Dogs can discriminate barks from different situations

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Abstract

We investigated if dogs can discriminate barks of another individual recorded in two markedly different situations: (a) when a stranger entered the property where the dog lived, and (b) when the dog was tethered to a tree and left alone. We used a habituation–dishabituation paradigm for testing discriminatory abilities. Three 25-s long samples of ''stranger'' bark were followed by a single ''alone'' bark sample. As a control, we used two types of mechanical noise (an electric drill and a refrigerator). Dogs ($n = 14$) were equipped with a portable heart rate monitor which recorded the data during the whole experiment. Upon hearing the first barking sound, the heart rate of the dogs increased significantly, followed by a habituation when the same barks were played back the second and third time. The fourth, different bark caused dishabituation of the heart rate. This suggests that heart rate can be a sensitive indicator of changes in attentiveness. The dogs did not show any significant evidence of dishabituation to the Control condition of the mechanical noises. Our experiment showed that dogs can perceive the difference between barks originating from different situations, thus barking is perhaps a communicative tool not only for dogs to humans, but for dogs to dogs as well.

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Keywords: Heart rate; Vocalization; Bark; Communication; Dog

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1. Introduction

There is growing evidence that dogs can rely on human visual signals (Soproni et al., 2001; Miklósi et al., 2004) and acoustic signals (Pongrácz et al., 2003; Virányi et al., 2004). Recently we have found that humans also understand the acoustic signals of dogs, more precisely, dog barks carry emotional information for humans (Pongrácz et al., 2005, 2006). Our own and others' studies (Pongrácz et al., 2005; Molnár et al., 2008; Yin, 2002; Yin and McCowan, 2004) showed that although the bark of each dog has its own features, patterns characteristic to a given situation are highly stable and recognisable across individuals. At the same time however, it is still doubtful whether dogs use barking in intraspecific communication. Although the acoustic communicative system of dogs is similar to the other canids' (Cohen and Fox, 1976), barking in the domestic dog has been suggested to be mostly without a clear communicative role. Many authors consider barking to be a by-product of domestication (e.g. Coppinger and Feinstein, 1991), due to relaxed natural selection.

As Heffner (1998) wrote: ''the common technique for studying intraspecies communication is to playback natural (i.e. conspecific) sounds to an animal to determine its unconditioned response to those sounds''. Since our aim was to find out whether barking could also be an intraspecific means of communication, we decided to use the habituation–dishabituation paradigm in which two kinds of pre-recorded calls were played back and the dishabituation response of the receiver was considered as an indicator of discrimination between the two signals (for example: Rendall et al., 1996; Rendall et al., 1999; Weiss and Hausser, 2002). As artificial laboratory experiments provide unnatural situations, we should be aware that our subjects' reactions might not be the same as would occur under more natural conditions. Therefore, we decided to use heart rate (HR) recording and analysis in our tests. HR measuring is a widely used method for detecting subtle changes of cognitive processes, emotional and physiological changes. The combination of behavioural and cardiovascular measurements could be especially useful when difficult-to-assess phenomena are investigated, such as mental workloads in adult humans (Vincent et al., 1996), or attention maintenance/termination in young infants (Richards and Hunter, 1997). Physiological measurements, like HR, can serve as a reliable source of data when subjects cannot be asked about their thoughts because they are animals in which behavioural parameters are difficult to detect. For example, sound recognition experiments in calves were supported by HR measurements because very young calves usually do not respond with detectable movements, which is supposedly part of the calves' predator avoidance behaviour (Marchant-Forde et al., 2002). Several studies have also investigated the HR responses of dogs to different emotional and potentially stressful situations (Palestrini et al., 2005; King et al., 2003; Beerda et al., 1997; Beerda et al., 1998). For instance, sound blasts (at an intensity of 100–120 dB) were shown to be potentially stressful for dogs and resulted in increased HR (Beerda et al., 1998).

In this study, our goal was to find out if dogs can distinguish between barks recorded in two different situations. These were (a) when an unfamiliar human enters the property where the dog lives (''Stranger''); and (b) when the dog is left alone on the street, tied to a tree by its leash (''Alone''). In our earlier experiments, we found that these types of barks are significantly different acoustically and humans can recognize them above the level of chance (Pongrácz et al., 2005, 2006). Using the habituation/dishabituation method, we hypothesized that dogs will show dishabituation, as assessed by heart rate, when they are exposed to a new type of bark, but will not dishabituate in the control situation, in which two types of mechanical noise are presented.

