

Title : Vocal folds vibratory patterns of “laryngeal mechanism M0” as investigated with high-speed cinematography and electroglottography.

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Abstract :

A human vocal production is characterized by the use of different laryngeal mechanisms (Roubeau, 1993 ; Henrich et al., 2003), among which laryngeal mechanisms M1 and M2 are the most frequently used and studied in speech and singing. Chest, or modal voice, is produced in M1, while falsetto, or female head voice is produced in M2. Besides that, another mechanism known as laryngeal mechanism 0 (M0) can also be found in speech and some types of singing. Vocal fry, pulse register, creaky voice, glottal fry are the terms frequently used to refer to this vocal production. Yet, these terms are sometimes considered as synonymous (Hollien, 1974), while in other cases, they would characterize different vocal productions. The M0 mechanism has mainly been studied for pathological voices, but it is also of interest for linguists, as it can be found in hesitations and at the end of utterances.

Thus our aim is to investigate the different vibratory patterns that can be involved in M0 thanks to high speed cinematography and to compare them with the EGG signal. The glottal vibratory movement has been simultaneously investigated in two ways: first, with the help of electroglottography (EGG), and secondly, with high-speed cinematography. The high-speed images have been recorded using a high-speed camera unit Wolf HS Endocom 5560, and the EGG signal has been recorded using a Laryngograph Ltd. Two male speakers were asked to produce a sustained vowel in M0 with or without vocal effort, and transitions between M1 and M0. The high-speed images and the EGG signal were recorded simultaneously at different sampling frequencies, respectively 4000 Hz and 44170 Hz. The data were then processed using Matlab. The EGG signal was differentiated, and both EGG and Differentiated EGG (DEGG) signals were synchronized with the high-speed images, so as to compare the EGG and DEGG data with the vibratory movements observed on the images. An image processing algorithm based on the detection of contrast (light energy threshold) was developed for relative measurement of glottal area, antero-posterior and transversal distances. It is a known fact that the glottal area function in M0 is characterized by short pulses, which can be single, double or triple within a fundamental period (Whitehead et al., 1984 ; Childers and Lee, 1991).

On a physiological point of view, the thyroarytenoid muscles tend to shorten, subsequently thickening the anterior-posterior dimension of the vocal folds, and allowing the anterior part of the vocal ligaments to vibrate (Hollien, 1974). However the physiological properties associated with the multiple vibratory patterns mentioned above are not fully described, especially regarding the precise movements of the vocal folds margins, the degree of vocal fold adduction and the contribution of the ventricular folds.

The analysis shows that different realizations of M0 can be found in this corpus especially when comparing (i) the M0 realized with vocal effort from (ii) the M0 realized without vocal effort. The first one is more likely to be characterized by a single pulse, while the second one is frequently produced with multiple pulses - both realizations having different typical EGG shapes. We also found that in the case of single pulse pattern, the anterior portion of the vocal folds is more involved in the vibrating process than the posterior one, while the posterior

portion of the vocal folds can also be active in the case of a multiple pulse pattern. Transitions produced by the two speakers were also investigated, thus revealing different which were possibly used. The validity of EGG signals rendering the different vibratory patterns will be discussed as well as implications for synthesis.