The nasal musculature as a control panel for singing - Why classical singers use a special facial expression?

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Abstract

Objectives: This study aims to explain the possible reason why classical singers seem to spread their nostrils and raise the cheeks before starting to sing.

Study Design: Experimental study.

Methods: Five subjects (3 classical singers, 2 non-singers) were investigated with nasofiberoscopy holding their breath after inhalation. The subjects were instructed to have a neutral expression first and then to take the singers' expression characterized by nostril flaring. In case of non-singers, the special expression was rehearsed beforehand, guided by a classical singer. The following measurements were made: 1) height of soft palate, 2) area of the hypopharynx, 3) area of the epilaryngeal tube inlet (*Aditus laryngis*), and 4) dimensions of the (visible) glottis (length, width and length-to-width ratio).

Results: All subjects raised the palate and widened the pharyngeal inlet, epilaryngeal inlet and the glottis during 'singer's expression'.

Conclusions: The results suggest that classical singers may take advantage of breathing and smelling related connections between nasal and facial muscles and the larynx to avoid a hard glottal attack and pressed phonation and possibly also to assist the production of mixed register (head voice), characterized by a relatively low adduction between the vocal folds.

Key Words: classical singing, singer's expression, nostril flaring.

1. Introduction

Classical singers seem to make special preparations before starting to sing. The preparations involve taking a good posture, deep inspiration, including lowering of the larynx and dropping of the lower jaw. Many singers also seem to spread their nostrils and raise the cheeks before singing.

Rubin et al. [1] stress that the necessity for proper posture has been recognized by singing teachers for centuries. However it has taken the medical community (and the general public) longer to recognize its value. A good body posture facilitates well balanced muscle function for breathing and laryngeal function, while a deviant body posture may be associated with laryngeal hypertension and voice disorders [2,3].

Breathing strategy is generally regarded as an important factor in operatic singing. High consistency of lung volume behavior and of the rib cage control has been reported in classical operatic singers [4]. The type of breathing has also been found to affect the voice source. Lowering of the diaphragm (in ordinary breathing at rest circa 1-3 cm, and in deep inspiration up to 10 cm [5] induces tracheal pull which reduces folding of the laryngeal tissues (i.e. draws the vocal folds and false vocal folds apart) and also lengthens the vocal tract up to about one centimeter [6]. According to [7], the diaphragmatic activation tends to increase the peak amplitude of the flow glottogram, suggesting a change of phonation toward ‘flow phonation’. Coactivation of the diaphgram may also stabilize the vocal tract and formant frequencies during pitch changes.

Articulation and vocal tract setting naturally affect resonance frequencies of the vocal tract [8]. Lowering of the larynx, accompanied by a narrowing of the epilaryngeal tube and widening of the pharynx, is known to be related to the establishment of the singer’s formant cluster which is essential for a classical male singer to be heard over the symphony orchestra [9,10]. A similar cluster can be seen also in female singers at the lower pitch range. At higher frequencies, the female singers tend to adopt another technique. When the target pitch is higher than the first resonance (R1), female singers tend to tune the first resonance to a frequency near that of the fundamental (f0). The articulatory tool for this tuning mainly seems to be jaw opening: the wider the jaw opening, the higher the first resonance [11-13]. Garnier et al. [14] discovered two different lip-opening strategies to achieve R1: f0 tuning. Some singers continuously increase lip opening with increasing pitch whereas other increase it only over the highest part of the f0 range. Spreading of the lips as in smiling also raises the resonance frequencies [8].

