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Ethological study of acoustic communication in family dogs

Doctoral theses

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H-1117. Budapest Pázmány Péter sétány 1/c

2009

Introduction

Vocal signals of animals may be affected by actual motivational state, anatomical traits, physiological state and environmental effects. Since unambiguous signals are advantageous for the caller, individuals of various species emit signals with similar acoustic characteristics in similar motivational states. In several vertebrate (bird and mammal) species aggressive calls are low pitched and atonal on one hand, and the submissive and 'friendly' calls are high pitched and tonal on the other hand. In certain species it has been suggested that they have referential calls which means their signals refer to an element of the environment without change in their motivational states.

In family *Canidae* the basic difference between vocal repertoires of family dogs (*Canis familiaris*) and wild canids (e.g. foxes, *Vulpes vulpes*; wolves, *C. lupus*) is the abundance of bark. While wild canids rarely bark, almost exclusively in aggressive contexts, dogs bark often in various motivational states. Early authors argued that mainly neutral factors caused this diversification of bark in dogs and they supposed bark had lost its communicative role during domestication process. Nonetheless in the last decade some authors suggested that the lifestyle of dogs among humans affected their vocal signals and bark might have a role in dog-human communication as well.

Some studies suggested that dog bark has context- and individual specific features. On this basis individuals (dogs or even humans) hearing the bark might gain specific information regarding to the barking dog. Both criteria should be met for the bark to be an efficient communication system. Before our studies, according to our best knowledge, no results were published on the information the possible receivers of barks can gain by listening to bark. During our research we conducted several experiments investigating what kind of (context- and individual specific) information humans and dogs can gain by listening to barks.

A state-of-the-art computerized method was applied for analyzing the suitability of bark to be categorized according to the context and individuality of caller. The importance of this study exceeds the acoustical investigation of dog bark since this method can be applied for the analysis of other data harvested in ethological research.

Aims of research

1st study: Categorization of dog barks based on a machine learning approach

The aim of this study is to investigate if a software is able to categorize dog barks recorded in different contexts and from different individuals, and to decide if unfamiliar barks can be successfully classify to this categorization system above chance level. If so, this means that the characteristics of dog barks depend on the context of recording and also contains individual-specific elements.

2nd study: Dogs' response towards barks in a habituation experiment

The aim of this study was to investigate the role of barks in intraspecific communication of dogs. If the receiver can distinguish among different contexts and different individuals, we can assume that dog barks have communicative role. As a first step of these studies, we conducted an experiment in the laboratory to decide whether dogs can discriminate between dog barks recorded either in two frequently heard contexts or in the same context but from two different individuals.

3rd study: Comparison of performance of people with different experience with dogs in a dog bark evaluation test

As our hypothesis that barks became diverse during domestication in order to facilitate a more effective communication with men, we should investigate what kind of information can people draw hearing dog barks regarding its context and what they think about the internal state of dog. Furthermore, we can assume that the possible ability of humans evaluating dog barks, can have an inherited component. If so, experience with dogs might have only secondary role in people's performance during the trial. To answer this question, we have compared the performance of people with different experience with dogs.

4th study: Can people discriminate among dogs based on their barks?

Many experiments with different animal voice showed that tonal acoustic signals are more suitable for individual discrimination than atonal signals. The difference in the anatomic parameters of animals' upper respiratory system gives the individual characteristics of animal voice. The oscillation of cords moves the air and the different components of voice strengthens while it passes

through the upper respiratory system. These components are called formants, and these are different from individual to individual. In atonal voices, as are dog barks, formants are not so expressed, so presumably not give much help to discriminate among individuals. In this experiment we test, if people can discriminate between dogs, based on their barks.

5th study: Comparison of performance of blind people and people with vision in a dog bark evaluation test

Many experiments shoved that blind people have more sophisticated hearings than people with vision especially in situations when spatial orientation is needed. However, as far as we know, no experiment has been carried out, where the performance of blind people and people with vision have been compared in animal voice classification test, so we do not know anything about their performance in this situation. Furthermore, we wanted to investigate the ability of categorization of dog barks of people, who have the least experience with dogs. Naturally, people who have been blind since birth also have acoustic experience with dogs, but we think, that in Hungary, they are the most appropriate subjects to investigate the effect of experience in the ability of categorization of dog barks.

