VISUALIZATION OF VOCAL FLEXIBILITY IN ASIAN ELEPHANTS

Veronika C. Beeck *1, Gunnar Heilmann 2, and Angela S. Stoeger 1

*Corresponding Author: veronika.beeck@univie.ac.at
1Department of Behavioural & Cognitive Biology, University of Vienna, Vienna, Austria
2MeCalc Technologies GmbH, Berlin, Germany

Background

Elephants demonstrate both biomechanical and cognitive flexibility in sound production. They are even among the few mammals capable of vocal production learning (Poole et al., 2005; Stoeger et al., 2012). Functions and mechanisms of this flexibility remain largely unknown. The small vocal repertoire of 8-13 call types spans from infrasonic rumbles (F0 8-35 Hz) to high pitched trumpets (F0 300-600 Hz) and, in Asian elephants, species-specific squeaks (F0 300-2300 Hz) (Stoeger & de Silva, 2014). In this project, we studied sound production and how it relates to potential information coding and social learning in Asian elephants, which have been studied much less than African elephants.

Methods

We used an acoustic camera (gfai tech, Berlin) to visualize sound emission in addition to audio and video data to analyse acoustic structures and body movements in captive Asian elephants. The acoustic camera uses an array of microphones to localize sound sources based on a sum- and delay-beamforming algorithm (Stoeger et al., 2012) and depicts sound pressure levels (SPL) by colour coding (Figure 1).

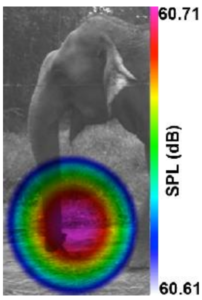

Figure 1. Nasal rumble.

Results

The acoustic camera showed that squeaks were emitted orally in three females (N_{calls} = 90) and nasally in one (N_{calls} = 14). Our data suggest oral squeaks are produced by vibration of the tensely closed lips, a mechanism unique in the animal kingdom except for humans (Beeck et al., 2021). We recorded squeaks only from 19 out of 56 subjects. One female squeaked through her narrowed nostril, revealing productive flexibility even within one call type. Together, this indicates the involvement of learning in squeak production. Trumpets (uttered through the trunk) and squeaks occurred in contexts of arousal and encoded individual identity. Rumbles in 9 females (N_{calls}= 203) were emitted either through the mouth or trunk (Figure 1) or both simultaneously, demonstrating velo-pharyngeal coupling and complex vocal tract resonances that increase the parameter space for potential information coding (Beeck et al., submitted).

Conclusion

Our results demonstrate how Asian elephants increase acoustic variability through anatomical and cognitive adaptations that overcome morpho-mechanical limitations of laryngeal sound production, where across taxa body size and the related vocal apparatus dimensions determine source and filter parameters. This supports the hypothesis that vocal complexity can be expressed in graded repertoires rather than only repertoire size. We set an important framework for elephants to be included in comparative analyses of the multiple dimensions of vocal complexity and their evolution across socially dynamic species, which include flexibility in sound production, vocal learning, and information coding.

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References

Beeck, V. C., Heilmann, G., Kerscher, M., & Stoeger, A. S. (2021). A novel theory of Asian elephant high-frequency squeak production. *BMC biology, 19*(1), 121. doi:10.1186/s12915-021-01026-z

Beeck, V. C., Heilmann, G., Kerscher, M., & Stoeger, A. S. (submitted). Sound imaging demontsrates velopharyngeal coupling and complex spectral variability in Asian elephants.

Poole, J. H., Tyack, P. L., Stoeger-Horwath, A. S., & Watwood, S. (2005). Elephants are capable of vocal learning. *Nature, 434*(7032), 455-456.

Stoeger, A. S., & de Silva, S. (2014). African and Asian Elephant Vocal Communication: A Cross-Species Comparison. In *Biocommunication of Animals* (pp. 21-39).

Stoeger, A. S., Heilmann, G., Zeppelzauer, M., Ganswindt, A., Hensman, S., & Charlton, B. D. (2012). Visualizing sound emission of elephant vocalizations: evidence for two rumble production types. *PLoS One, 7*(11), e48907. doi:10.1371/journal.pone.0048907

Stoeger, A. S., Mietchen, D., Oh, S., de Silva, S., Herbst, C. T., Kwon, S., & Fitch, W. T. (2012). An Asian elephant imitates human speech. *Current Biology, 22*(22), 2144-2148.