What is Glottal Whistle ?

The extreme end of the whistle register or a distinct vocal register?

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Introduction

Whistle register / Flageolet register

- the whistle or flageolet register is associated (Di Corcia & Fussi 2016) with M3 (Roubeau et al. 2008)
- most descriptions note frequencies above 1000Hz up to 1397Hz (F6 in Mozart's *Queen of the Night* aria), or somewhat higher
- formant tuning interaction (Miller & Schutte 1993)
- ingressive productions show similar range (Di Corcia & Fussi 2016)
- often described as having a separate tuning mechanical principle, in which the vocal folds no longer close and only a small part of them vibrates (despite Echternach et al. 2013 showing full glottal closure)

Split tones / Chink tones

- term used in analogy to phenomena in wind instruments („Spalttöne" in German); cf. Klingholz (1986, 98) ref. to whistle register in women and children
- presumably resulting from a periodic vortex shedding as driving force of air particles for inducing a phonation like phenomenon (cf. Herzel & Reuter 1997, Habermann 1986) i.e. complex interaction of aerodynamical and biomechanical forces leading to areas of bifurcation > biphonation (Berry et al. 1996)
- Schütz (1953) mentions laryngeal whistle by Schultz (1902) with a range from G5 (775Hz) to F7 (2760Hz);
- Tsai et al. (2008) suspect a vortex mechanism in a 4kHz-voice of a Taiwanese singer

Glottal Whistle (GW)

- differs from the whistle register in its auditory impression (softer with reduced sonority) and therefore theorised as M4 (Edgerton et al. 2013)
- reported by Edgerton 2013 to range between 1 and 3kHz); similar for both sexes
- however, in the example of Demetrio Stratos f0 raised up to 6900Hz (Cantare la voce, 1978)
- egressive & ingressive productions appear similar in range, pitch seems to singers 'not controllable'
- biphonic portions seem to be frequently occurring with glottal whistle
- vocal production mechanism unknown so far: vortex mechanism or partial vocal fold vibration?

Methods

A digital recorder (*Roland R-05*) was used for recordings (resolution of 96kHz/24bit, downsampled to 44kHz/16bit) of a soprano (author1), who is familiar with multiphonic vocal sounds. The results of acoustic spectral analysis of high pitch vocalization (recorded in 2012) and transition to glottal whistle will be discussed. The selected spectrum settings were 0-8000Hz, window length 0.04s, dynamic range 60dB. A flexible endoscope from *Xion Medical* (*EndoSTROBE Spectar*) and an EGG (*Xion Medical*) were used for video stroboscopy. EGG would not give reliable results and left out from analysis.

Results

GW reminds of nonlinear dynamics as found in neonatal cries, "extreme voices", voice disorders, and mammalian vocalization (cf. Miller & Schutte 1993). In transition from high pitched whistle register phonation becomes noticeable irregular in terms of creaky-like perturbations (Fig.1 and Fig.2).

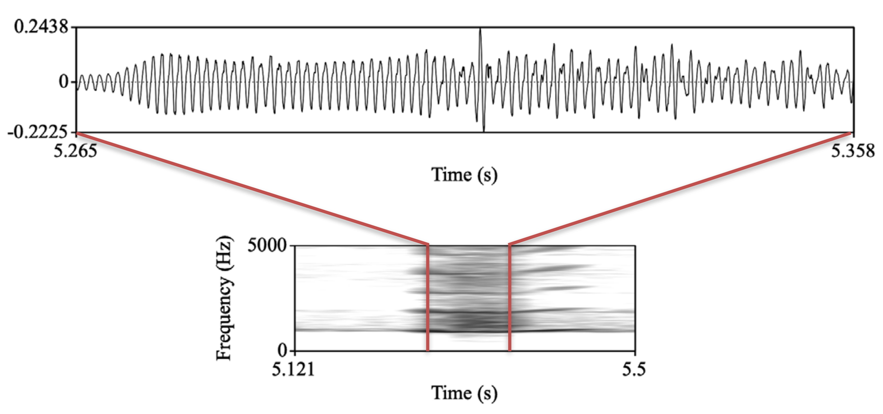

Figure1: transition from periodic to irregular phonation

The spectrogram reveals harmonics which are not parallel, some even move in opposite directions to each other and do not seem to be part of a harmonic coupling, indicating independent fundamental frequencies. During transition amplitude and/or frequency modulations (Fig. 3) generate so called *sidebands* (cf. Wilden et al. 1998) which become seemingly independent from f0. These occurrences of independent 'harmonics' give a strong indication of a true biphonation.

