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The effect of vocal tract impedance on the vocal folds – F Agerkvist

The importance of the interaction between the acoustic impedance of the vocal tract with the flow across the vocal cords is well established. In this paper we are investigating the changes in vocal tract impedance when using the different modes of phonation according to Sadolin [1], going from the soft levels of the *Neutral* mode to the high levels of the fully 'metallic' *Edge* mode. The acoustic impedance of vocal tract as seen from the mouth opening is measured via a microphone placed close to the mouth when exciting the system with a volume velocity source [2]. At the same time a *Laryngograph* frontend is used to measure the electroglottograph signal which reflects the opening and closing pattern of the vocal folds. The measurements were carried out for all four modes (Neutral, Curbing, Overdrive and Edge) for the vowel [a] in three different pitches: C3(131 Hz), G3 (196 Hz) and C4 (262Hz) . The results show changes in the resonance frequencies of the vocal tract with increasing pitch, whereas the changes between the modes are less clear due to the measurement signal being weak in comparison to the louder modes, especially at high pitches. The electroglottograph shows a very different waveform for the *Neutral* mode compared to the other, so-called metallic modes. The differences in waveform between *Curbing*, *Overdrive* and *Edge* modes are minor. However, the spectrum of the *Overdrive* mode shows stronger 2nd harmonic and weaker 4th and 6th harmonic compared to *Curbing* and *Edge*.
Finally the *Overdrive* mode, which is the mode that is most limited in pitch range, was tested at its pitch limit C5 (523 Hz) under normal conditions and when the singer has inhaled Helium. When inhaling Helium the acoustic impedance of the vocal tract is reduced in magnitude and the resonances are scaled upwards in frequency due to different density and speed of sound in Helium. The electroglottograph shows a change in waveform when the singer inhales helium. The percentage of the glottal cycle when the vocal cords are open, the so-called open quotient, increases from 40 to 55%. When inhaling helium the male singer was able reach Eb5, a minor third over the normal limit for males, this seems to indicate that the vocal tract impedance is at least partially responsible for the pitch limit in 'Overdrive'.

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Glottal area waveforms study from high speed video-endoscopic recordings and voice production model with aeroacoustic coupling driven by a forced glottal folds model – T Hézard, T Hélie, B Doval, R Caussé, G Degottex [invited paper]

Source-filter paradigm is one of the most common approaches used by the scientific community to establish models for analysis and synthesis of voice sounds. But, if the source-filter models are easy to compute, they ignore some physical phenomena which are important for the naturalness of the sounds. In this presentation, we investigate how we can modify the usual source-filter model in order to take into account some simplified aeroacoustic coupling between vocal folds and vocal tract while keeping low-cost computation and efficient analysis methods. After presenting a glottal area waveform model, we establish a complete voice model based on the preceding glottal area waveform model and evaluate its relevance by comparing analysis and synthesis methods based on this model and on a usual source-filter model.
1. A glottal area waveform model based on