Acoustic Characterization of the Noise Sources for the Kabyle **Fricatives Consonants**

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ABSTRACT

The study is centered on the exploration of human speech sound production, acoustic modeling, and signal analysis. It introduces an experimental framework designed to acoustically characterize the Kabyle phonological system, with a specific focus on fricative consonants. In this research, to compute the transfer function of the vocal tract, we utilized a Pseudo-Random Excitation method (PRE), this method grants us the capability to calculate the noise source spectrum. We compiled a database of vocal tract transfer functions for various fricative consonants, including [s, f, \int , v, 3, z, h, h, \hat{s} , c, j], as pronounced by two female and two male Kabyle language speakers. Through an analysis grounded in direct measurements on human subjects, we scrutinized the resonance and anti-resonance frequencies within the ensemble-averaged fricative spectra. Furthermore, we calculated the noise source spectra for all the studied phonemes and compared the results with findings from previous studies. Interestingly, in some cases, we observed a similar trend in the results, despite variations in experimental conditions.

Keywords: Vocal Tract Transfer Function, PRE Method, Noise source

1 Introduction

Kabyle, a variant of the Berber or Tamazight language, exhibits notable differences in its phonetic and phonological systems when compared to other Berber languages. These distinctions include the introduction of spirantization in previously occlusive consonants, labio-velarization of velar and uvular consonants, palatalization of select consonants, and the presence of affrication [1]. The limited availability of data and research on characterizing the phonological system of the Kabyle language has driven our study, aiming to address several key questions: - Acoustic mechanism of fricative consonants [2], [3]: We seek to uncover the acoustic mechanisms underlying fricative consonants in Kabyle.

- Characteristics of noise source: Our research investigates the specific characteristics of noise source in Kabyle fricatives.
- Comparing noise source strength: We aim to determine whether the noise source in unvoiced fricatives is weaker compared to the voice ones.

2 Methodology

In this study, we carried out the direct measurement of the vocal tract transfer function with phonation using the PRE method [4], [5]. The general structure of the experimental system is shown in the block diagram of Figure 1. The system consists of:

Computer, vibrator type "BK4810" used for external excitation of the vocal tract. The frequency range is from DC to 18 kHz and the first axial resonance of the moving element is above 18 kHz.

Power Amplifier type "BK2718"; it has been designed to drive small vibration exciter particularly Minishaker type 4810 to full rating, hence to be used in acoustical measurement. Unidirectional microphone, headphones, an acoustic insulation used to minimize acoustic radiation from the exciter to the microphone.





Figure 1: Block diagram of the transfer functions and source spectrum calculation with PRE method

3 Results and Discussions

Prototypes of the measured transfer functions and source spectra are given in Figure 2.



Figure 2: Vocal tract transfer functions for voiced pharyngeal /ς/(left) and Source spectrum of / ς /: (top curves) phonation, (bottom curves) without phonation

We noticed that the curves are superimposed well for the ten repetitions. The peak frequencies F1, F2 and F3 are apparent. The average values of the three first formants and the standard deviation are calculated for each formant. The obtained source spectra in this study are calculated from the transfer functions measured by PRE method and the radiated signal recorded at about 2 cm from the lips, the source spectra is obtained by the ratio of the vocal tract response to vocal tract transfer function, which are already measured by the PRE method.

4 Conclusion

In this study, the Pseudo Random Excitation method on human subjects is developed, a database of direct measurement of the vocal tract transfer functions for the fricatives and glottal consonants of the Kabyle language have been constructed. From the obtained transfer functions and the radiated signal, noise sources spectra were determined. The obtained results are compared to the previous studies and a similar trend of the results in certain cases is noticed even if the experimental conditions are different.

5 Competing Interests

The authors declared that no conflict of interest exists in this work.

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