Abstract about current research in the field of physical modelling of speech which motivates the participation of N. Ruty and A. Van Hirtum to the German-French Summerschool on "Cognitive and physical models of speech production, perception and perception-production interaction" (19-24/09/2004).

The effect of acoustical feedback on buzzing. From lips to vocal folds ?

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The interaction of expiratory airflow with the vocal folds tissues is known to be the primary source of human voiced sound production. The airflow through the larynx induces instability of the vocal folds. The resulting vocal fold vibrations modulate the airflow giving rise to a periodic sequence of pressure pulses which propagates through the vocal tract and is radiated as voiced sound. Modelling of the ongoing fluid-structure interaction and the vocal fold oscillations is important in the understanding of phonation, the synthesizing of voiced sound and the study of voice disorders.

Physical modelling of the vocal folds and the 3D fluid-structure interaction between the living tissues and the airflow has a long and rich history. Simplifications of the physical reality are favoured due to a historical interest for speech control and synthesis applications which requires a limited number of physiological meaningful and measurable model parameters. Therefore physical models strive to represent the main features of phonation while assuming severe simplifications in the biomechanical structure and fluid mechanical flow modelling.

A major simplification in the physical models is the assumption of the separation or the independence of voice source and filter. The source-filter separation neglects pressure reverberations in the vocal tract and as such assumes no impact of acoustical feedback on the dynamics of vocal folds oscillations.

The wide and successful application of the resulting vocal folds models proofs the assumption to hold in normal speech conditions. However the hypothesis is shown to be of limited efficiency in abnormal speech conditions like singing or pathologies. Under these conditions the source is coupled to the vocal tract and/or the trachea meaning that pressure reverberations may return to the vocal folds and hence influence vocal folds oscillation. Therefore the impact of the delayed feedback of acoustical pressure reverberations on the vocal fold dynamics needs to be considered. The time delay is determined by the speed of sound.

The study of acoustical feedback in speech benefits from the study of wind instruments in musical acoustics where acoustical coupling is an essential feature in the sound generation process.

The approach presented in (Cullen et al, 2000) is applied to study the effect of acoustical feedback on lip replica oscillatory behaviour (Vilain et al, 2003). The on- and offset of oscillation for different mechanical boundary conditions is discussed considering oscillatory frequency and applying lung pressure as control parameter. Results are discussed with respect to vocal folds and lip behaviour.

References

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