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AN ACOUSTIC ANALYS OF 'KULNING' (CATTLE CALLS) RECORDED IN AN OUTDOOR SETTING ON LOCATION IN DALARNA (SWEDEN)

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ABSTRACT

The Swedish cattle call 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 adds to and extends the results presented in a previous study [7], where kulning and head voice ("falsetto") was acoustically analysed in two indoor settings: a normal room and an anechoic chamber. In the present study, the same singer, singing the same kulning in the same two modes (kulning and head voice), was recorded in an outdoor setting (close to the singer's home), thus allowing for a comparison between "clinical" and more ecologically valid data.

Keywords: Kulning, head voice, falsetto singing, cattle calls, acoustic analysis, LTAS, FFT, LPC

1. 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 [14] and whistled languages [3] and such long-distance calls have been used for both human–human communication and for human–animal calling.

Kulning is the most common term (see [18: 8] for an extensive listing of alternative words) for a specific type of cattle or herding calls used mainly in the provinces Dalarna, Härjedalen and Jämtland (all in Sweden). Kulning is used to call cows or goats, gracing freely in the mountains, when it is time to be milked. The tradition of cattle calls dates far back in history and was most common in Dalarna, 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 high-pitched, and 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 to remedy that situation by investigating some of the acoustic properties of kulning, compared to head ('falsetto') register singing.

2. PREVIOUS RESEARCH

Kulning is mentioned in both [16: 38 et passim] and [13], but mainly in passing. For example, Ling [13: 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 [16: 37] points out that it is normally sung on vowels, without lyrics in the traditional sense. Johnson [11, 12: 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 (up to +39 mm) when high notes are produced. 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 [12: 228] reports SPL values up to 105 dB (without mentioning any reference values). The results presented in Johnson are largely replicated by Rosenberg [18: 24]. As for the acoustic properties of kulning, Uttman [19] studied partials spectra of kulning songs obtained from CD recordings, and reported strong partials up to the 16–18 kHz register, compared to ~6 kHz in normal folk singing.

In a previous study [7], we studied the acoustics of kulning produced in two indoor settings, a normal room and an anechoic chamber. In the present study, we recorded the same song, produced by the same singer (FP) and using the same microphone, but this time the recording was made "on location", i.e. out in the forest where the singer grew up. This way, we

can compare somewhat "clinical" data with data of high ecological validity. Since one comment made by the singer in our previous study was that it felt somewhat "unnatural" to sing in the indoors settings, we were also interested in comparing the previous indoor recordings with the present outdoor recordings, to see whether a more natural setting would exhibit different acoustical characteristics.

3. DATA COLLECTION AND METHOD

All data were collected on 7 September 2013, on location in Säter, Dalarna in Sweden, a location close to where the singer (FP) grew up. Two different professional microphones were used: (a) one Audiotechnica AT813 cardoid-pattern, condenser mono microphone (these recordings are not used in this paper), and (b) two Shure Pro Beta 58A, used for simultaneous recordings at different distances. Both Shure microphones independently fed into high-definition Canon HG-10 video cameras (one per microphone) placed at different distances from the singer. The recordings were also calibrated at 97 dBa using an Extech sound-level meter. Air humidity at the time of recording was around 70% (data obtained from http://freemeteo.com).

The singer (FP), the same singer as in [7], is educated in kulning at Musikkonservatoriet in Falun and Malungs Folkhögskola, and by Agneta Stolpe and Ann- Sofi Nilsson. Data consisted of FP singing the same cattle call (cattle call from Äppelbo in a traditional arrangement by Agneta Stolpe, Vallslinga från Äppelbo) as was recorded in our previous study, and was produced in three different singing modes: (1) kulning voice; (2) head register (sometimes incorrectly referred to as "falsetto"); and (3) modal voice (chest register). The duration of the song was around one minute. An additional recording of outdoor echo time was recorded (at both 1 and 11 meters from the singer), and was found to be clearly audible for around 2 seconds.

For analysis, data were resampled to 44.1 kHz, 16 bit, mono (using the video converter software TMPGEnc 4.0 XPress 4.7.9.311).

Acoustic analyses were carried out using Cool Edit Pro 2.0, WaveSurfer 1.8.8p4 and Praat 5.3.84.

4. ANALYSIS

In order to match the data in our previous study, we only used data from kulning and head register versions, and similar to our previous study, we carefully excised and analysed the first high-pitched [ɤ̟] vowel. The frequency varied to some degree between different takes, but generally was around 700 Hz, corresponding to (a somewhat sharp) E5. Unlike our previous study, the sound files were not bandpass filtered since our aim was to analyse the "naturalistic" sound quality, e.g. amplitude tilt, where filtering could risk missing interesting acoustic phenomena.

