SWEDISH VOICES IN MUSIC

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ABSTRACT

Two exotic forms of singing in Swedish folklore are presented, kölning and jojk. Data on tuning of scale tones, formant frequencies, and articulatory characteristics are presented for two representative examples of each of these singing styles. The substantial differences from Western operatic singing are discussed.

INTRODUCTION

The voice is an important music instrument in Sweden. Sweden has produced a number of great international singers in the operatic tradition, e. g., Jussi Björling, Birgit Nilsson, Ann Sofi von Otter, Gösta Winbergh and Håkan Hagegård. This style of singing has generated a considerable amount of research during the last decades.

Apart from this, choral singing is exceptionally common in Sweden. Of the Swedish population a total of about 5 to 10% is or has been a choir singer. My colleague Sten Ternström has analyzed acoustical aspects of choral singing extensively and has published the result in a great number of articles (for a review, see [1]).

The acoustic voice characteristics in speech and singing differs considerably. In the case of classical operatic singing the main reason for these differences is reasonably well understood; the need for being heard over a loud orchestral accompaniment without straining the voice.

Also in the folkloristic subcultures in Sweden the voice is commonly used as a music instrument. It is used not only in folk songs, but also without a text, with vowel sequences or nonsense syllables, more like an instrument. In some Swedish subcultures very peculiar styles of singing have evolved. Two examples will be presented here. Both offer interesting examples of differences between singing and speech.

Kölning

My first example is an exotic kind of herding song practiced by the maids in the province Dalecarlia during the summer, when the cattle was brought up to the woods in the mountains to graze. The type of singing is called kölning, a derivative of kalla (call) and has been described elsewhere [2]. The extramusical function of kölning was mainly to collect the cattle in the evening, but kölning was also used by the maids to communicate with their colleagues on other mountains.

The structure of these songs is a sequence of short melodic patterns, some of which are repeated. Kölning is typically performed on sustained vowels without interleaved consonants. The acoustic and articulatory characteristics of this type of voice use were investigated some time ago [3]. Next, typical results from these investigations will be reviewed and compared to Western operatic singing as studied in another, similar investigation [4].

The subject was a woman, born 1909, who had learned this singing style from an unbroken oral tradition. She was also a choir singer, so her kölning technique

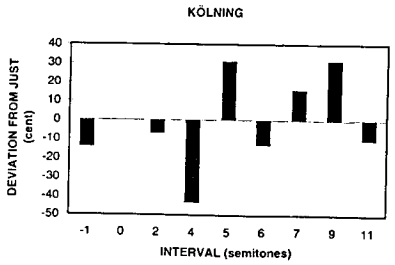

Figure 1. Mean F0 values, determined by means of histograms, for the scale tones in kölning as deviations from just tuning. The unit is cent, i. e., hundredth of a semitone.

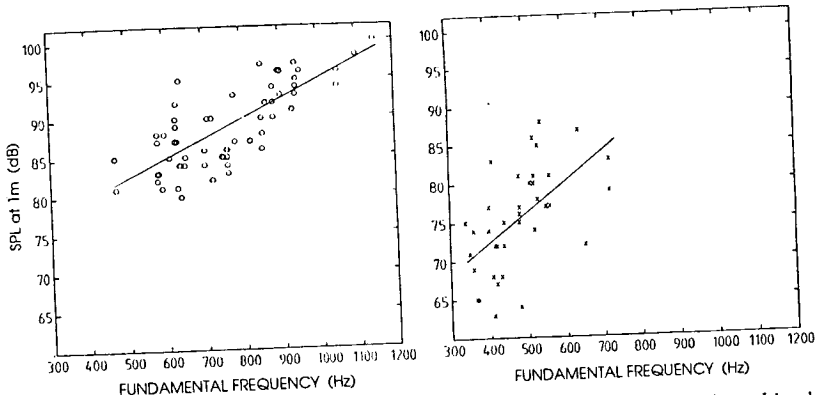

Figure 2. SPL values measured in an anechoic room at 1 m distance in the subject's kölning and singing (left and right panels). The line shows the best linear fit.

could be compared to a more regular type of singing.