6th study: Effect of age on the performance showed in a dog bark evaluation test

Many experiments investigated the ability of perceiving other people's emotional state in children's with different age. A study showed that children are able to recognize the possible motivational state of Macaque voice, unfamiliar to them. No such experiments were carried out using dog barks. Our aim was to investigate the effect of age in the six-, eight- and ten-year-old age group.

Methods

1st study: Categorization of dog barks based on a machine learning approach

A computer program developed by Frédéric Kaplan and colleagues at Sony research institute in Paris is able to automatically recognize those acoustic features upon which the unfamiliar samples input can be categorized according to a criterion. 6646 bark samples were analyzed by this algorithm in this study. In the first (learning) phase of process the algorithm analyzed more than 150

acoustic features of familiar samples. Afterwards, across several so-called evolutionary steps, those were chosen upon which the best categorization could be reached. In second (test) phase we ran the program on unfamiliar samples and its task was to categorize them into the context and individual categories.

2nd study: Dogs' response towards barks in a habituation experiment

We investigated if dogs were able to distinguish among barks recorded from the same dog in different contexts and from different dogs in the same context in the lab. We used barks recorded while dogs barked at a stranger person and while they were leashed to a tree and left alone. The habituation-recovery paradigm was applied. This paradigm is often used to investigate if subjects are able to distinguish between two stimuli. In first (habituation) phase we played three barks recorded from the same dog in same situation to subjects. Subjects were expected to become habituated to stimulus. In the next (recovery) phase an 'other type' of stimulus was played to them (in sub-experiment 1 the context of bark, in sub-experiment 2 the caller identity was changed). Orientation response in the direction of sound was measured. Results were compared with data measured in control group (where all four stimuli were recorded in the same circumstances).

3rd study: Comparison of performance of people with different experience with dogs in a dog bark evaluation test

Barks recorded from Mudis in six situations were played to subjects with different experiences with dogs (Mudi owners, dog owners and non owners). Barks were recorded in contexts when dogs barked at a stranger, during Schutzhund training, while left alone, when dog asked for a ball and during a play session. In first sub-experiment subjects task was to describe the motivational states of dogs using a questionnaire by giving points to aggression, fear, despair, playfulness, happiness. In sub-experiment 2 their task was to guess in which context the given bark was recorded. We did correlation tests to investigate if some of the subjects' description of motivational states was affected by some of the acoustic features of barks.

4th study: Can people discriminate among dogs based on their barks?

In this experiment bark pairs were played to subjects and their task was to guess if the heard bark pair were recorded from the same or different dogs. In first sub-experiment bark pairs consisted of two individual barks. Since this time the effects of frequency and tonality on subjects' success were tested we chose barks according to these criteria. In sub-experiment 2 played pairs consisted of bark sequences of 5-5 individual barks. This time effects of variable interbark interval and context were

tested. We used barks recorded in stranger, alone and ball contexts. Every sample was played to subjects two times: with the actual interbark intervals and with normalized intervals. For analyzing the results Signal Detection Theory was applied which is commonly used in such tests.

5th study: Comparison of performance of blind people and people with vision in a dog bark evaluation test

For this study the protocol described in study 3 was modified to meet the special needs of blind subjects. Barks recorded in the same six situations were used as stimuli and the same sub-experiments were conducted. The difference was that this time not the subjects but experimenter filled the questionnaire after raised questions to subjects. Only non owner subjects were tested, they were categorized in three groups: sightless from birth, sightless with prior visual experience and sighted.

