Kulning (Swedish Cattle Calls): Acoustic, EGG, Stroboscopic and High-Speed Video Analyses of an Unusual Singing Style

Ahmed Geneid [1], Anne-Maria Laukkanen [2], Anita McAllister [3], Robert Eklund [4]

[1] Department of Otolaryngology and Phoniatrics – Head and Neck Surgery,
Helsinki University Hospital and University of Helsinki, Finland

[2] Speech and Voice Research Laboratory, School of Education, University of Tampere, Finland

[3] Division of Speech and Language pathology, Karolinska Institutet, Sweden

[4] Department of Culture and Communication, Linköping University, Sweden

ABSTRACT

The Swedish cattle call singing style 'kulning' (to use the most common term) is surprisingly understudied, despite its almost mythical status in folklore.

While some acoustic and physiological aspects have been addressed previously (Eklund, McAllister & Pehrson, 2013; Eklund & McAllister, 2015), a more detailed analysis is still lacking.

Previous work (Eklund & McAllister, 2015) showed that sound pressure level (SPL) in kulning tapered off less than in head register as a function of distance, which warrants a study of underlying physiological mechanisms responsible for this.

In the present paper, the same singer, singing the same song – in kulning and in head register ("falsetto") mode – was recorded indoors. Electroglottographic (EGG), stroboscopic, high-speed endoscopic and audio registrations were made. Analyses examined differences between kulning and head register.

Results show somewhat higher SPL in kulning than in head register confirming the previous findings. EGG showed longer relative glottal contact time and higher amplitude of the signal in kulning. This suggests better vocal fold contact in kulning.

Flexible nasofiberoscopy and high-speed recordings during kulning showed medial and antero-posterior narrowing of the laryngeal inlet, a clear approximation of the false vocal folds and marked adduction of the vocal folds.

INTRODUCTION

The Swedish cattle call singing style 'kulning' is an example of long-distance calls with extreme carrying power.

Kulning is used to call free-grazing cattle and was developed to carry over large distances.

Typical kulning setting (Photo by Hilding Eklund)

Kulning is high-pitched, lacks vibrato, generally has no lyrics, but is sung on vowel-heavy syllables.

Kulning is also very loud and SPL values up to 105 dB at 0.3 meter have been reported.

PREVIOUS RESEARCH

Kulning is mentioned in early works on Swedish folk music (Moberg, 1955; Ling, 1978).

Johnson (1984, 1986) reported that kulning is characterized by a strong correlation between frequency and amplitude (especially in higher registers), and that the larynx moves with the frequency and can be raised with ~39 mm. Jaw opening also followed frequency. Johnson also reported that the larynx during kulning was extremely tightened.

Uttman (2002) analyzed partials obtained from CD recordings and reported clear partials up to 16–18 kHz, as compared to ~6 kHz in normal folk singing.

Eklund, McAllister and Pehrson (2013) compared kulning and head voice in an indoor setting and replicated Uttman's observations on partials.

Previous work (Eklund & McAllister, 2015) showed that sound pressure level (SPL) in kulning tapered off less with distance than in head register at 1 and 11 meters from the source: –9,4 dB vs –25,2 dB, respectively.

DATA COLLECTION AND METHOD

The singer (Fanny Pehrson) was the same as in our previous studies (Eklund & McAllister; see References), 29 years old at the time of recording.

The same song as in our previous studies (see above) was recorded in different settings:

1. A hospital corridor, at 1 and 11 meters, simultaneously using two identical microphones.
2. While using nasoendoscopy (ORL Vision RS1 CCD by Rehder and Partners) with a rigid endoscope.
3. While using high-speed imaging (4000 frames per second, 512 × 256 pixels, using KayPentax model 9710).
4. While using electroglottography (EGG; dual-channel device by Glottal Enterprises).

Kulning and head voice versions were recorded.

ANALYSES

- SPL was measured at 3 cm from the source, and at 1 and 11 meters from the source, in the corridor (using a Brüel & Kjaer 2238 and an Extech 407332 sound-level meter simultaneously, at all distances).
- Visual inspection of pharyngeal and epilaryngeal structures, using nasoendoscopy.
- Inspection of vocal fold vibrations, using high-speed imaging.
- Analysis of Contact Quotient (CQ), calculated from the EGG signal (using VoceVista software); note that CQ reflects phonation type and is larger in pressed phonation compared to normal phonation.