The mean F0 of the scale tones she used in one recording of a kölning was analyzed by means of F0 histograms. In Figure 1, the values are shown in terms of deviations from just tuning, the unit being cents, i. e., hundredths of a semitone (st). Just tuning is obtained by multiplying the frequency of the center tone of the piece by ratios between small integers, such as 3:2, 4:3, 4:5, etc. It is used in Western traditional music along with other, rather similar tunings such as the equally tempered tuning.

In the figure, the values would all stay on the 0 deviation line, if kölning adhered to just tuning. Keeping in mind that a deviation of 100 corresponds to a semitone, some deviations from just tuning are considerable. However, the minor and major seconds, the augmented fourth, the fifth and the major seventh (1, 2, 6, 7, and 11 st) are only about 10 cents away from just. The major third is very flat indeed, nearly halfway down to the minor third. These deviations from just tuning are similar, though far from identical to those previously found in an analysis of a different example of kölning performed by another subject representing the same tradition [5]. We may conclude that kölning has developed a special kind of scale which systematically deviates from just intonation. In particular, the third is neutral, halfway between minor and major, and the fourth is sharp. Thus, in this respect kölning offers a striking

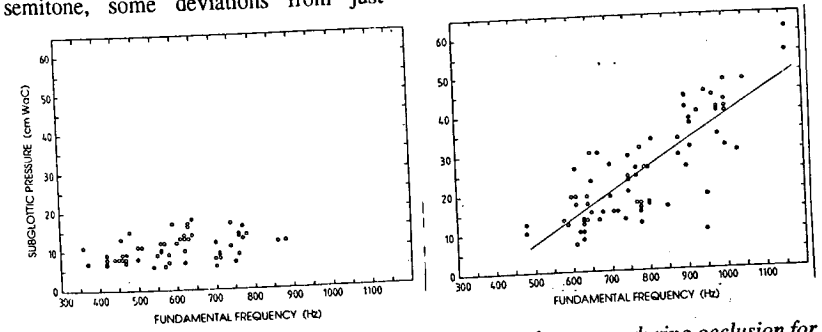

Figure 3. Mean subglottal pressures captured as the oral pressure during occlusion for [p] in the subject's kölning and singing (left and right panels). The line shows the best linear fit.

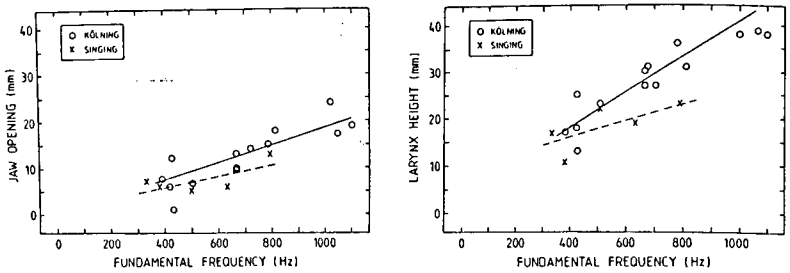

Figure 4. Jaw opening relative to clinched jaws and vertical position of the larynx relative to the resting position in the subject's kölning and singing (left and right panels).

example of the restricted applicability of the tunings used in traditional Western music.

The sound level in kölning was measured in an anechoic room. It was quite high and dependent on F0, as shown in Figure 2. In normal singing at F0=500 Hz the subject produced 76 dB @ 1 m distance, on the average, and the mean increase was about 16 dB/octave. In kölning, the sound level at 500 Hz was about 13 dB higher and the increase with F0 was only 7 dB/octave.

As expected, these high SPL values were paid in terms of high subglottal pressures as illustrated in Figure 3. The mean pressure at F0=550 Hz was 10 cm H_2O and increased linearly with fundamental frequency by about 7 cm H_2O/100 Hz. This clearly exceeds the maximum 20 cm H_2O which the subject used when she sang in a more traditional style.

Articulatory characteristics were studied from tracings of lateral X-ray images of the vocal tract taken at different moments during kölning. Thus, a material of 14 radiographs were collected from a representative choice of pitches within the relevant range. For comparison 5 radiographs were taken when the subject sang a melismatic part of a folk song, using different vowels. The pitch associated with each image was measured from an audio recording. In addition, the kölning data can be compared with corresponding data from a professional soprano singer, the technique of whom was studied in a different investigation [4]. This subject sang the vowels [a:, i:, u:] at three different pitches, F0=240, 480, 960 Hz.