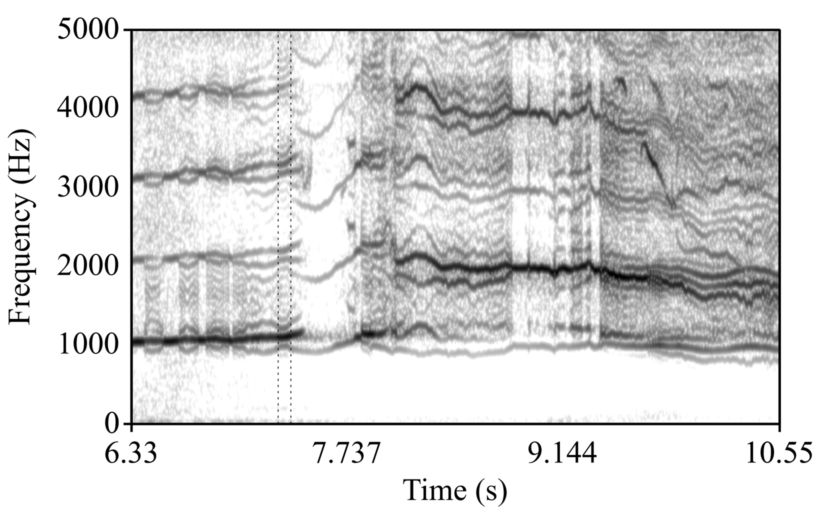

Figure 2: transition from an irregular high pitched voice to glottal whistle; spectrograms starts with irregular phase in whistle register

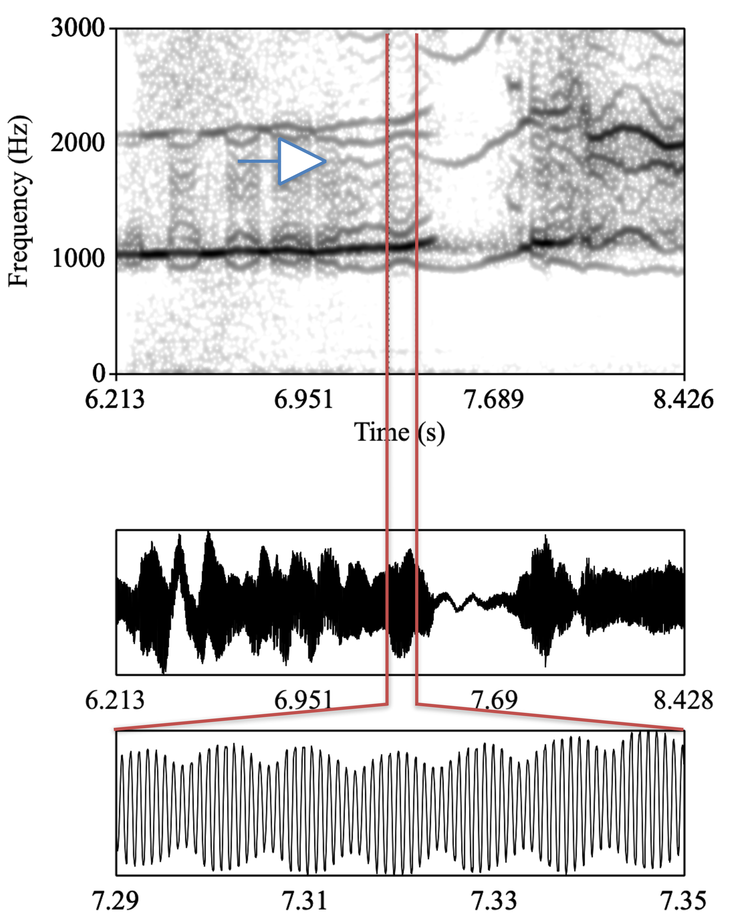

Figure 3: amplitude modulation (modulating frequency of approximately 110Hz), accompanied by a sideband (arrow).

In Figure 4, independent movements of harmonic-like sidebands occur at the beginning of the passage, with different behaviours in 900 to 2000Hz range versus 2 to 4kHz ranges. In the lower range two stronger sidebands (ca. 750 and 1500Hz) draw continuously further parallel, with more energy in the upper band. In the higher range two other at 2.8 and 3.5kHz appear. For the GW passage, varying but parallel bands at (1.1,) 1.8, 2.6, 3.4 and 4.2kHz overlap with those straight parallel bands at 0.75, 1.5, 2.25, 3.0, 3.75kHz.

