressure difference generated by each subject.

For the post alveolar sources fricatives [ʃ, ʒ], three main peaks appeared, the first is at 1500 Hz, the second at 3200 Hz and the third is at 4500 Hz representing the resonances of the vocal tract walls and dental sources.

For the pharyngeal, the spectra obtained are similar for the subjects. 4500Hz, 3200 Hz appeared for the three fricatives [ς, ħ, h], the band below 500 Hz is dominated by the effect of voicing for the voiced fricatives [ς, h] for the fricative [ς] a broad peak appeared at 400 Hz. For [h] is at 200 Hz. For the [ħ] a broad peak appeared at 1500 Hz.

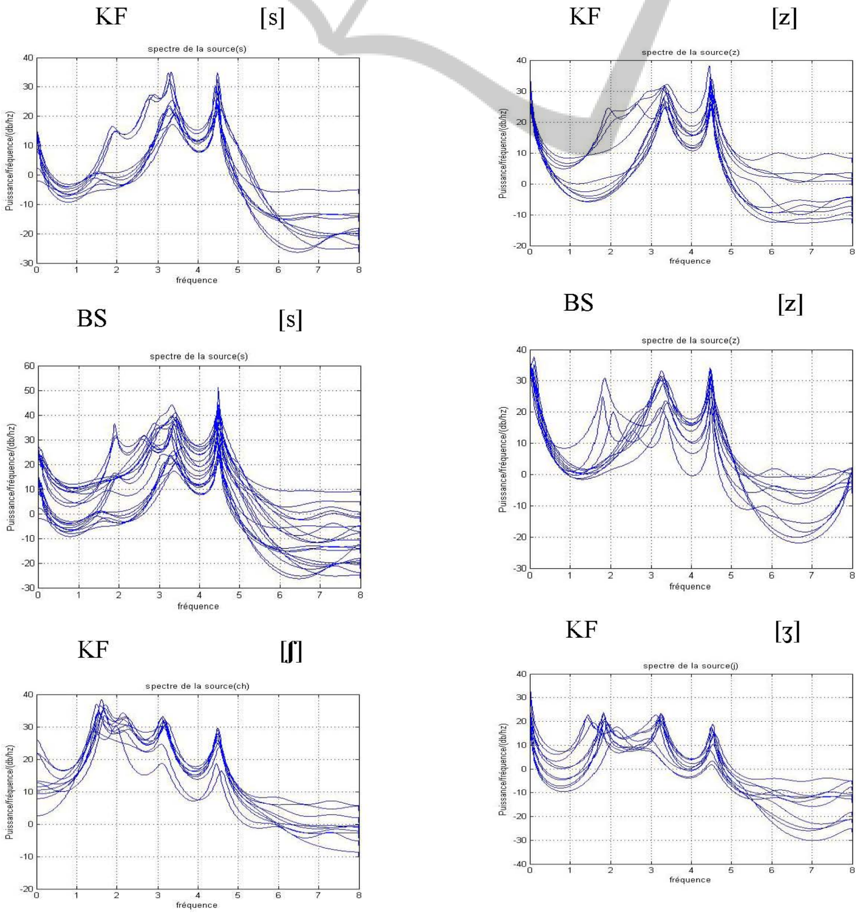

Figure 2: Sources spectra for unvoiced fricatives [s, ʃ] (left) and voiced fricatives[z, ʒ] (right) spoken by subjects KF, BS.

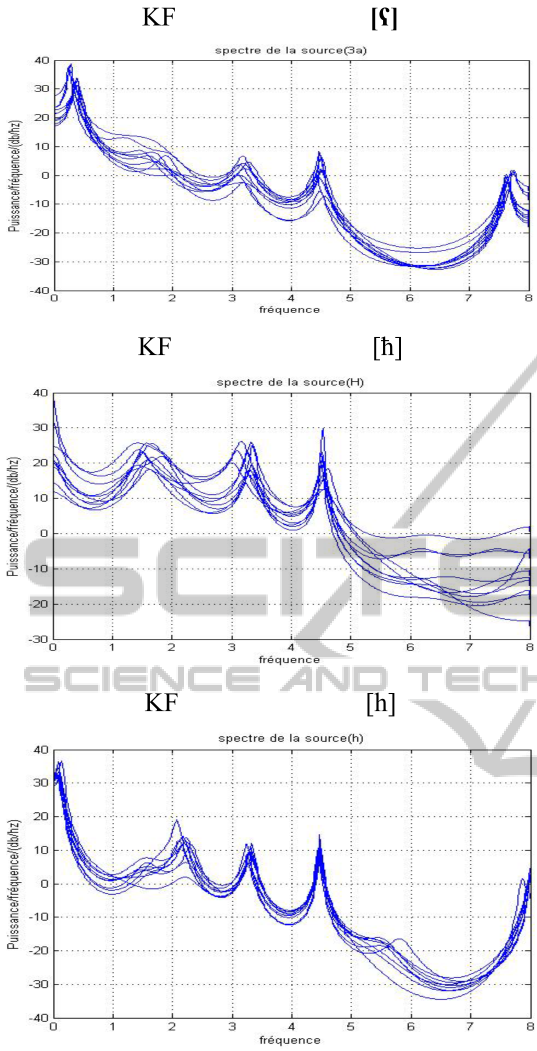

Figure 3: Sources spectra for pharyngeal fricatives consonants [**ʕ,** ħ, h] spoken by subject KF.

4 CONCLUSIONS

In this framework, we have implemented the PRE method for direct measurement of the vocal tract transfer function on human subjects.

From the transfer functions obtained and the output signal spectrum we determined the acoustic parameters of the friction sources concerned during the production of the fricative consonants.

We conclude from this analysis that the spectra of the sources of friction of voiced consonants and unvoiced consonants are similar, they exhibit the same resonances in the high frequencies, while in the low band frequency the effect of the glottal source is dominant. The amplitude spectrum for voiced sources decreases compared to unvoiced ones due to the drop in pressure at the glottis. The amplitude also differs between speakers due to the difference in pressure emitted by each subject during the production of these fricatives.

These results are in agreement with the preceding results studies particularly those obtained by Abeer Alwan and Shrikanth Narayanan for [s, ʃ].

On prospects, continue this study and propose a complete model for a source of friction for Arabic consonants:

- A signal generator whose spectrum is the one we obtained in this work
- Command parameters that would allow the use of this generator in a synthesis of fricative consonants.

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