5. RESULTS

5.1. Relative amplitudes

We first analysed general amplitude levels (using Praat) by comparing average dB levels between the Shure recordings simultaneously made at 1 meter and 11 meters from the singer. Results are shown in Table 1.

Table 1: Decibel (dB) values at two distances for two singing modes. Analysis done in Praat 5.3.84.

Mode	1 meter	11 meter
Kulning	84.2	74.8
Head voice	81.5	56.3

As is shown in Table 1, in kulning there is an amplitude drop of 9.4 dB, which means that the perceived loudness 11 meters from the singer as compared to 1 meter from the singer of is about halved [1:233; 8:49; 10:115].

The corresponding value for head voice is 25.2 dB, which indicates that kulning carries better than head voice in an outdoor setting, where kulning is normally applied.

5.2. Long-Term Average Spectrum: FFT/Partials

We then created Long-Term Average Spectra, Fast Fourier Transform (Hamming Windowing), to compare harmonics characteristics between kulning voice and head voice, at two distances. The results are shown in Figures 1 through 4.

In our previous study [7], partials were visible up to around 5 kHz for head voice, while partials were clearly visible up to around 15 kHz in kulning. While this is more or less the case in our present data at the 1 meter distance, higher partials are seen at a distance of 11 meters for head voice (Figure 4), where partials are seen up to 11 kHz.

The main and striking difference, however, is how similar and stable the two kulning analyses are, showing almost no difference at a distance of 1 meter and 11 meters. In fact, comparing Figure 1 and Figure 3 is more or less like looking at the same figure, "downshifted" around 10 dB (compare Table 1 above). This clearly shows that although the two singing modes can sound somewhat similar to an untrained ear, kulning seems better adapted to an outdoor setting, where the basic "design feature" is to carry over long distances in an unperturbed way.

5.3. Long-Term Average Spectrum: LPC/Formants

We also performed LPC analyses. The results are shown in Figures 5 through 8.

Figure 1: Kulning [ɸ] at 1 meter.
LTAS/FFT/Hamming analysis.

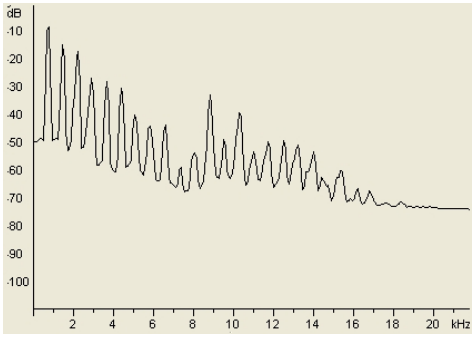


Figure 2: Head voice [ɸ] at 1 meter.
LTAS/FFT/Hamming analysis.

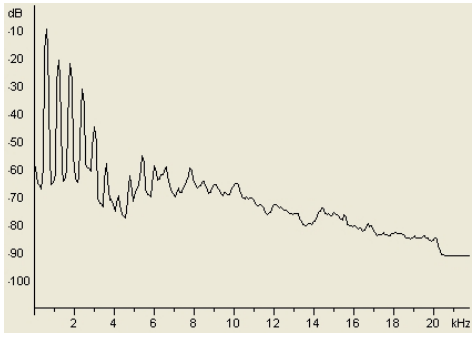


Figure 3: Kulning [ɸ] at 11 meters.
LTAS/FFT/Hamming analysis.

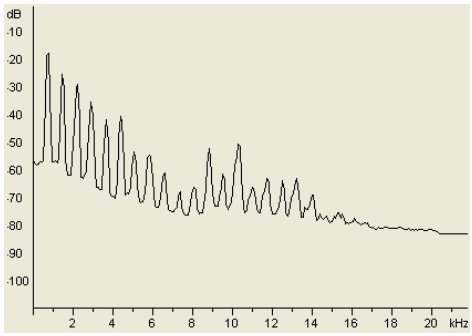


Figure 4: Head voice [ɸ] at 11 meters.
LTAS/FFT/Hamming analysis.

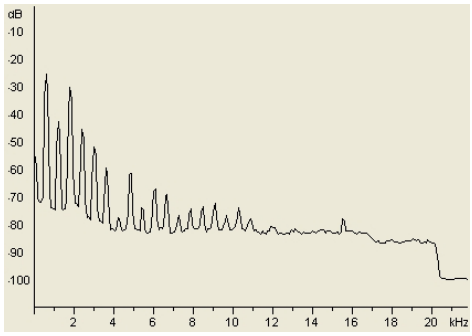


Figure 5: Kulning [ɸ] at 1 meter.
LTAS/LPC/Hamming analysis.