There were clear articulatory differences with regard to e. g. tongue shape, jaw opening, and larynx position. The jaw opening and the vertical position of the larynx tended to increase linearly with F0, particularly in kölning, but also in singing, as illustrated in Figure 4. The larynx was above resting position in both singing styles, and the rise with F0 was quite substantial in kölning, about 23 mm between F0=400 and F0=1000 Hz. In a corresponding study of a professional soprano the larynx was also found to rise with pitch, but the larynx was constantly below the resting level, touching it only for the top F0. During both singing and kölning the subject's distance between the upper and lower lip showed a linear increase with jaw opening and the retraction of the mouth corners was linearly related to this distance. In kölning the tongue shape varied with F0 so that similar shapes were found for vowels produced at similar F0, particularly in the upper part of the pitch range, see Figure 5a. The tongue was pharyngeal with a frontal position of the tongue tip. With rising pitch the tongue root and the dorsum were substantially raised because of the increased jaw opening and the raised larynx. In operatic singing, by contrast, the tongue shape was different for different vowels except in the top part of the range, as can be seen in Figure 5b.

The summed effect of all these articulatory changes with pitch on vocal tract length was substantial, as can be

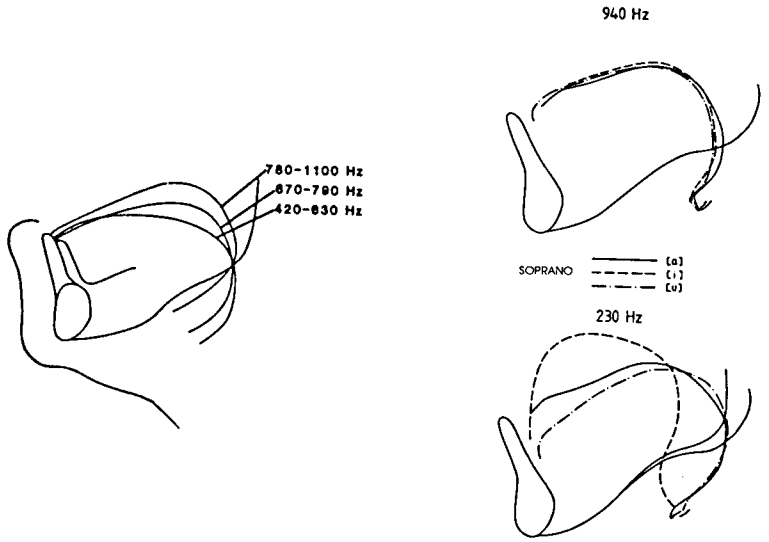

Figure 5a. Tongue shapes relative to the contour of the lower mandible observed in the F0 ranges indicated during the subject's kölning (left panel). Figure 5b (right panel) shows the corresponding data for a professional soprano singer at the F0 values indicated (data from Johansson & al., 1985 [4]).

expected. On average, the tract was shortened by 35 mm between F0=300 Hz and F0=800 Hz, saturating at about 130 mm for higher F0 values. A more moderate decrease was found in the subject's singing.

The formant frequencies were estimated from area functions derived from the radiographs. Lateral tracings of the mid sagittal vocal tract contour were made and these tracings were then converted to area functions by means of the method described by Lindblom & Sundberg [6]. The area functions were then realized in terms of tubes consisting of piles of Plexiglas washers with center holes of different sizes. The resonance frequencies of these area functions were determined by sine sweep excitation by means of the ionophone sound source [7]. The resulting formant frequencies are shown in Figure 6. In kölning, F1 tended to match F0 rather accurately while F2, F3 and F4 remained at about 1700 Hz, 2500 Hz, and 3000 Hz throughout the pitch range studied. Also in the performance of the folk tune, F1 tended to track F0, but the other formants showed more variation with F0. In the same Figure corresponding data collected from the professional soprano singer are shown, revealing a different pitch dependence of F2, decreasing with F0 for the front vowels and increasing for the back vowels.