In addition to varying the degree of jaw and mouth opening and spreading or protruding the lips, which obviously alter the resonances, the singers tend to use a special facial expression which does not seem to depend on gender, voice classification, pitch, vowel or conveyance of emotions. This facial expression with particular flaring of the nostrils and raising of the cheeks can be seen before starting to sing as well as throughout singing (see Figure 1). This expression can be observed frequently when watching professional classical singers on stage and in the videos and photos taken of world-famous operatic singers while singing. According to Miller: “This slight elevation of the zygomatic musculature is commonly observed among major singing artists who adhere to the international school of resonance balancing.” [15]. A special facial expression is taught by many song pedagogues [16]. They use instructions like ‘open up the upper hall for head resonance’ or ‘smell the scent of a flower/ if something is burning here’ or ‘think of the beginning of yawning’, or ‘think of a bad smell / something disgusting’ or ‘use an inner smile’ [see e.g. 17] when they apparently try to urge this kind of involvement of facial muscles in the preparation. The instruction ‘sing into the mask’, i.e. when it feels that you have an extra layer like a mask over your face and your voice lies between your face and the mask, also seems to be related to the special facial expression.

Many pedagogues have linked all facial expressions to voice quality through resonances. In his book Solutions for Singers Richard Miller reasons how zygomatic muscles affect singing by altering the shape of the vocal tract, and thereby the vocal timbre [15]. He discusses the importance of the zygomatic muscles as they relate to resonance balancing.”When a pleasant expression (not a smile) accompanies complete inspiration, prior to velopharyngeal closure, the velum rises slightly, changing the shape of the resonator tract in the velopharyngeal area”. [15] Miller also writes that a typical French singer seems to raise the upper maxillary area, including the cheeks, nearly as one does in laughter. [18] Some spectrographic observations have been made on the effects of singer's expression on the voice [16], but on the basis of mere acoustic output it is naturally not possible to draw conclusions of what exactly changes inside a singer during a facial expression.

Please insert Figure 1 about here

Figure 1. (a) soprano Angela Georghiu, **(b)** bass Matti Salminen, **(c)** tenor Roberto Alagna, **(d)** mezzo-soprano Elīna Garanča. Reference: www.youtube.com

Even though the singer's expression may be a part of a larger preparation including deepening of the inspiration, lowering of the larynx and thus increasing the pharyngeal volume, and perhaps an increase in the overall state of alertness [see e.g. 19], the present study focuses on the role of the facial expression *per se*. The main muscle responsible for the singer's expression seems to be the alar part of the nasal muscle, *musculus nasalis*, which is the largest of the nasal muscles. It has two parts with opposing functions. The transverse part compresses the nares, and the alar part opens the nares thus causing flaring of the nose. Procerus muscle between the eyebrows helps to open the nostrils. Another muscle that may play a role in the singer's expression is *levator labii superioris alaeque nasi*, lifter of the upper lip and of the wing of the nose, which may give the face a somewhat scornful expression, as in disgust. Yet another muscle, zygomaticus minor muscle (*musculus zygomaticus minor*), may assist in raising the cheeks, without necessarily causing a smile related shaping of the mouth [20].

In this study, we aim to answer two questions:

1) Does something change in the nasopharynx, hypopharynx and larynx of classical singers when they without singing take the singer's expression with flaring of the nostrils?
2) Do the same possible effects on the vocal tract occur also in non-singers when they imitate this posture?

2. Methods

2.1 Participants and tasks

Five volunteers with a healthy larynx participated in the study. Three of them (1 male, 2 females) were trained professional classical singers (age from 37 to 70) with at least 10 years of professional training and 10-40 years of experience in professional operatic singing and teaching of classical singing. The other two were non-singers (a 55-year-old female with some occasional classical singing training in total for about 3 years, and one 38-year-old male with no singing training at all). The non-singer subjects were first shown how a singer's expression looks like, and then imitated and rehearsed it for 1-2 minutes, guided by a professional classical singer. The participants were instructed first to take a deep breath like before starting to sing and hold it, and then to take the singer's expression. In this way we aimed to eliminate all possible breathing related changes in e.g. laryngeal position.

2.2 Nasofiberoscopy

The subjects were scoped in sitting position. Nasofiberoscopic registrations were made by an experienced ENT/phoniatrician using an endoscope (ORL Vision RS1, CCD supplied by Rehder & Partners). The tasks were repeated, so that first the scope was in the nasopharynx, and then so that the scope was inserted in the pharynx. The position of the scope was carefully held the same in both tasks by monitoring the view on a screen. Topical anesthesia was used if needed. All participants tolerated the experiment well.

