

Correlation between Three Facial Pattern Vibration Measurement Methods

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Abstract – This paper deals with the facial surface vibration measurement performed by three different methods. Facial vibrations were measured during performing the resonance voice exercises with different shape of vocal tract or with different length of the resonance tube. Vibrations were measured on the upper lip by vibrometer and on the ala of nose by accelerometer. The amplitude of oscillation was also monitored by high speed camera in the direction x and y axes and also total amplitude. Correlations between all three methods showed a significant agreement in measurement. One-way analysis of variance (ANOVA) for different type of vocal tract and length of resonance tube and two-way ANOVA with the type of vocal tract and pitch were applied. It revealed the significant differences of amplitudes of vibration dependent on the pitch and the vocal tract type.

Keywords-vibration, accelerometer, vibrometer, high-speed camera, facial surface, resonant voice

I. INTRODUCTION

In recent years vibration measurement using optical full-field methods is being more spread in research and industry, e.g. vibration limits compliance control such as impact testing. These methods are based on taking images by high-speed camera and their analysis using digital image correlation [1].

In the voice measurement area facial vibrations have been associated with the production of resonant voice [2]. For parts of cheek vibration recording accelerometers or laser Doppler vibrometers are being used.

Study [3] described nasal bridge vibration measurement using the accelerometer. Results showed significantly higher magnitudes of facial bone vibrations caused by nasal stimuli as compared with non-nasal stimuli. Resonant voice as compared with strained and non-resonant voice produced the highest vibrations presented as RMS values of accelerometer signal measured in mV. Results of the other study [4] using accelerometers showed significant resonance increase in the nasal bridge area after resonant voice practice. It also found different values of vibration during different type of phonations. The highest values were recognized during phonations of nasal sounds and then for vocals “u”, “i” and “a”, so the vibrations decreased with the opened vowels.

Studies [5] and [6] dealt with facial vibration measurement using scanning laser Doppler vibrometer. Their results showed stronger vibrations presented as RMS values of vibration velocity (dB) in the mouth opening area as compared with other face regions. During nasal consonant “n” production the vibration was stronger in the nasal area than during production of vocal “a”. Comparison of different vocals showed more vibrations around the nose during phonation of vowel “i”. During phonation in falsetto register vibrations around the cheek and forehead increased as compared with phonation in modal register.

Semi-occlusion or vocal tract narrowing in association with vocal tract lengthening by tube are widely used methods in voice education and therapy. They make possible better control of exhaled breath and they emphasize vibration feeling in the cheek area, they reduce oscillation threshold pressure and increase source-vocal tract interaction. Study [7] using models showed threefold increase of mouth pressure just behind the lips in the case of using resonance tube as compared with vocal “u”. Abovementioned results motivated us to use resonance tubes, vowel “u” and brumendo for vibration comparison measurement.

II. MOTIVATION AND GOALS

The main target of this study was to verify whether high-speed optical methods could relevantly identify facial surface vibrations. Therefore correlations between three different methods of facial surface vibration measurement during resonant voice production were looked for. Dependence of type and length of vocal tract and pitch was investigated. Vibrations were monitored by the piezoelectric accelerometer, the laser vibrometer and the high-speed camera.

III. METHODS

A. Vibration Measurement Sensors and Placement

The piezoelectric accelerometer type PCB Electronics 352C23 with sensitivity ($\pm 20\%$) 0.5 mV/(m/s²) was placed on the right side of the subject’s nasal bridge. To achieve a better grip on the skin surface a special wax was applied to the accelerometer and for more stability of the accelerometer on the nasal bridge, the sticking-plaster