Summarizing, as compared with normal singing and professional soprano singing, kölning seems quite special with respect to sound level, subglottal pressure, articulation, and formant frequencies. Apart from this, the intonation and the melodic patterns are also quite characteristic. It is difficult to realize why this particular singing style has developed in the Swedish herding culture. The high sound levels would reflect the need for reaching out over large distances. These high sound levels of course raise certain demands on the voice which may entail the formant frequency behavior. However, also operatic soprano singers need to produce extremely loud tones in order to be heard

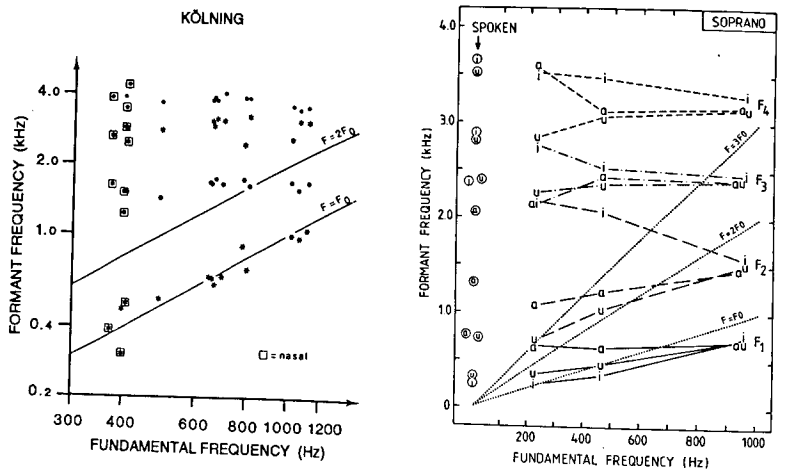

Figure 6. Formant frequencies in kölning estimated from area functions derived from tracings of the X-ray profiles during the subject's kölning (left panel). The right panel shows corresponding data for a professional soprano singer (data from Johansson & al., 1985 [4]).

in large opera houses and there, a different type of singing technique has developed. Thus, keeping in mind that kölning attracts rather than repels the cattle, we may ask whether the special kölning technique has developed to meet the esthetic and auditory demands of the cattle. This question, however, must be left for further investigation.

Jojk

Further north in Sweden another vocal peculiarity can be found, the jojk. This is a song mostly performed by males in various situations, offering another example of a rather special voice use. An acoustical investigation of jojk was carried out. The material was a documentary recording kindly supplied by Svenskt Visarkiv.

A jojk contains text and melismatic tone sequences on various vowels. The melodical structure is repetition of a short melodic sequence mostly using very few tones within a narrow F0 range. Jojks are performed with a hoarse, speech like voice quality, very far from operatic singing.

Formant frequencies were determined for some vowels from a jojk. The result is shown in Figure 7 in terms of a F1&F2 graph. The most striking difference as compared with speech is that F2 remains close to 1000 Hz for all back vowels while for front vowels a more speech like pattern is observed, starting around 2000 Hz for [i:] like vowels and approaching 1600 Hz for the [ae:] vowel. F3 is generally quite low, suggesting a constantly retracted tongue tip.

F0 patterns also are quite special. As in most folkloristic styles of singing there is no trace of the Western diatonic scale. In addition, however, F0 continually glides upward. An example is offered in Figure 8 showing measured F0 values of the four scale tones contained in this jojk. In the figure, the boundaries between

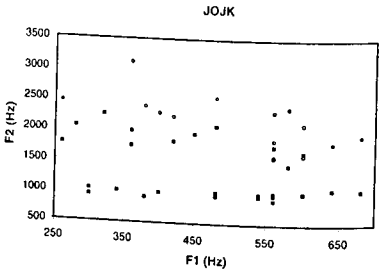

Figure 7. F2 (filled squares) and F3 (open circles) as function of F1 measured in a jojk.

verses are marked by a break in the heavy line joining the data points for the fifth. F0 for all scale tones are seen to increase linearly with time. The rise for the top pitch is almost perfectly linear; the mean rate across all scale tones is 1 Hz/sec. The greatest variability is observed for the lowest tone, probably because of measurement difficulties.