2.3 Analyses
Measurements of vocal tract dimensions

The nasoendoscopic images were analyzed as follows. 1) The positioning of the soft palate (*velum*) was studied by measuring the distance from the highest part of the velum to the roof of the nasal cavity (see Figure 2 a). 2) The areas of the pharyngeal inlet, the epilaryngeal inlet (*Aditus laryngis*) and the dimensions of the (visible) prephonatory glottis (length and width, and length-to-width ratio) were measured (Fig. 2 b). The area of the epilaryngeal inlet is the space surrounded by the epiglottis in the front, arytenoid cartilages in the back and the ary-epiglottic folds at the sides. ImageJ software (Java8, 64 bits) was used in the measurements. The distances and areas were measured only qualitatively (in pixels), since no calibration was possible to obtain. However, the camera was carefully kept at the same position for both types of samples (i.e. without and with the singer's expression) that were produced in a row. Measurements were made independently by two researchers to evaluate the measurement accuracy.

Please insert Figure 2 about here

Figure 2 (a). Distance from the roof of the nasopharynx, point A, to the soft palate, point B (black line), **(b)** area of the pharyngeal inlet (black line), area of the epilaryngeal inlet (white line), and length and width of the (visible) prephonatory glottis (white cross). The measurements of the areas (in pixels) were accomplished for the spaces that are surrounded by black or white lines. Glottal length and width were measured as distances from point A to point B, and from C to D, respectively. Lower black arrow points to epiglottis and upper arrow to (right) arytenoid cartilage.

3. Results

There was a good correlation between the measurements of the two researchers (Spearman's rho: r 0,85- r 0,98, p 0,007 – p 0,021.)

The results show (Table 1, Figures 3-4) that the velum rose, and the pharyngeal and epilaryngeal inlet and the glottis widened when the subjects took a singer's facial expression. For Subject A (the trained male), the permanently narrow epilaryngeal inlet made it impossible to measure the glottal distances. The size and position of the steady structures did not vary much between the pairs of figures to be compared (i.e. one for without expression and the one with expression). Therefore it can be concluded that the distance between the camera and the objects of study remained sufficiently stable. The length to width ratio of the glottis decreased in all subjects, confirming that the glottis widened, which is obvious also by looking at the images. The ratio calculated between the pharyngeal and epilaryngeal areas shows that in most cases the epilaryngeal area increased relatively more than the pharyngeal area, especially in the trained singers (Table 1).

Please insert Figure 3 about here

Figure 3. Height of the velum, to the left: after normal inhalation, to the right: during flaring of the nostrils.

Please insert Figure 4 about here

Figure 4. Pharyngeal, epilaryngeal and glottal dimensions, to the left: after normal inhalation, to the right: during flaring of the nostrils.

Table 1. Results for measurements of the nasopharynx (= height of velum), pharynx (area of the pharyngeal inlet), epilarynx (area of the epilaryngeal inlet), and the glottis (length and width) in pixels. Changes are presented in percentage.

	After inhalation	With nostril flaring	Difference (%)
Nasopharynx			
Subject A (male)	1152	872	-24,3
Subject B	1512	1170	-22,6
Subject C	98,8	93	-5,8
Subject D (non-singer)	1004	800	-20,3
Subject E (male non-singer)	2722	2068	-24
Pharynx			
Subject A	231367	297900	28,8
Subject B	2357101	2901650	23,1
Subject C	2533190	3391584	33,9
Subject D	375547	461933	23
Subject E	74974	98983	32
Epilarynx			
Subject A	26710	33336	24,8
Subject B	432576	754669	74,5
Subject C	460084	917575	99,4
Subject D	80203	185036	130,7
Subject E	26368	26590	0,8
Pharynx/Epilarynx			
Subject A	8,7	8,9	3,2
Subject B	5,4	3,8	-29,4
Subject C	5,5	3,7	-32,9
Subject D	4,7	2,5	-46,7
Subject E	2,8	3,7	30,9
Glottal length			
Subject A			
Subject B	150	548,5	265,7
Subject C	522,4	454,2	-13,1
Subject D	240	290	20,8
Subject E	509	492	-3,3
Glottal width			
Subject A			
Subject B	120,3	573,2	376,3
Subject C	329,3	611,6	85,7
Subject D	66,9	196	192,9
Subject E	355	549	54,6
Length/width ratio			
Subject A			
Subject B	1,2	1	-23,2
Subject C	1,6	0,7	-53,2
Subject D	3,6	1,5	-58,7
Subject E	1,4	0,9	-37,5