2. Materials and methods

2.1. Experimental room

The playback experiments were conducted in a 3 m × 5 m visually separated experimental room. The experimenter operated the playback device on a PC in the adjacent room. In one of the corners of the experimental room there were two chairs next to each other in which the owner of the subject and an assistant sat during the experiment. At the other end of the room, on the mid-line, a speaker was placed on a shelf 1 m above the floor for the playback.

2.2. Subjects

Subjects were pet dogs recruited from among participants of dog training schools. All dogs were older than 1 year (average age = 5 years, with a range of 2–8.5 years; nine males and five females). We set two more criteria: dogs had to be of a size sufficient to properly fit the electrode cups onto their body (average weight = 31 kg, with a range of 17–40 kg) and they were required to have taut skin to enable the proper attachment of the electrode cup. The subjects belonged to the following breeds (German Sheperd Dog (4); Tervueren, Border Collie, Golden Retriever (2); German Pointer, Labdrador Retriever, Czechoslovakian Wolfdog, mongrel (1).

2.3. Equipment

A telemetric system (ISAX – Integrated System for Ambulatory Measurement and Spectral Analysis of Heart Period Variance) – developed by Láng and co-workers (Láng and Szilágyi, 1991; Láng et al., 1992, 1998) – was used to measure the cardiac activity of dogs. ISAX consists of portable monitoring equipment for 24 h ambulatory measurement of the electrocardiogram (ECG) (and optionally other physiological variables) and a software package for further analysis of the stored data. The recorded ambulatory data are stored in the built-in NVRAM. The recorded data are later read and processed by a personal computer. Two channels serve the purposes of event marking.

The acquisition module is a small plastic box (10 cm × 15 cm × 2 cm; weighing 300 g) mounted in a pocket of a specially designed harness fastened on the dog. Before the experiment, the hair of the dog is removed by a razor in three circles (5 cm in diameter) on the chest: at the sternal part of *reg. cardiac* (exploring electrode), at the right side of *reg. sternalis* between the two frontal legs (indifferent electrode) and on the left side at the border of *reg. costalis* and *reg. sternalis* between the 7th and 8th costae (ground). The three ECG electrodes (Metec Austria, S50 LG Ag/AgCl) are then placed on these spots and connected by wires to the recording equipment. After the test, the recording equipment is connected to a personal computer and the raw data is transferred.

2.4. Procedure

Experiments were conducted in the morning hours. The fitting process of the portable HR monitor started 30 min before the experiment. The hair was removed by the experimenter with an electric razor. Before we commenced with the experiment, we allowed the dog to explore the experimental room.

During the experiment, the owner sat on the chair that was positioned closest to the speaker. The dog, kept on its leash, sat in front of him/her on the floor, facing the same direction as the owner. We asked the owners to keep the dogs in a sitting position as calmly as possible. During the playbacks, the owners were not allowed to touch their dogs.

The assistant sat beside the owner. His task was to talk with the owner during the experiment as we wanted to make the situation more natural. We reasoned that if the owner sat silently with the dog, or talked to the animal during the experiment, the subject may develop an anticipatory response, sensing from its owner that something was about to occur. So the owner and the assistant talked about ambient topics and did not pay attention to the sounds or to the dog as much as possible.

Sound samples were played back with a 60 s inter-trial interval. The assistant held in his hand a remote control device attached to the HR recorder and pushed the button right after the end of each sound sample. This served as an event marker on the HR recording, which was needed for the synchronization of the video and the HR recordings.

2.5. Bark samples and mechanical noises

A detailed description of the sound recording devices and the computerized bark sample preparations can be found in Pongrácz et al. (2005). Barks from the Mudi (a Hungarian sheepdog breed) were used for this study. We recorded bark samples from five adult individuals (male/female: 2/3, age: 4.70 ± 2.38 years) in two behavioural contexts: 'Stranger arrives' and 'Left Alone' situation. Two kinds of mechanical noise were used as control sound samples: 'Drilling machine on the brick wall', and 'Refrigerator'.