The tonal center of this jojk is the fifth, the tuning of which shows a systematic variation with melodic structure. The tuning is gradually sharpened during the three final tones of each verse, and then starts somewhat flatter at the beginning of next verse. The dashed lines represent pure intervals relative to the central scale tone, the fifth. The minor sixth is almost perfectly tuned, while the third grows increasingly flat.

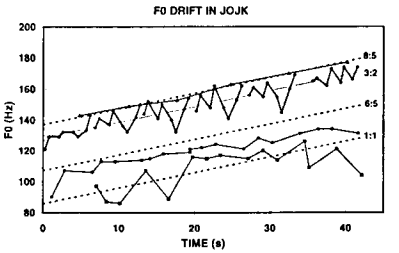

Figure 8. Mean F0 values, determined by means of histograms, for the scale tones in a jojk shown as deviations from just tuning. The unit is cent, i. e., hundredth of a semitone. The thin line shows the best linear fit for the fifth of the scale, and the heavy dashed lines represent pure intervals for the other scale tones.

Discussion

It is interesting to observe these very special data on articulation, formant frequencies and intonation in these two folkloristic examples of Swedish voices in music. In earlier investigations great differences have been revealed between speech and Western operatic singing [8]. However, these folkloristic singing styles deviate from speech in a different way than operatic singing. We have analyzed only one example of kölning and one example of jojk. Still it is interesting to observe the very special characteristics of these two examples of singing styles. They certainly invite to speculations as to the background of these characteristics in these two particular examples. Also, as the two examples analyzed were published as documentary recordings, there seems to be no reason to doubt that they are representative.

With respect to the special tuning of the scale tones the differences between kölning and jojk, on the one hand, and operatic singing on the other, the reason may be acoustical. The main reason would be that, although harmonic spectra are produced in both cases, kölning and jojk are performed without accompaniment. In operatic music, singing is mostly accompanied by instruments which also produce harmonic spectra. Under such conditions beats will occur in consonant intervals if the tuning differs too much from just. The reason is that some partials are common to the tones produced, and these partials will differ in frequency and thus generate beats, if the tuning does not approach just. In kölning and jojk the singers are free to chose intonation as they please. It is frequently assumed that part of the beauty of music relies on the use of ratios between small integers for the scale tone frequencies. The departures from just tuning in kölning and jojk shows that this is by no means true.

The steady rise of the tuning reference in the jojk is interesting. We may speculate that the perceptual effect is an exciting conflict between the perceived intervals, i. e., the pitch difference between the scale tones which reamains basically constant, and the perceived tuning reference which constantly is drifting upward. It is also interesting that small perturbations of the change in reference was used for marking the structure; the drift was increased toward the end of each verse and started with a relatively lower pitch at the beginning of each verse.

The reason for the differences between speech and operatic singing seems to be the need for a loud voice capable of successfully competing with the sound of a loud orchestral accompaniment. A loud voice is needed also in kölning. Yet, the formant frequency strategies used in these cases are not the same. In both cases the principle is used that F1 is raised to a

frequency close to F0 as soon as F0 would otherwise exceed F1. In the front vowels, on the other hand, F2 is lowered with rising F0 in operatic singing while in kölning it seems to remain close to 1700 Hz regardless of F0. The reason may be that only front vowels seem to be used in kölning which results in a homogenity of vowel timbre. Thus, there is no need to reduce vowel quality differences between vowels. This would be important in operatic singing.

Loud voice production is not a concern in jojk. Here, both back and front vowels occur, although F2 values lower than 1000 Hz were not observed. It is possible that the simple melodic structure allows a greater freedom with regard to vowel quality.

The extremely high larynx positions used in kölning is another interesting finding. An elevated larynx position is generally regarded as harmful to the voice among singing teachers. This is certainly true under certain conditions. The behavior of our subject, who had performed kölning during most of her long life and suffered from no phonatory problems, indicates that an elevated larynx position does not necessarily cause damage to the voice.

Conclusions

In conclusion, these folkloristic styles of singing offer striking examples of man's desire to decorate reality with ornaments and patterns. The great differences from operatic singing suggest that the conditions under which music is performed represent a factor of relevance to the articulatory and acoustic characteristics of vocal art. The study of folkloristic singing styles is likely to widen the views and complement our understanding of both music and voice function.

Acknowledgements

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