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Acoustic Properties and Effects on Phonation

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The relevance of nasal resonance is sometimes discussed among voice clinicians and singing teachers, although often leading to no conclusions. This seems to be a typical result of access to nothing but personal experience combined with lack of objective knowledge. During the latest decades, I have had the privilege of joining forces with friends in different research areas to investigate the effects of nasal resonance. After a brief description of the nasal tract anatomy, the results of these investigations will be presented and discussed.

Two of the studies were made with singing teacher Peer Birch and his associates. In the first we documented the occurrence of a velopharyngeal opening in 18 professional opera singers by means of nasal fiberscopy. The results revealed that more than half of the singers produced the vowels /a/ and /u/ with a VPO of different shapes and widths. Perceptual evaluation revealed that a narrow VPO does not make the vowel sound nasalised. In a following study, the effects of VPO on the vocal tract sound transfer function was measured in 20 cm long cylindrical tube connected via a VPO-type hole to a 10 cm long cylindrical tube. As predicted by acoustic theory, this model acted as a shunt, producing a sharp minimum in the transfer function of the long tube.

A sequence of later studies were carried out together with phoniatrician Miriam Havel, München and her associates. Here, the source transfer function of the nasal tract was measured in ex vivo as well as in 3D models of the several nasal tracts. The results showed a great individual variation of the nasal landscape and also documented acoustical effects of the maxillary and sphenoidal cavities. Further, three models of nasal tracts were connected via coupling tubes of different dimensions to 3D-models of vocal tracts of five vowels. Results showed a dip in the transfer functions at the main resonance frequency of the nasal tract. The dip grew deeper with increasing width of the coupling tube, and only wide coupling tubes produced dips caused by resonances in paranasal sinuses. Also, connecting the vocal tract to a nasal tract increased the frequency and reduced the amplitude of the first formant peak.

Filipa Lã, Madrid and Brian Gill, Bloomington IN, and I analysed the effect of a VPO on long-term-average spectra. Nine advanced singer students sang vowel sequences into a divided flow mask under three conditions; wide open, narrow and closed velopharyngeal port. Nasal and oral airflow were recorded. The results corroborated the effects observed in the

model experiments; the LTAS peak of the first formant was attenuated already by a narrow VPO, thus changing the spectrum balance in favour of high frequency partials.

It is well known that phonation through a long, hardwalled tube causes strong register breaks, due to source-filter interaction. Recently Filipa Lã, Svante Granqvist, Stockholm and I joined forces in an experiment where untrained voices produced pitch glides through such tubes. The glides were produced under three conditions, (1) with the far end of the tube open with no VPO (2) with VPO and the far end of the tube open and (3) with no VPO and the far end attenuated with a piece of cotton. The cotton significantly increased the losses of acoustic energy in the tube and attenuated particularly the first resonance. The number of voice breaks was about twice as frequent under condition (1) than under conditions (2) and (3).

These experiments show that without adding a nasalized quality to the voice, a narrow VPO can enhance high frequency components. They further suggest that a narrow VPO can reduce the risk for voice breaks.