An acoustic comparison of voice characteristics in 'kulning', head and modal registers

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Abstract

The Swedish folk singing style 'kulning' is surprisingly understudied, despite its almost mythical status in Swedish folklore. While some physiological–productive aspects of kulning have been treated in previous work, acoustic properties are still much lacking description. This paper compares kulning, head ('falsetto') and modal voice from an acoustic perspective.

Introduction

Throughout history, long-distance calls have been created at several different locations where there has been a need of making oneself heard over long distances. Examples include e.g. yodeling (Luchsinger, 1942) and whistled languages (Busnel & Classe, 1976), and such long-distance calls have been used both for human–human communication and for human–animal calling.

Kulning is the most common term (see Rosenberg, 2003:8, for an extensive listing of alternative words) for a specific type of cattle or herding calls used in some parts of Sweden (e.g. Dalarna, Härjedalen and Jämtland) and is used to call cows or goats gracing freely in the mountains when it is time for milking. The tradition of cattle calls dates far back in history and was most common in the province of Dalarna, Sweden, where young women looked after the live stock during summer in small mountain farms, away from the homestead. Kulning generally has no lyrics and consists of vowel-heavy syllables that feel comfortable to the singer. The singing technique is often used by women, and is high-pitched, without vibrato to make the sound carry over long distances. Despite its well-nigh mythical status in Swedish folklore, kulning has received surprisingly little attention from a research point of view. This paper aims at remedy this situation by looking at some of the acoustic properties of kulning, and comparing them to head ('falsetto') and modal register singing.

Previous research

Kulning is mentioned in both Moberg (1955:38 et passim) and Ling (1978), but mainly in passing. For example, Ling (1978:22) states that kulning is not really "singing" in a traditional sense but is more like some kind of falsetto-like calling in very high registers, and that it requires a tightened larynx, while Moberg (1955:37) points out that it is normally sung on vowels, without lyrics in the traditional sense.

Johnson (1984, 1986:216–259) reports that kulning production is characterized by a strong correlation between frequency and amplitude in higher registers (not so much so in lower registers) and that, contrary to classical singing, the larynx moves with the frequency, and is raised considerably when high notes are produced (up to +39 mm). Jaw opening is also correlated with high frequency (in line with classical singing). The vocal tract length is varied with up to 37 mm, compared to 22 mm in normal singing: Also, the pharynx is tightened, even to the point of making optical glottography impossible. Johnson (ibid.) also reports SPL values up to 105 dB (without mentioning any reference values). The results presented in Johnson are largely repeated in Rosenberg (2003:24).

As for the acoustic properties of kulning, Uttman (2002) studied partials spectra of kulning songs obtained from outdoor recordings, and reported strong partials up to the 16–18 kHz register, compared to ~6 kHz in normal folk singing.

Data collection

Data from one female subject (the third author) were collected in two settings: a normal room approximately 5.5 × 7 meters, and in an anechoic chamber (AC), slightly smaller in size.

Recordings were calibrated at 88–90 dBa using a sustained vowel and a sound-level meter (Brüel and Kjaer 2215). The results were announced on the recording. Sound was doubly recorded, but the recordings used in this paper were made using a professional Audiotechnica

AT813 cardoid-pattern, condenser mono microphone that fed into a high-definition video camera (Canon HG-10).

The third author (FP) is educated in kulning at Musikkonservatoriet in Falun and Malungs Folkhögskola, and by Agneta Stolpe and Ann-Sofi Nilsson. Data consisted of FP singing three versions of a cattle call (cattle call from Äppelbo in a traditional arrangement by Agneta Stolpe, Vallslinga från Äppelbo) in each of the two rooms described above. Each song was sung in three ways: (1) kulning voice; (2) head register (sometimes incorrectly referred to as "falsetto"); and (3) modal voice (chest register). Each version of the song was initiated by giving the start pitch using a pitch pipe. The starting tone had the same F_0 independently of room condition. The duration of the song in all of the different versions/singing techniques was approximately one minute.

The recording sessions were unproblematic, although FP reported that singing in an indoors setting, without the characteristic outdoors echo, was a new experience which possibly affected the performance. This was especially true for the anechoic chamber, of course. In both rooms, and for the above reason, FP reported having problems producing a really loud tone, something which was somewhat exacerbated by the fact that FP recently had recovered from a light cold.

Analysis

For analysis, the following post-processing was carried out. Data were resampled to 44.1 kHz, 16 bit, mono. The six different versions were carefully excised from the audio files so as to omit all extraneous sound (like the authors discussing recordings settings). From these files, the first high-pitched [ɥ] was excised. The frequency was around 670 Hz, corresponding to (a somewhat sharp) E5.

The fundamental frequency mode value is the most frequent value occurring in the song. The values were obtained from the entire extracted song in head, modal and kulning registers and for both settings, and F_0 was extracted using Soundswell. The files were all low pass filtered at 1000 Hz, with a maximum frequency 1100 Hz and with a high pass filter set at 40 Hz. As mentioned above, while F_0 mode values were obtained from the modal/chest register and the two conditions, due to the frequency difference of one octave (the modal version being sung one octave lower than the head and kulning versions) no comparisons between modal and kulning/head versions were made. Modal register singing comparisons with kulning/head register singing were only made based on the two different room conditions.

