EXPERIMENTAL INVESTIGATION INTO THE AERODYNAMIC CONSEQUENCES ASSOCIATED WITH DYSPHONIC CONDITIONS

By

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ABSTRACT

This work examines the irregular vocal fold motions associated with neurological diseases, namely vocal fold paralysis and paresis. An increased understanding of the effects these diseases have on speech production inherently improves current corrective surgical techniques, and also increases the understanding behind normal voice production. To this end, two scaled up models were created to examine the effects asymmetrical vocal fold motions have on speech production. Digital Particle Image Velocimetry measurements were taken to examine the flow field downstream of the two experiments.

The first experiment used two rigid models driven by stepper motors to create a forced oscillatory motion. Full control of the vocal fold motion successfully decoupled the effects the fluid flow has on the vibratory motion of the vocal folds. Five varying cases resembling plausable vocal fold motions during vocal fold paresis and paralysis were tested. The operating Strouhal number of the forced oscillation experiments was 0.065 with a varying Reynolds number of 4400 and 8000. Asymmetries within the glottal jet were present in all asymmetrical wall motion cases. The asymmetrical glottal jet stems from two main characteristics, namely the glottal jet velocity, and the time open of the glottis. The increased time open of the glottis allowed for the development of the Coanda effect disrupting the glottal jet downstream of the vocal folds.

The second experiment examines the fully coupled fluid-structure interactions during phonation. Two vocal folds created out of stainless steel, attached to leaf springs provide the restoring force necessary for the free oscillation of the vocal folds. The natural frequency of the left and right side is 4.57 hz and 4.65 hz, respectively. The Strouhal numbers observed were 0.03, 0.05, 0.07 with corresponding Reynolds numbers of 1200, 1500, and 1800. Two regions of interest were present in the freely oscillating case. The first, a quasi-periodic beating, was present in the freely oscillating motion. The second occurred when the amplitude modulation was the smallest. During this time the vocal fold models oscillated out of phase, never allowing the vocal folds to completely close. This allowed the Coanda effect to develop, consequently pulling the glottal jet to one particular direction.