VOCAL FOLD RESONANCES AT LOW AND HIGH PITCH TUNING

-preliminary results

KTH Speech, Music and Hearing

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ABSTRACT

Four trained singers were examined with high-speed recording during external acoustic excitation of the vocal tract with the vocal folds kept in a phonatory position, but without phonating (so-called Kaneko manoeuvre). Automatic glottal area analysis was made and spectral analysis was performed on the obtained area waveform curves. The results showed resonance frequencies close to habitual phonation frequency in three out of the four subjects. Intended pitch at phonation as well as the voice category seems to affect the resonance frequency of the subjects.

INTRODUCTION

Previous stroboscopic examinations indicate that the mechanical properties of the vocal folds differ between high- and low pitched singing. The mechanical properties of the vocal folds are pertinent to both the speaking and singing voice. The aim of the present study is to examine the vocal fold resonances at low and high pitch tuning. A second aim was to study differences between 3 different voice categories, soprano, mezzo-soprano and barytone from the stimulation experiment.

Material and Task

Four singers, one soprano, one mezzo-soprano and two barytones (age between 40 and 47 years) participated in the study.

The task was to perform the Kaneko manoeuvre, i.e to phonate followed by a cease in phonation but keeping the phonatory vocal fold setting during the frequency sweep. The subjects were provided live feedback from the camera monitor in order to complete this rather difficult task. Two recordings were made of each subject, first phonations / manoeuvres at habitual pitch (chosen by the subject) and later at a higher pitch (approximately one octave higher).

Experiment Apparatus

For the experiment a loudspeaker was connected to a plastic tube. A laryngeal endoscope was passed through a hole in the tube and connected to a Weinberger high-speed camera (image resolution 256x64pixels at 1904 frames/s). Sinusoidal sweep tones were used for the excitation (females: 500-100 Hz, males: 250-50 Hz), at a typical SPL of 140-150 dB inside the tube and the vocal cavity.

Analyses

The software High speed toolbox was used for area detection in the high speed recordings. The area waveform corresponds to the motion of the

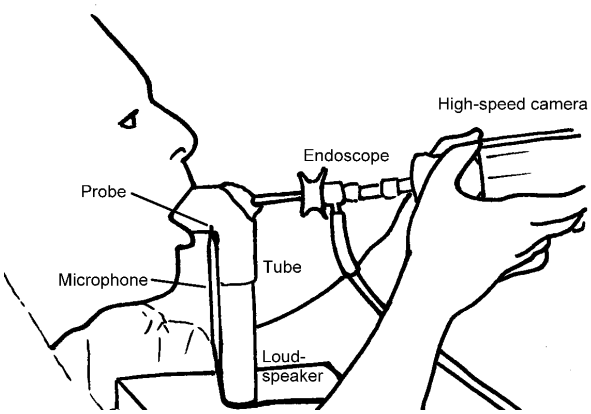

Figure 1: The experimental apparatus. The subject is phonating with the mouth closed around a tube where the acoustic excitation is fed from a loudspeaker. An endoscope connected to the high speed camera is passed through an airtight hole in the tube

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Poster is available at http://www.speech.kth.se/~svante/smac03/vocalfoldresonances.pdf

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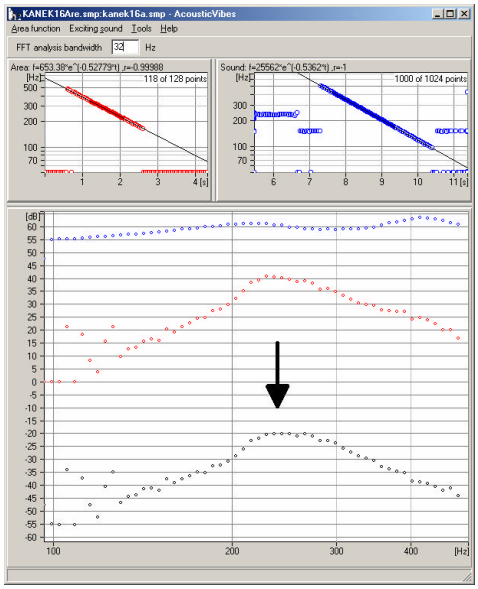

Figure 2 Analysis of resonance frequency in the glottal area variation during the sinusoid sweep. The sweeps are shown in the upper panels, and the response curves are shown in the lower panel. The lower curve in the bottom panel shows the compensated response curve of the glottal area; note the resonance at around 230Hz (arrow).

vocal folds as excited by the frequency sweep. A special software was used for FFT analysis of the area and sound waveforms (Figure 2)

The software used a simple algorithm to detect F0 in the waveform files; the highest peak in the FFT spectrum was assumed to correspond to the F0.

Results

The results showed that all subjects had a resonance frequency close to the F0 of the phonations before the Kaneko manoeuvre. Barytone 1 also had a lower resonance at 80 Hz. The resonances of the high-pitched phonatory settings were difficult to analyse but seemed to be lower than the F0 of the phonations before the Kaneko manoeuvres. There were also clear differences between the different voice categories, as expected with the soprano and mezzo-soprano showing the highest habitual setting resonances.

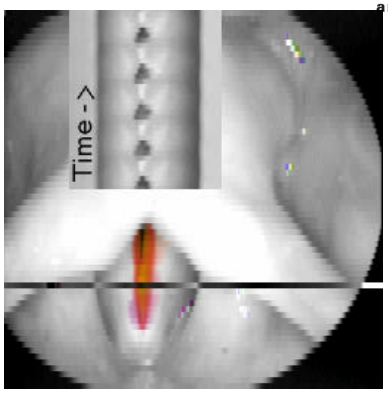

Figure 3 Laryngoscopic image and kymogram for the recording in Figure 2 at f=230 Hz. The oscillating area is marked with red colour.

Subject	**Phonation 1** Resonance (habitual pitch setting)	**Phonation 2** Resonance (higher pitch setting)
Soprano	230Hz (230Hz)	300Hz (345Hz)
Mezzosoprano	200 Hz (210Hz)	300Hz (420Hz)
Barytone 1 (pro)	75Hz (115Hz)	80Hz and 180Hz (220-225Hz)
Barytone 2 (amateur)	120Hz (120-140Hz)	180Hz (190Hz)

Table 1: *Resonances found for the habitual phonatory settings and for the phonatory settings with higher pitch, within brackets:F0 for the phonations before the Kaneko manoeuvre.*

DISCUSSION and CONCLUSIONS

The method of exciting the vocal folds by means of an acoustic signal seems to work well, and thus it seems possible to study vocal fold resonances with the technique used. The area analysis is rather time-consuming. The technique also requires subjects who are able to perform the Kaneko manoeuvre. The results indicate that the method can be used for studying the vocal fold's small-signal resonances. These resonances are probably important factor in the description of vocal fold mechanics and tissue characteristics.

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