FORMANT ANALYSIS OF SNORING SOUNDS

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I. INTRODUCTION

Snoring sounds can be defined as noisy signals whilst inhaling, with a disturbing effect on the patient him/herself or his/her surroundings. A snoring sound can be produced at various levels along the vocal tract. Research does not yet provide consistent results, due to 1) the abundancy of noise features and 2) the large intra- and interindividual variability. However, as vocal tract anatomy and acoustical characteristics are individually unique, we hypothesized that 1) the formant structure of snoring sounds contains similarities compared to the formant structure of inhaled open vowels and 2) the eventual differences in formant distribution between various snores could be linked toward the level of constriction.

II. METHODS

A female subject produced a muffled vowel /a/ on an inward airstream and several snoring sounds at various levels: the laryngeal level, the tongue base level and the velopharyngeal level, the latter with a closed and open mouth. The signals were processed with PRAAT and BioVoice.

Statistical analysis

Due to the small sample size only descriptive statistical analysis was performed (Excel).

III. RESULTS

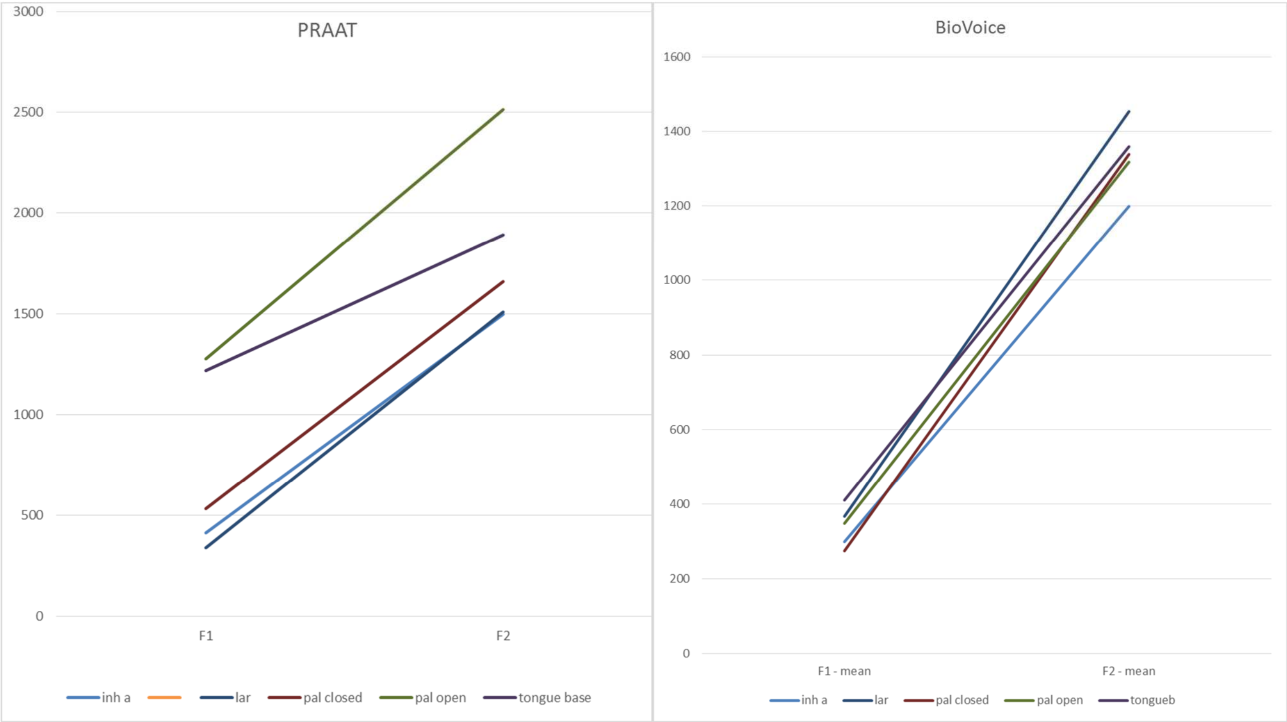
Analysis with PRAAT reveals a similar formant distribution for the laryngeal snore compared to the inhaling /a/. Formant distribution of the velopharyngeal snore demonstrates a clear F1 and F2 raise, linear to the laryngeal snores and the inhaling /a/. Closing the mouth has an adverse effect on the F1 and F2 raise. F1 in tongue base snores approaches the F1 in the velopharyngeal snore; F2 lies in between the F2 of the laryngeal snore and the velopharyngeal snore. BioVoice does not differentiate the various acoustical samples through formant analysis. However, this software analysis program clearly shows that snores (mainly tongue base and open palatal snores) contain a lot of noise and irregularity and therefore urges for caution in interpreting the results.

IV. DISCUSSION

In sound production at the laryngeal level, the vocal tract keeps its full length and resonator capacities, which concurs with the observed identical formant distribution between the inhaling vowel /a/ and the laryngeal snore. In tongue base and velopharyngeal snores, the sound source lies anatomically higher. Whether this also induces an F1 and F2 formant raise due to a shortening of the acoustical tube, still remains unclear as sound propagates multidirectionally. The F1 and F2 increase in velopharyngeal and tongue base snoring can at least partially be explained by an enlarged jaw and mouth opening whilst sleeping. The F2 lowering in tongue base snores indicates a narrower pharynx comparative to velopharyngeal snores. Striking is the effect of closing off the oral cavity. Perhaps this can be explained by a lengthening of the resonator tube due to cutting off an acoustically relevant side path. Some drawbacks have to be mentioned: the abundant signal irregularity and noise might blur the F1 calculation and possibly cause a F1 "jump".

F1-F2 formant analysis of snoring sounds compared to inhaling /a/

Figure



Table

praat	F1	F2	F1/F2
inh a	412,478 (99,6)	1494,818 (131)	0,276
lar	339,659 (50,0)	1506,950 (43,9)	0,225
pal closed	533,481 (456,3)	1657,885 (363,5)	0,322
pal open	1275,820 (201,8)	2515,591(324,5)	0,507
tongue base	1216,589 (145,8)	1890,281 (499,0)	0,644

biovoice	F1	F2	F1/F2
inh a	298,763 (9,8)	1198,935 (198,3)	0,249
lar	366,012 (81,9)	1453,453 (104,4)	0,252
pal closed	275,432 (39,5)	1339,312 (122,1)	0,206
pal open	347,792 (48,5)	1318,838 (87,1)	0,264
tongue base	410,845 (264,6)	1359,435 (285,9)	0,302