CT BASED FE MODELING OF THE ACOUSTIC EFFECTS OF NASALITY FOR VOWELS [A:] AND [I:] IN FEMALE VOICE

Tomáš Vampola*, Jaromír Horáček, Anne-Maria Laukkanen*****

*CTU in Prague, Dept. of Mechanics, Biomechanics and Mechatronics, Prague, Czech Republic
**Institute of Thermomechanics of the Czech Academy of Sciences, Prague, Czech Republic
***Speech and Voice Research Laboratory, Faculty of Social Sciences, Tampere University, Tampere, Finland
tomas.vampola@fs.cvut.cz; jaromirh@it.cas.cz; anne-maria.Laukkanen@tuni.fi

INTRODUCTION

Classical singers use nasal consonants as 'resonance exercises', and aim at vibratory sensations at the nose and facial structures. According to [1], a male singer used slight velopharyngeal opening for [a:] but not for [i:]. This was explained as a means to increase the prominence of the singer's formant during [a:] by decreasing the acoustic energy at F1 region. On the other hand, the nasal cavity may also serve as a narrowing for the main vocal tract, which might increase reactance over a wide range, thus supporting vocal fold vibration. This study investigates the effects of nasality at the wide region of fo variation in singing.

METHODS

A novel, computerized tomography based model of the vocal tract and the nose from the same female volunteer was used. She sustained the vowels in speech range.

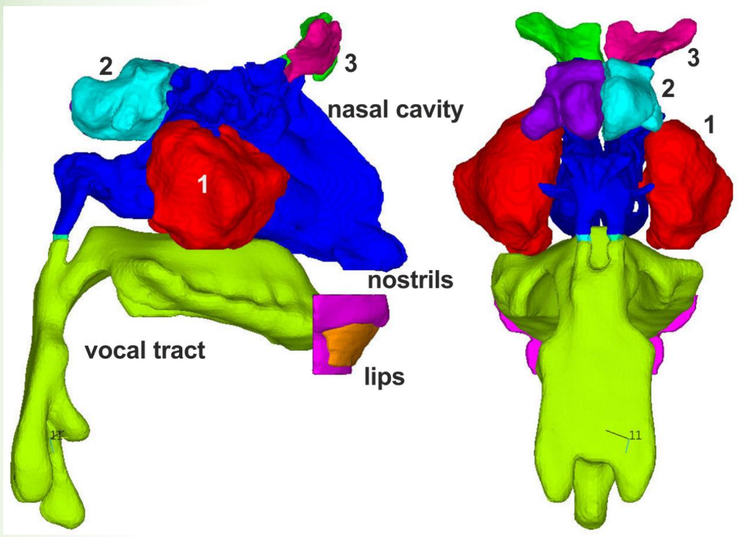

Figure 1: *Computer volume model of the human vocal tract for the nasalized vowel [a:] with the paranasal sinuses: 1 - maxillary, 2 - sphenoid, 3 - frontal.*

RESULTS

Figure 1 shows reactance calculated over the frequency range 0-1.5 kHz for vowel [a:] and 0-1.1 kHz for [i:] without and with nasality. With nasality, the lowest resonance frequency R1 clearly increased, and the reactance decreased throughout the range compared to non-nasalized phonation.

[a:]	R1 [Hz]	R2 [Hz]	[i:]	R1 [Hz]	R2 [Hz]
without	599	1260	**without**	231	2209
with nasality	625	1265	**with nasality**	339	2233

Table 1: *Lowest resonances for vowel [a:] and [i:] without and with nasality .*

DISCUSSION

The findings for R1 are in line with those observed for male speaker based on MRI [2] but differ for the other resonances. Nasality seems to lower acoustic energy in general for the female. The only potentially beneficial effect of nasality in this participant might be that due to higher resonance frequencies, the vocal tract seems to be inertive at *passaggio* regions 300 Hz (for [i:]) and 500 Hz and also at ca 1000 Hz (for [a:]) which is near the high c for sopranos. Also [3] reported that tenors in their study used velopharyngeal opening at *passaggio*.

CONCLUSIONS

Some nasality may offer assistance for phonation at *passaggi*. This requires further investigation.

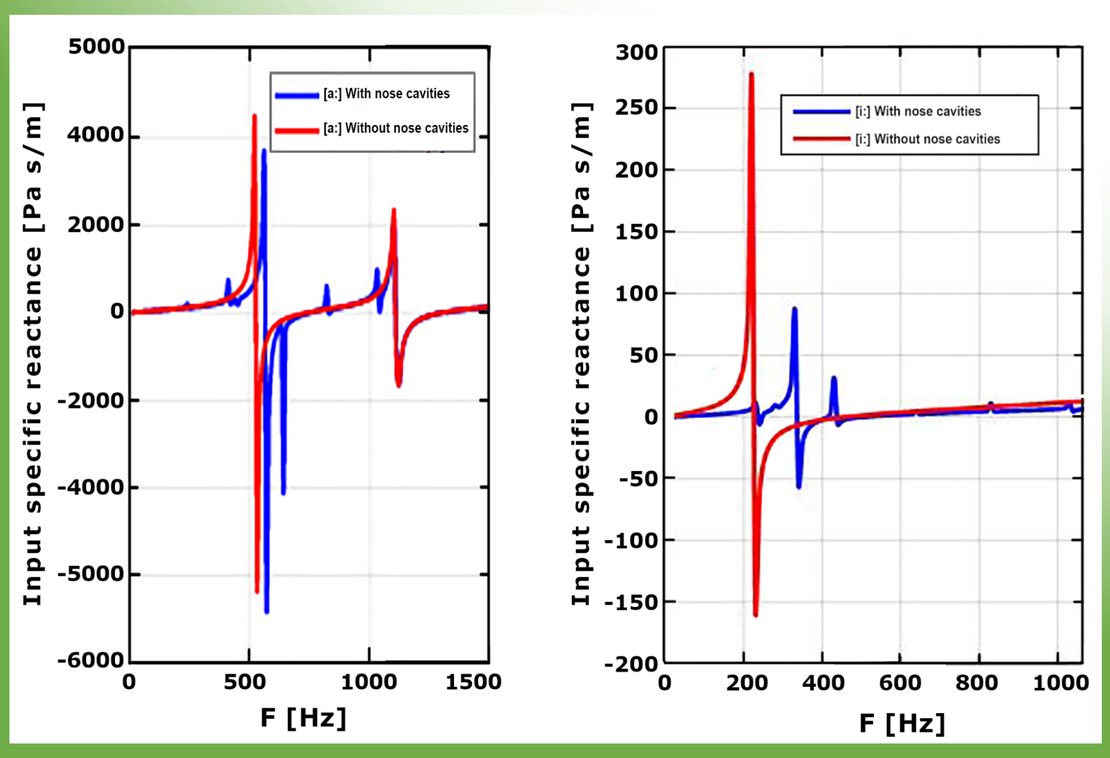

Figure 2: *Reactance with and without nasality for vowel [a:] and [i:] in a female amateur singer.*

ACKNOWLEDGEMENTS

The study was supported by a grant GACR 19-04477S.

REFERENCES

[1] Sundberg J et al, J Voice 21(2): 127-137, 2007.

[2] Vampola T et al, Acta Acustica, 94:448-460, 2008.

[3] Birch P et al, J Voice 16(1):61-71, 2002.