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Sound and video examples complementing the article „Three registers in an untrained female singer analyzed by videokymography, strobolaryngoscopy and sound spectrography"

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This memo offers and describes the sound and video examples which were analyzed in the paper [1] Švec JG, Sundberg J, and Hertegård S: Three registers in an untrained female singer analyzed by videokymography, strobolaryngoscopy and sound spectrography. Journal of the Acoustical Society of America 123 (1): 347-353 (2008). There has been a lack of objective data on the singing voice registers, particularly on the so called "whistle" register, occurring in the top part of the female pitch range, which is accessible only to some singers. This memo offers unique sound recordings and laryngoscopic video recordings of an untrained female singer capable of producing three distinct voice qualities, i.e., the chest, head and whistle registers. The transition from chest to head register, accompanied by pitch jumps, occurred near B4-C#5 (500 - 550 Hz) and was found to be associated with a slight decrease in arytenoids adduction, resulting in decrease of the closed quotient. The register shifts from head to whistle, also accompanied by pitch jumps, occurred around tones E5-B5 (670-1000 Hz) without any noticeable changes in arytenoids adduction. Some evidence was found for the vocal tract influence on this transition. The mechanism of the vocal fold vibration in whistle register was found principally similar to that at lower registers: vibrations along the whole glottal length and vertical phase differences (indicated by sharp lateral peaks in videokymography) were seen on the vocal folds up to the highest tone G6 (1590 Hz).

The sound and video examples described in this memo can be downloaded from the web at www.ncvs.org/ncvs/library/tech.

Keywords: voice registers, whistle register, singing, pitch jumps, register transitions, bifurcations, laryngostroboscopy, vocal fold vibration

1. Chest - head register transition:

File "Fig1_sound.wav": Singing ascending scale from chest to head register, sound

This is the sound file analyzed in *Figure 1* of the article in the Journal of the Acoustical Society of America (JASA). The subject is singing a scale starting in chest register at the fundamental frequency of c. 350 Hz (tone F4) progressively raising the pitch. The sixth tone (C#5, c. 550 Hz) is initiated in head register but jumps back to the chest register. The seventh (D#5, 620 Hz), eight (E5, 670 Hz) and ninth tones (F5, 700 Hz) are produced in the head register. Notice the sudden difference in the sound quality when changing the register from chest to head. This phonation, as well as all the other phonations, was recorded during laryngoscopic examination (the subject was singing with a rigid laryngoscope in the mouth allowing observing the vocal folds).

File "Fig1_videoStrobe.mpg": Singing ascending scale from chest to head register, strobolaryngoscopy

This video recording shows the vocal folds in stroboscopic light during the ascending scale analyzed spectrographically in *Figure 1* of the JASA article. The sound of the video example is the same as in the file **"Fig1_sound.wav".** The chest-head register transition is accompanied by a slight decrease in arytenoids adduction: notice the difference in the posterior part of glottis (upper part of the video image) between the 6th tone (C#5, time c. 13-15 seconds) produced in the chest register and the 7th tone (D#5, time 15-17.5 seconds) produced in the head register. The phases of maximum glottal closure and maximum glottal opening during these tones were used to generate *Figures 2 and 3* of the JASA article.

File "Fig4_sound.wav": Another ascending scale from chest to head register, sound

This is another sound example of the chest to head register transition, which was spectrographically analyzed in the *Figure 4* of the JASA article. Starting at the frequency of c. 245 Hz (tone B3) in the chest register and progressively raising the pitch, the transition occurred during the 8th tone in a form of an upward pitch jump from c. 490 Hz (tone B4) to c. 560 Hz (tone Db5). This sound was recorded during videokymographic examination the results of which are shown in *Figure 5* of the JASA article.

2. Head - whistle register transition:

File "Fig6_sound.wav": Singing ascending scales from head to whistle register, sound

This sound file was spectrographically analyzed in the *Figure 6* of the JASA article. The file contains two ascending scales both of which start in the head register and end in whistle register. There are transitions in the form of pitch jumps as well as the transition in the sound quality when the frequency goes above 1000 Hz (tone B5). The highest tone achieved was G6 with the fundamental frequency of 1590 Hz.

File "Fig6related_videoStrobe.mpg": Singing ascending scale from head to whistle register, strobolaryngoscopy

This is the strobolaryngoscopic video recording showing the vocal folds when singing the ascending scale starting in the head register and continuing into the whistle register up to the highest tone of G6 (1590 Hz). We did not recognize any distinct changes in the gross laryngeal adjustment during the head-to-whistle register transition recorded here. The vocal fold vibrations are well visible in the lower tones and around the transition. With further increasing the pitch, the vibrations are fuzzy for a few tones as the stroboscope loses track of the vocal fold vibrational frequency but the stroboscopic triggering comes back for the highest tones. Notice that the vocal folds are clearly vibrating along their whole length in the highest tones in the whistle register. Apart from the complete lack of glottal closure and smaller amplitudes, the overall vibration behavior of the vocal folds at this highest pitch appears to be principally similar to that of the lower registers.

File "Fig8_videoStrobe.mpg": The highest whistle register tone G6, F0 ~ 1590 Hz, strobolaryngoscopy

This strobolaryngoscopic video recording is extracted from the previous file "**Fig6related_videoStrobe.mpg"** and shows only the highest whistle register tone of G6 (1590 Hz). The stroboscope was reporting the frequencies of 445-619 Hz (these appeared on the display during the recording) but the latter analysis showed that these were incorrect (since the true fundamental frequency was above the intended analysis range of the stroboscope circuitry) – the true vibrational frequency of the vocal folds achieved here was around 1590 Hz. The phases of maximum glottal closure and maximum glottal opening during this tone were used to generate *Figure 8* of the JASA article.

File "Fig9_sound.wav": Pitch glide, with two subsequent pitch jumps during the head-whistle transition, sound

This sound file was used for the spectrographic analysis shown in *Figure 9* of the JASA article. It captures a glide upwards in pitch starting in head register and finishing in whistle register. There were two successive pitch jumps during this phonation: from 740 to 880 Hz and from 1000 to 1150 Hz.

File "Fig9_videoLaryngoscopy.mpg": Pitch glide, with two subsequent pitch jumps during the head-whistle transition, laryngoscopy

This laryngoscopic video recording shows the vocal folds in continuous light during the ascending scale analyzed spectrographically in *Figure 9* of the JASA article. The sound is identical to that provided in the file "**Fig9_sound.wav**." Due to the absence of stroboscopic light, no vibrations of the vocal folds are visible, but the activity of the laryngeal structures surrounding the vocal folds can be observed here. The first break appears to be accompanied by a slight lateral retraction of the ventricular folds. No apparent sudden change in the gross laryngeal adjustment was recognized during the second break.

Literature

[1] Švec JG, Sundberg J, Hertegard S: Three registers in an untrained female singer analyzed by videokymography, strobolaryngoscopy and sound spectrography. J.Acoust.Soc.Am. 123 (1): 347-353 (2008).

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Revisions

1.0 Jan Švec: Main document, Eric Hunter (NCVS Webmaster) for some formatting and library formatting (Nov. 2007).
1.1. Jan Švec: update of the JASA reference (Jan. 2008)