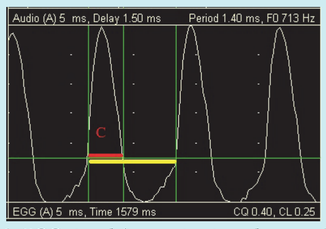


Figure 1. EGG signal (increasing impedance = decreasing contact downwards). CQ measured as closed time (red line) divided by period time (yellow line).

RESULTS (1)

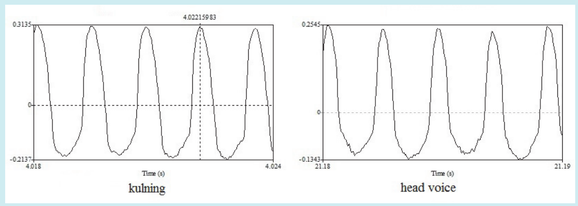
- SPL at 3 cm from the source was 93–102 dB(a) for head voice and 93–123 dB(a) for kulning.
- SPL attenuation at 11 meters compared to 1 meter from the source was 21 dB(a) for head voice and 15 dB(a) for kulning.
- Pharyngeal and epilaryngeal analyses showed that in kulning (compared to head voice) the lateral walls of the epilarynx moved medially and the antero-posterior distance from epiglottis to the backwall of the laryngeal inlet was diminished.
- The piriform fossae were more open in head voice.
- As for vocal fold vibratory pattern, there was marked adduction of the false vocal folds in kulning.
- Vocal fold adduction was also tighter in kulning than in head voice.

RESULTS (2)

As for EGG analysis, the CQ was higher in kulning than in head voice.

EGG amplitude was also higher in kulning.

Results are shown in the Figures and the Table below.



Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Kulning CQ	493	,40	,55	,4734	,02715
Head Voice CQ	493	,26	,57	,4052	,06057
Kulning F0	493	620,97	875,00	759,5502	41,87060
Head Voice F0	493	641,67	802,08	693,7666	17,81907
Valid N (listwise)	493				

CONCLUSIONS AND FUTURE RESEARCH

Comparing kulning to head voice:

- SPL was higher in kulning.
- SPL attenuation with distance was lower in kulning.
- Vocal fold contact was much tighter in kulning.
- Kulning exhibited medial and antero-posterior narrowing of the laryngeal inlet.

Subglottic pressure might be higher in kulning than in head voice but was not measured in the present study.

The observed medialization of the false vocal folds and the epilaryngeal narrowing might create interaction between the voice source and supraglottal acoustics, which would enhance SPL and diminish spectral tilt and could provide an explanation for the reported extreme loudness of kulning

Planned future studies include both real-time MRI registration and MRI based modelling of the vocal tract acoustics.

REFERENCES (SELECTED)

Eklund, Robert, Anita McAllister & Fanny Pehrson, F. 2013. An acoustic comparison of voice characteristics in 'kulning', head and modal registers. *Proceedings of Fonetik 2013*, 21–24.

Eklund, Robert & Anita McAllister. 2015. An acoustic analysis of 'kulning' (cattle calls) recorded in an outdoor setting on location in Dalarna (Sweden) In: *Proceedings of ICPhS 2015*, 10–14 August 2015, Glasgow, Scotland.

Johnson, Anna. 1984. Voice Physiology and Ethnomusicology: Physiological and acoustical Studies of the Swedish Herding Song. In: D. Christensen (ed.), *Yearbook for Traditional Music* 16, 42–66.

Johnson, Anna. 1986. *Sången i skogen: Studier kring den svenska fäbodmusiken*. PhD thesis, Dept. of Musicology, Uppsala University.

Ling. Jan. 1978. *Svensk folkmusik*. Stockholm: Prisma.

Moberg, Carl-Allan. 1955. Om vallåtar. En studie i de svenska fäbodarnas musikaliska organisation. *Svensk Tidskrift för Musikforskning*, 1–27.

Uttman, Magdalena Tellenbach. 2002. Eine Untersuchung der Teiltonspektren bei Kulning und Lockruf-techniken anhand von Beispielen aus Schweden und Finnland. *STM Online* 5. http://musikforskning.se/stmonline/vol_5/tellenbach/index.php?menu=3

THANKS TO FANNY PEHRSON