6th study: Effect of age on the performance showed in a dog bark evaluation test

We modified the motivational state evaluating and context categorizing protocol according to the needs of children for this study. 6, 8, 10 years old children and adults were tested (both dog owners and non owners). Barks recorded in stranger, alone and play contexts were used as stimuli. In first sub-experiment subjects' task was to choose from thee emotion categories (happy, angry and fearful). In sub-experiment 2 the given bark was asked to categorize into one of the three contexts.

Results

The computer algorithm was able to categorize dog barks above chance level based on both their context and individual characteristics. The software was successful in the categorization of stranger and Schutzhund contexts, but less successful in discriminating among individuals. Contrary to this, in ball and play situations the algorithm could differentiate among individuals, but was less effective in categorizing the dog barks to the proper situation.

In the habituation experiment we showed that dogs are able to discriminate between to individuals' barks recorded in the same situation, and also between barks recorded in two situations (stranger and alone) from the same individual.

There is no remarkable difference in the performance of people with different experience with dogs in the dog bark evaluation test. We showed that all the three groups were more successful in categorizing the dog barks to different contexts, and they have similar ideas on the motivational state of the dog. Some acoustic parameters of dog barks (frequency, tonality, time interval between individual barks) have an effect on the estimation of the emotional state of the bark.

According to the results of the 4th study, people are not able to confidentially discriminate if two barks are from the same individual or not. Their performance not improve remarkably if the can hear not one-one, but five-five barks. Their performance is better if the bark is atonal, or if they have to discriminate two barks recorded in the stranger context. We have not found any difference in the performance of people with different experience with dogs.

There was not significant difference in the performance of blind people and people with vision in the dog bark evaluation test. They have successfully categorized the barks in the same rate, and described the possible emotional state of dogs, similarly.

Apart from the six-year-old children who do not have dog, all groups' performance were above chance level in categorizing dog barks to different contexts. The effect of experience with dogs was not significant in any age group. The number of correctly categorized barks was increased with age. Subjects described the possible motivational state of dogs similarly.

Discussion

The results of our computerized analysis suggest dog bark has context- and individual specific acoustic features. If barks had had not such features the algorithm would not have succeed to categorize them with higher efficiency than expected by chance. Since context categorizing algorithm was most successful when analyzing stranger and Schutzhund barks presumably dog barks in these situations are more uniform. This might be the result of the dominating aggression. On the other hand individual recognizing algorithm was more successful in playful barks which suggests these barks are more diverse. We assume the selection constrain tending to uniform barks was less strict this time.

Dogs are able to recognize these context- and individual specific characteristics since they could distinguish between barks recorded in different contexts and from different dogs in a lab

experiment. On the other hand human subjects can only differentiate barks recorded in different contexts. In this experiment performances of dog owners and non owners were not different. This suggests that even people not having a dog have enough opportunity to learn to classify dog barks, but this also might suggest that this ability of humans have some genetically inherited background. This argument is backed by results of sightless people and children where these groups were able to described the motivational states of dogs in a comparable way to sighted adults.

In sum we can assume that, according to our results, bark seems to be an effective communicative system both in dog-human and dog-dog communication.

Publications

Molnár Cs, Pongrácz P, Dóka A & Miklósi Á 2009. Seeing with ears: Sightless humans' perception of dog bark provides a test for structural rules in vocal communication. *Quarterly Journal of Experimental Psychology*, *in press*. Impact factor: 1.760

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Publications nor closely related to theses

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information for humans. *Applied Animal Behaviour Science* 100, 228-240. Impact factor: 1.404 Cumulative impact factor: 13.907.

Acknowledgement

I would like to express my gratitude to my supervisor, Péter Pongrácz for his professional help. I am also thankful to Ádám Miklósi, head of Department of Ethology, ELTE and to Antal Dóka. I would like to thank my family, my wife, Andrea Molnár, my mother, my father, my sister for their essential help. I am thankful to owners of recorded dogs and Lilla Udvardyné Tóth. I am grateful to Celeste Pongrácz for correcting our English in our papers. I would like to thank the heads of State Institute of the Blind, the National Alliance of the Blind, the schools and kindergartens for their consent to our experiments.