Additional analyses were carried out using Cool Edit Pro 2.0, Cool Edit 2000, WaveSurfer 1.8.8p4 and Soundswell.

Results

Fundamental frequency

First, fundamental frequency in the two settings was examined. The results show a clear effect on F_0 mode value as a function of the two room conditions; see *Figure 1*.

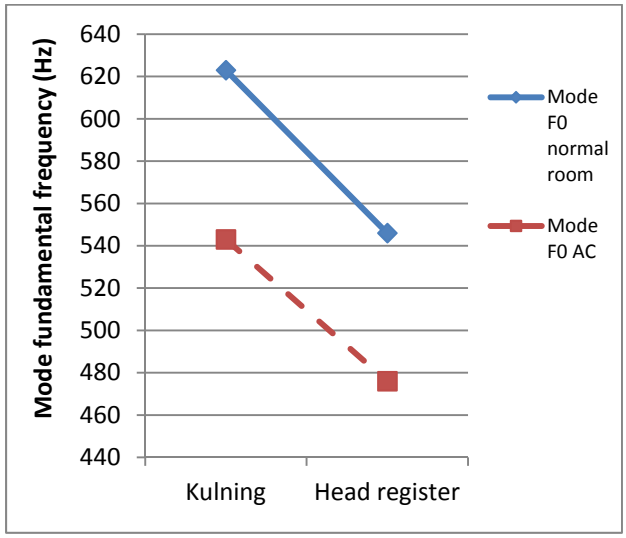

Figure 1. Fundamental frequency mode values for kulning and head register singing in the normal room and in the anechoic room (AC).

The observed effect was 80 and 70 Hz for kulning and head register, respectively, showing that F_0 mode value for kulning was higher in both recording conditions. The observed room difference was 67–77 Hz higher in kulning for the normal room and the anechoic chamber, respectively. The room effect for modal/chest register showed the opposite pattern: here a higher F_0 mode value of 20Hz for the anechoic room was observed.

Our general observation that kulning is higher in frequency than other singing more or less repeats the results reported in Johnson (1986:253) who compared kulning and normal folk singing, and observed roughly similar frequencies for one vowel/tone, [ɥ], and higher frequency in kulning for another [ɥ] vowel/tone.

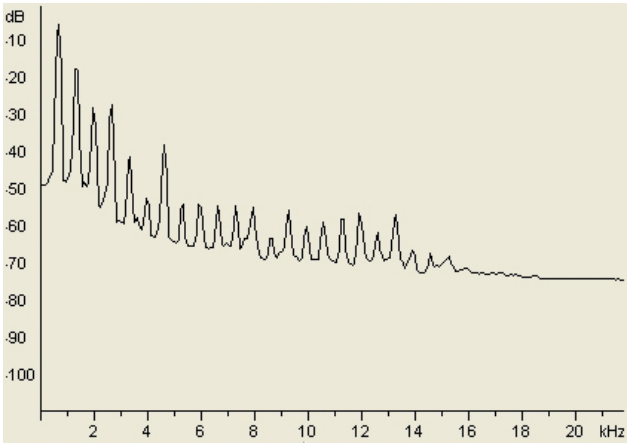

Figure 2: Kulning [ɬ] produced in normal room, LTAS/FFT/Hamming analysis.

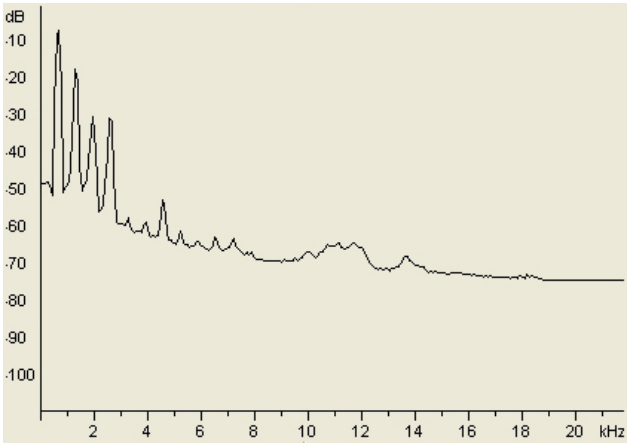

Figure 3: Head [ɬ] produced in normal room. LTAS/FFT/Hamming analysis.