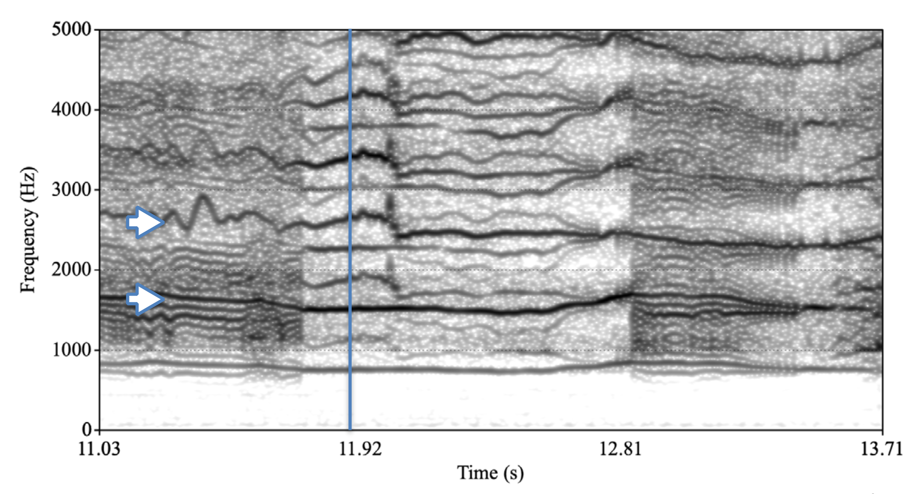

Figure 4: seemingly independent sidebands / 'harmonics' (arrows) in the transition and during glottal whistle phonation (blue line).

Our preliminary endoscopic examination reveals a highly constricted larynx entrance, especially in the mediolateral plane by means of the lateral pharynx walls. Due to the backward movement of the epiglottis during glottal whistle, the tip of the endoscope had to be placed between the epiglottis and the back wall of the pharynx. The laryngeal configurations (Fig.6-7) are described by grid parameters (cf. Painter 1991; Grawunder 2009, 59), following a scale of 0 to 4 (normal to extreme; narrow) in the mediolateral dimension: distance between VFs/glottal width [3], ventricular folds width [3], distance between arytenoids apices [3], epiglottic width as measured the junction with the superior ridge of the aryepiglottic fold on each side [2]; and in the anteroposterior dimension: glottal length [2-3], epiglottic tip position [2]; cuneiform fronting [3].

Figure 6a: configuration of the supralaryngeal vocal tract at phonation onset

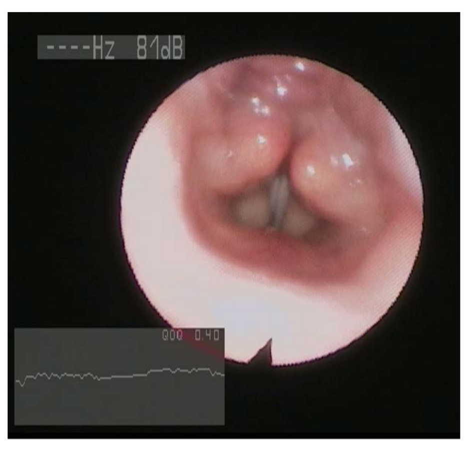

Figure 6b: configuration of the supralaryngeal vocal tract during phonation at lower level than Fig. 6a

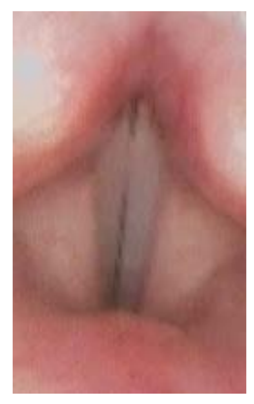

Figure 7: Only a small part in the posterior area of the VFs seems to be connected.

Discussion

Although the mechanism of the underlying voice production of 'our' glottal whistle cannot be resolved yet, on the one hand, the laryngeal configuration are reminiscent of a previously inspected 4kHz voice (Tsai et al. 2008), favouring a vortex-like mechanism. On the other hand, given the found complete closure in whistle register phonation by means of high-speed video (Echternach et al. 2013), our preliminary results allow to speculate about a possible partial glottis with ‚dual appearance', i.e. two separate shorter portions of a medially compressed glottis, thus biphonic passages. Hence, a continuity of these productions would need to be shown for different individuals, airstreams modes etc.

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