Please insert Table 1 about here.

4. Discussion

Even though the singer's expression may be a part of a larger preparation including deepening of the inspiration, lowering of the larynx and thus increasing the pharyngeal volume, the main reason for exploiting a singer's expression *per se* does not seem to be to change the shape and size of mouth opening and thus to affect the vocal tract resonances, but rather to take advantage of the connection between nasal and facial muscles and the larynx. We compared the nasopharyngeal, pharyngeal and glottal measures before the singers' started to sing without facial expression to those measures that were observed with the expression. The results showed that the singer's facial expression resulted in lifting of the velum, and widening of the hypopharynx, epilarynx and the glottis also when recruited without any other changes e.g. in breathing. These pure facial maneuvers seem to be related to inhalatory and smelling related reflexive muscle functions.

Flaring of the nostrils is known to improve breathing by widening the glottis involuntarily. So-called nose wing breathing (Nasenflügelatmung) has been listed as one of the symptoms seen in patients with difficulties in breathing. Voluntary flaring of the nostrils has been documented in the clinical tips that aid in examining the movement of the vocal folds. It is reported among different other tips in an upcoming Phoniatrics textbook [21]. Patients with Vocal Cord Dysfunction usually also report ease of attacks when shifting the breathing from through the mouth to through the nose, which opens the glottis more. Furthermore, it is interesting to note that flaring of the nostrils has been reported as a common associated gesture in patients with Abductor Spasmodic Dysphonia [22] This can be explained by the fact that nasal muscles have a relation to respiratory muscles. The nuclei controlling these muscles are located close to each other in the brain stem [see e.g. 23].

As related to singing, widening of the glottis (before the phonation starts) may assist not only a quick air intake but also establishing a gentle adduction, which helps to avoid hard glottal attack and pressed phonation [24]. Therewith the collision between the vocal folds during phonation and thus the mechanic load on the vocal fold tissue decreases [25]. When the vocal folds are barely adducted prior onset of phonation it favors the so-called resonant phonation or flow phonation [24,26] which has been regarded as optimum. Furthermore, a wider prephonatory glottis possibly also assists the production of mixed register (head voice), characterized by a relatively low adduction between the vocal folds [27]. It is possible that raising the velum may also cause some vertical stretching on the vocal fold tissue, which could be helpful for mixed register phonation. Together with an adequate vocal tract setting the gentle glottal adduction may increase acoustic-mechanic interaction between the vocal folds and supra- and subglottal resonances. The increase in acoustic-mechanic interaction would allow lower phonation threshold pressure and wider amplitude of the vocal fold vibration without excessive collision, and thus improve effective and economic vocal fold vibration [28].

Widening of the pharynx (e.g. by lowering the larynx, relaxing the pharyngeal constrictors and to some extent by raising the velum) and narrowing of the epilarynx may be seen beneficial to establish the singer's formant [9,10]. Narrowing of the epilaryngeal tube has been documented in classical singers [28,29]. A widening of the epilaryngeal inlet, which was seen in the present study, may be explained by the fact that we documented the situation just prior onset of phonation, not during it. It is possible that the singer's expression, which remains throughout singing, helps the singer to control the three sphincters of the larynx [29] separately, i.e. to keep the adduction gentle while at the same time narrowing the epilarynx.

The results of the present study suggest that flaring of the nostrils may be a useful, concrete tool in voice and speech training and voice therapy to promote soft voice onset and to avoid or reduce vocal hyperfunction.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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