Electroglottographic assessment of *in vivo* Japanese Macaque sound production

Christian T. **HERBST**[1*], Hiroki **KODA**[2], Takumi **KUNIEDA**[2], Juri **SUZUKI**[2], Maxime **GARCIA**[1], Tecumseh **FITCH**[1], Takeshi **NISHIMURA**[2]

[1] Bioacoustics Laboratory, Department of Cognitive Biology, University Vienna, Althanstrasse 14, 1090 Wien, Austria
[2] Primate Research Institute, Kyoto University, Inuyama, Aichi 484-8506, Japan
corresponding author's email: herbst@ccrma.stanford.edu

Introduction

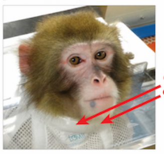
- primates are humans' closest phylogenetic relatives
- primates' call repertoire is well described acoustically
- … but little physiological/physical data is available
  → experimental difficulties in vivo
- get physiological correlate of vocal fold vibration
- document with electroglottography (EGG)
  → supporting data from excised larynx

Methods

- one female Japanese Macaque **
- trained to vocalize upon stimulus
- SPL-calibrated microphone signals
- simultaneous EGG recordings
  → compare to excised larynx data
- Green's call classification (1975)

** with permission #2015-148 of the Kyoto University Animal Welfare and Animal Care Committee

In **electroglottography (EGG)**, a low intensity, high-frequency current is passed between two electrodes placed on each side of the larynx. The admittance variations resulting from vocal fold (de)contacting during laryngeal sound production are largely proportional to the time-varying relative vocal fold contact area (VFCA; Hampala et al., 2015)



Results

See Table 1 and Figures 1 and 2.

For the 26 mixed coo/grunt phonations, the EGG signals show transitions between the individual call types occurring within as little as one to five vibratory cycles (Figure 3).

call type	n	avg. f_o [Hz]	avg. *df* [Hz]	avg. SPL [dB(C)] @ 10 cm
coo	368	580.5 (± 44.7)	677.4 (±202.2)	83.0 (±5.2)
growl	17	304.5 (±117.9)	419.7 (±291.1)	80.2 (±4.6)
chirp	3	1001.2 (± 88.6)	2591.4 (±775.2)	92.3 (±3.4)

Table 1: in vivo data summary, only periodic signals considered; *df*: dominant frequency

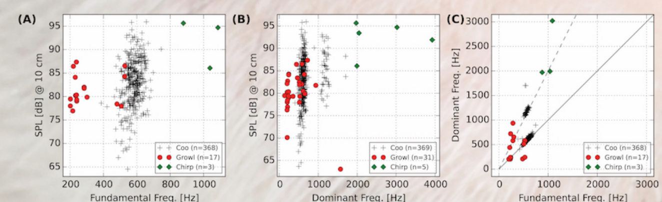


Figure 1: in vivo data summary: (A) phonetogram, data averaged per call. Supplementary non-stationary analysis of the "coo" calls revealed an average increase of 0.072 dB per Hz f_0; (B) dominant frequency (*df*) vs SPL; (C) f_0 vs. *df*. In 11.9 % of all cases, the *df* was at twice f_0, suggesting vocal tract modifications in between phonations.

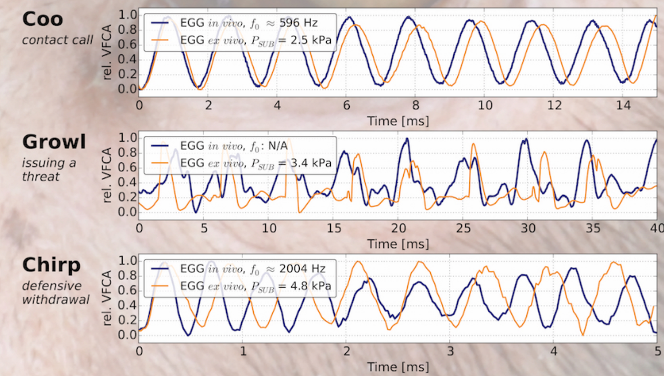


Figure 2: Stereotypic EGG signals, *in vivo* and *ex vivo* (excised larynx). The *ex vivo* chirp could only be achieved at high subglottal pressures and tensed vocal folds. The evidence for vocal fold vibration (corroborated by high-speed video data) suggests that the "chirp" is not a "glottal whistle".

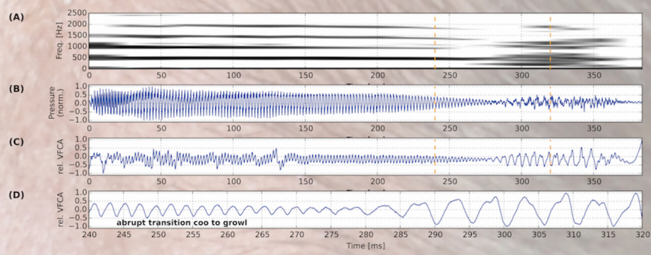


Figure 3: Abrupt transition from "coo" to "growl". (A) Spectrogram; (B) acoustic signal; (C) EGG signal; (D) portion of the EGG signal, extracted at 240 – 320 ms.

Discussion & Conclusion

- **first calibrated phonetogram for non-human species**
- **mapping of three distinct call types.**
- **coos/grunts/chirps: distinct laryngeal mechanisms**
  → *analogous to "registers" in human singing*

The Japanese Macaque larynx constitutes a simple system that is capable of generating complex behavior via modification of only few physiologic parameters. Such a trait, requiring much simpler neural input and control as compared to human language, is important for establishing the species' vocal communication repertoire.

References

Green, S. (1975). "Variation of Vocal Pattern with Social Situation in the Japanese Moneky (Macaca fuscata): A Field Study," in Primate Behaviour. Developments in Field and Laboratory Research, edited by L. A. Rosenblum (Academic Press, New York), pp. 1-102.

Hampala, V., Garcia, M., Svec, J.G., Scherer, R.C., Herbst, C.T. (2016). "Relationship between the Electroglottographic Signal and Vocal Fold Contact Area". Journal of Voice, 30 (2), 161-171.

COGBIO Department of Cognitive Biology — ÖAW — KYOTO UNIVERSITY

* Christian T. Herbst is a recipient of an APART Fellowship awarded by the Austrian Academy of Sciences