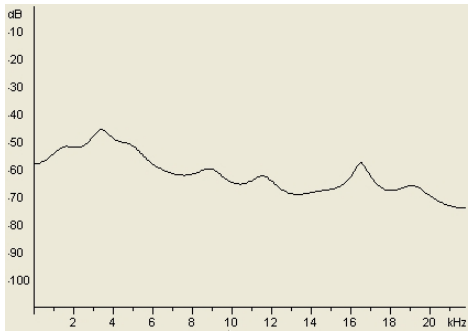


Figure 6: Head voice [ɸ] at 1 meter.
LTAS/LPC/Hamming analysis.

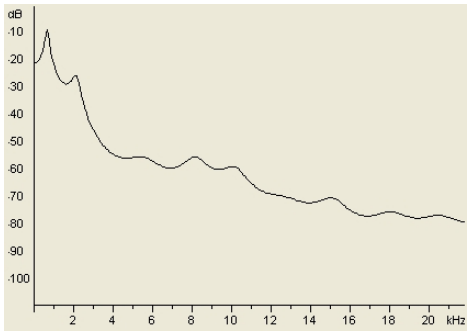


Figure 7: Kulning [ɸ] at 11 meters.
LTAS/LPC/Hamming analysis.

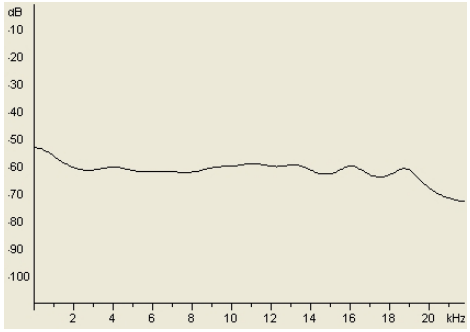
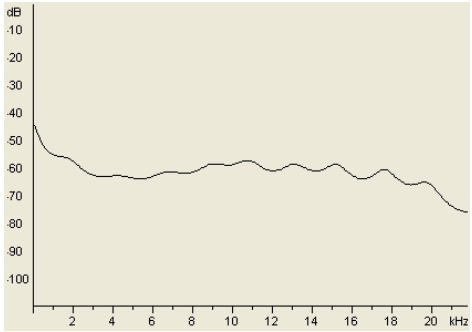


Figure 8: Head voice [ɸ] at 11 meters.
LTAS/LPC/Hamming analysis.



As is shown in Figures 5 through 8, formants do not behave according to the pattern found in the FFT analysis of partials. First, at 1 meter, formants are much more clearly defined in head voice than in kulning. Second, the most marked peak in kulning appears at around 3 kHz, not at lower frequencies. Third, there is also a second peak at around 16.6 kHz. Fourth, in both head and kulning modes any signs of formants more or less disappear at 11 meters, this difference being far more apparent in head voice. Since cattle are not likely to pay attention to exact vowel quality, this should not be a problem, but is should of course be borne in mind that in the present study only one vowel was analysed, and that other vowels sounds might exhibit different characteristics.

5. DISCUSSION AND FUTURE RESEARCH

The most important finding in the present study, as compared to our previous study, is that while the previous study was "somewhat counterproductive from a kulning point of view" [7: 23] – since it was an indoor analysis of what is fundamentally an outdoor phenomenon, which might not yield results that well represent the object under scrutiny – the present study analysed ecologically valid data. From this perspective, it is interesting to see that our previously reported observation that partials are much more clearly defined in much higher frequency bands is replicated in our present, ecologically valid, recordings.

Since our present study used simultaneous recordings at different distances (using the same exact type of equipment), we could also analyse how the different modes carry over distances, and it was shown that kulning fell off less with distance from an intensity point of view, and also that partials in kulning – but not in head voice – remained more or less unperturbed 11 meters from the singer, as compared to 1 meter from the singer. Both results help explain why kulning as a singing mode was developed for calling cattle that might be at considerable distance from the singer.

That sounds carry in different ways as a function of a number of different characteristics has been shown for a long time, e.g. in analyses of different animal vocalizations [2, 6, 9, 15, 17], where e.g. primates adapt their calls in order to enhance long-distance propagation [20] and it seems that the results presented in our study show that the kulning singing technique seems to have been developed to serve the same purpose.

Planned future studies include inverse analyses of the data in order to study glottal flow properties, like e.g. the closed quotient and the crest-factor. Both measures are related to vocal loudness. Measures on loudness should be included in future comparisons of kulning and head register, as already mentioned.

We have also made recordings with two different microphones at 1, 2, 4 and 8 meters from the singer, which allows us to compare recordings made using different microphones, which might be interesting from a methodological perspective.

Finally, it is interesting to note that yodelling has been devoted some recent interest [4, 5]. From an acoustic perspective, comparisons between kulning and yodelling should be of potential interest given the similar rationales for the two singing styles.

7. ACKNOWLEDGMENTS

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