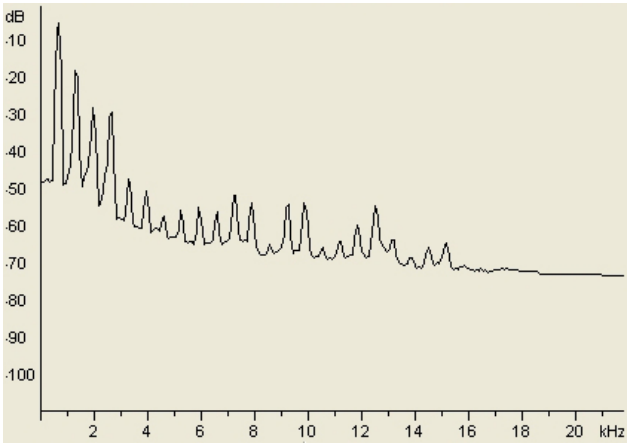

Figure 4: Kulning [ɬ] produced in echo-free room, LTAS/FFT/Hamming analysis.

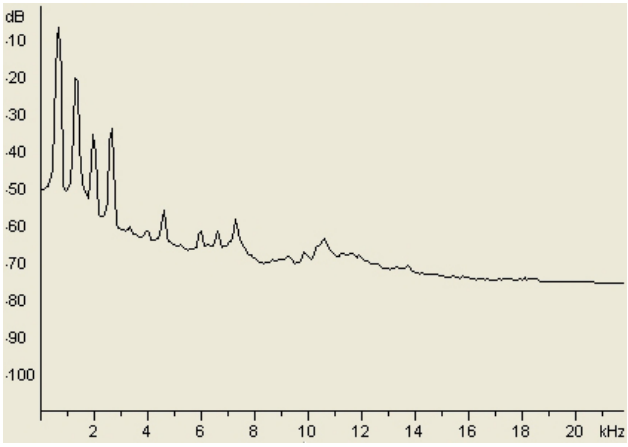

Figure 5: Head [ɬ] produced in echo-free room. LTAS/FFT/Hamming analysis.

Long-Term Average Spectrum analysis

The first [ɬ] in the song was then extracted in the kulning and head register versions (for two room conditions) and a Long-Term Average Spectral (LTAS) analysis (using Fast Fourier Transform/Hamming window) was performed. The results are presented in *Figures 2–5* above.

As can be seen, the partials are much more distinguishable in kulning than in head voice, under both recording conditions, and while only four peaks are clearly visible in head register, and more or less disappear above 5 kHz, partials in kulning register are easily observed up to 15 kHz before fading out.

Discussion

First, it should be mentioned that both recording settings described in this paper are somewhat counterproductive from a kulning point of view, where the basic concept is crucially based on an outdoor setting, far from the echo-attenuating feedback encountered here. FP's previous experience of kulning has, quite naturally, been outdoors or at least in large rooms with good acoustics and feedback properties, which means that both recording conditions here were new and somewhat artificial to her, which likely affected the performance. Naturally, especially the anechoic chamber was perceived as difficult to accommodate to. This is likely the underlying cause behind the observed lower F_0 mode values observed for both kulning and head register singing. Interestingly, however, this effect was reversed in modal/chest register, where a higher F_0 mode value was observed in the anechoic room. A possible explanation for this could be that this was the last recording and that the singer experienced a warm-up effect after performing the other songs.

With regard to singing technique, F_0 mode value was higher for kulning compared to head register, independently of room setting, despite making sure that all recordings used the same starting tone.

The spectral comparison revealed a marked difference between kulning and head registers in that kulning exhibited distinct partials up to approximately 15 kHz, while only four partials were clearly visible in head register. Head register also showed a clear decline in palpable partials at around 5 kHz. A partial (pun intended) explanation for this could be ascribed to loudness differences between the two effects, but no such analysis was carried in this pilot paper of limited space. Given that reference dB values were carefully recorded, future studies could easily encompass a deeper study of this phenomenon.

It is interesting to compare our finding of clearly marked partials in kulning to Uttman (2002). She, too, reported very high partials for all four singers studied, with a variation between the singers ranging from 12 kHz (for the singer Maria Röjås) to 18 kHz (for the singer Lena Willemark). The other two singers (Agneta Stolpe and Kerstin Sonnbäck) studied had their highest (visible) partials at 16 kHz. Since Uttman used phonograms, there is no way (or at least very difficult) of knowing details about the recording conditions (e.g. microphone specifications), but while our own data are "clean" and controlled, Uttman's data are more ecologically valid. Ideally, future studies of kulning should use controlled outdoors recordings sessions, including dB reference values, coupled with detailed technical specifications. Outdoor recordings would also enable analysis of sound transmission characteristics for different singing styles in different outdoor environments (cf. Marten & Marler, 1977)

Future studies should/could also include analyses of glottal properties, like the closed quotient and the crest-factor. The closed quotient can be related to pressed phonation and the crest factor is related to closure speed. Both measures are related to vocal loudness. Measures on loudness should be included in future comparisons of kulning and head register, as already mentioned.

Finally, it is interesting to note that yodelling has been devoted some recent interest (Echternach, Marki & Richer, 2011; Echternach & Richter, 2010; Schlöminger-Their et al., 2009). From an acoustic perspective, comparisons between kulning and yodelling could be of potential interest given the similar rationales for the two singing styles.

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