Inverse Vocal Tract Adjustment: Spectral Dependence and MRI Data

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Keywords: Inverse Source Filter Model; Formant Tuning; 3D-MRI; Simulation

Introduction

Voice production is a complex process including respiratory adaptions, vocal fold vibration and shaping of the vocal tract. Recently, we proposed a novel route to the specific adjustment of the vocal tract without phonation [1]. The approach is based on an inversion of the source-filter-model were the sound source is placed outside the open mouth and the vocal tract adjusted in order to amplify the resulting sound without phonation. As the vocal tract is essential for resonance and timbre, the technique may enable a training toward defined spectral energy distributions.

Methods

One male subject adjusted the vocal tract toward high amplification of up to three distinguished sinusoidal frequencies related to vowels [a] and [e] in German pronunciation. MRI Data were obtained according to [2]. The acoustic data were recorded simultaneously using a non-magnetic microphone. The procedure of the simulation is described elsewhere [3].

Theoretical Background, Results and Discussion

During the amplification of the sinusoidal frequencies, the detected phase/intensity relation can be explained within the concept of forced oscillation with the speaker being the driving source and the vocal tract being the oscillator [4]. Following this basic model, an amplification is possible if (i) the frequency of the acoustic signal matches the resonance frequency of the resonator (vocal tract) and (ii) the damping of the vocal tract is low. A training towards higher amplification of externally offered sinusoidal frequencies at resonance conditions should thus result in lower acoustic losses. Due to the frequency dependence of the vocal tract impedance, training at selected frequencies should result in different spectral characteristics if the shape of the vocal tract stays constant during subsequent phonation as well.

Fig. 1 shows MRI images of the vocal tract towards adjusted to different sinusoidal frequencies related to the vowel [e] with normal breathing and without phonation.

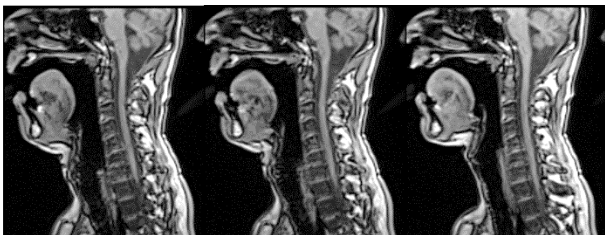

Figure 1: MRI cross-sections after adjustment to an external sinusoidal frequency (from left to right): 350 Hz; 350 and 1850 Hz; 1850 and 2700 Hz ***without phonation and open glottis.***

Fig. 2 shows the MRI obtained directly after the adjustment shown in Fig. 1 but during phonation.

Figure 2: MRI cross-sections after adjustment to an external sinusoidal frequency (from left to right): 350 Hz; 350 and 1850 Hz; 1850 and 2700 Hz ***during phonation.***

Changes related to the adjustment frequencies occur at full length of the vocal tract. Comparing the images without and with phonation (Fig.1 and 2 respectively) changes are observed mainly at the supralaryngeal tube area, which is more narrow during phonation. In contrast, tongue, jaw and velum position remain approximately stable. An adjustment at higher frequencies results in a shifted tongue position towards the front corresponding to a modified vocal output in subsequent singing.

In the presentation, we offer an acoustical analysis from recorded voices, the corresponding area function and simulation results.

References

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