Categorizing Vocal Repertoires of Nonhuman Primates

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Abstract

The vocal repertoire of animals consists typically of a limited number of call types which vary substantially within these categories. One can find all variation from highly graded to more or less distinct vocal repertoires, and it may be unavoidable that call variants at category boundaries are difficult to categorize. This must not be a disadvantage for the communication of animals which grew up in the same community, because the efficiency of categorical perception allows the receiver to respond correctly even in highly graded signaling systems. However, to understand the evolution of acoustic communication and to compare studies in bioacoustics it is necessary to have comparable units, or to know how different categorization levels influence the outcome of an acoustic analysis.

In bioacoustics it is not uncommon to use the visual cues of spectrograms to establish vocal repertoires. In some cases the visual approach is support by a parametric description of the Fourier transformed wave signals. In other cases the classification of calls is guided according to their proposed function, grouping them to ‘alarm’, ‘contact’ or ‘food calls’. All these procedure have the disadvantages that they rely on prior assumptions. In cases of distinct vocal repertoires a time-consuming statistical analysis seems to be dispensable. However, vocal repertoires of most mammals consist of call types which vary substantially within their categories and it is difficult to identify reliable boundaries without any statistical approach. Therefore, it seems to be important to have more objective procedures to establish vocal repertoires.

In a case study of Barbary macaques’ vocal repertoire Hammerschmidt and Fischer [1] have tested a k-means cluster approach to establish vocal categories. As k-means cluster procedures do not directly present the optimal cluster solution, they calculated two indices to assess the power of the different cluster solutions: First, they calculated $Eta_{(k)}$ which reflects the relative reduction in variance by a given cluster solution in relation to the overall variation of the unpartitioned data set ('Zero-model'). With a growing number of clusters Eta increases successively. Therefore, it is mainly of interest to identify peaks in the course of Eta, which indicate promising cluster solutions. This can be done by a coefficient (pre) which describes the relative improvement in the reduction of variance compared to the previous solution ($pre_{(k)}$=1-(sum of $squares_{(k)}$/ sum of $squares_{(k-1)}$)).

The most difficult part conducting such cluster approaches is the identification of relevant acoustic variables. A high number of variables make it difficult for cluster algorithms to find appropriate cluster centers. In addition, acoustic parameters are often highly correlated which can shift the result in the direction of these parameters. A principle component analysis (PCA) can be a useful strategy to reduce the number of acoustic parameters. In addition the factors of a PCA are uncorrelated and can be used instead of the original acoustic variables. However, cluster analyses based on factor loadings have a tendency to find a lower number of clusters. Therefore, we decided to estimate the best cluster solutions for all possible combination of characteristic acoustic variables.

In a last approach we focused on question whether classical cluster algorithms based on Euclidean distance measures are really the appropriate tool to describe vocal repertoires of nonhuman primates. As mentioned at the beginning the categorical perception of a receiver must not work in Euclidean fashion. To achieve this goal we replaced the Euclidean distance measure by a log-likelihood distance measure. This probability based distance has the additional advantage to be able to handle both continuous and categorical variables. We used a two-step cluster procedure and took the Schwarz-Bayesian criterion (BIC) as measures of the best cluster solution. In the talk we will present data of vocal repertoires of Barbary macaques and Baboons as examples of graded and discrete vocal repertoires and compare the results of the different approaches.

References

1. Hammerschmidt, K., Fischer, J. (1998). The vocal repertoire of Barbary macaques: A quantitative analysis of a graded signal system. *Ethology* **104**, 203-216.