For the playback experiments, 25 s long samples were used which were cut randomly from the original recordings with sound editor software. Each subject was tested with a randomly assembled, unique set of four sound samples. All the sound samples were played back at the same volume level.

2.6. Playback tests

Each dog was tested under two conditions: in the Experimental condition we tested if the dogs reacted differently to barks recorded in different situations; whereas in the Control condition we tested the dogs with the two mechanical noises. The two conditions were counterbalanced by assigning the dogs randomly to one of the conditions first. The two tests were run separated by a half hour interval. Each test consisted of two phases: (1) habituation phase, in which we played three different bark samples from the same individual recorded in the 'Stranger' context, or, in the Control group, we played three samples from the noise of an electric drilling machine; (2) dishabituation phase, in which we played one bark sample which was recorded from the same individual in the 'Alone' context or, in the Control group, a sample of a refrigerator noise.

We analysed the HR of our subjects before and during the playback events. Three 10 s long intervals were used for this: one of them preceded the playback; the second interval started with the playback; and the
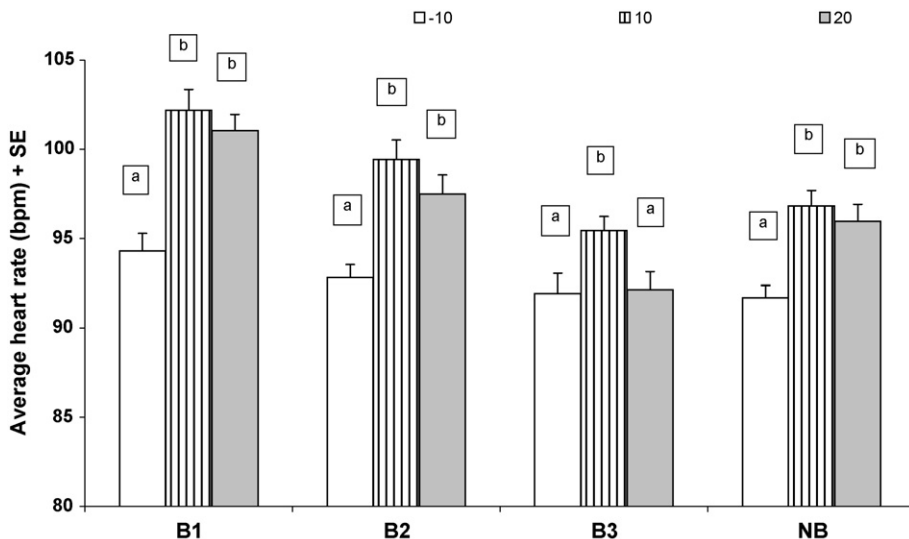

Fig. 1. Average cardiac changes of 14 dogs during a 10 s period preceding (-10), and two consecutive 10 s periods during (10 and 20), the bark playbacks. Significant differences between heart rate values (within a given playback event) were marked with different letters.

third period started right after the second interval ended. With the two recording periods during each sound playback, we were able to detect the possible changes created by the long lasting effects of the sounds.

2.7. Data processing

R peaks of the QRS complex from the ECG record were detected and the R–R intervals (all intervals between adjacent QRS complexes) were measured and stored (Izsó et al., 1999; Izsó and Láng, 2000). The R–R interval series were further processed by the ISAX programme. The original R–R data were linearly interpolated and re-sampled at 1 Hz to create an equidistant time series of R–R–s for analysis (Izsó et al., 1999; Izsó and Láng, 2000). For easier convenience, the R–R–s that were calculated for each second, were further converted to second by second heart rate (HR) measures (HR: 60 000/R–R). The mean HR for each dog was then calculated for the three 10 s long periods.

3. Results

In the following paragraphs and figure we will use the keys (abbreviations) listed below:

Key	Explanation
B1/N1 (−10)	10 s before the first barking sound/mechanical noise
B1/N1 (+10)	10 s after the first barking sound/mechanical noise
B1/N1 (+20)	20 s after the first barking sound/mechanical noise
B1/N1	1st barking sound/mechanical noise
B2/N2	2nd barking sound/mechanical noise
B3/N3	3rd barking sound/mechanical noise
NB/NN	new (4th) barking sound/mechanical noise

Figs. 1 and 2 show the average HR changes of 14 dogs during the four sound playback sessions in the bark and noise playbacks, respectively.
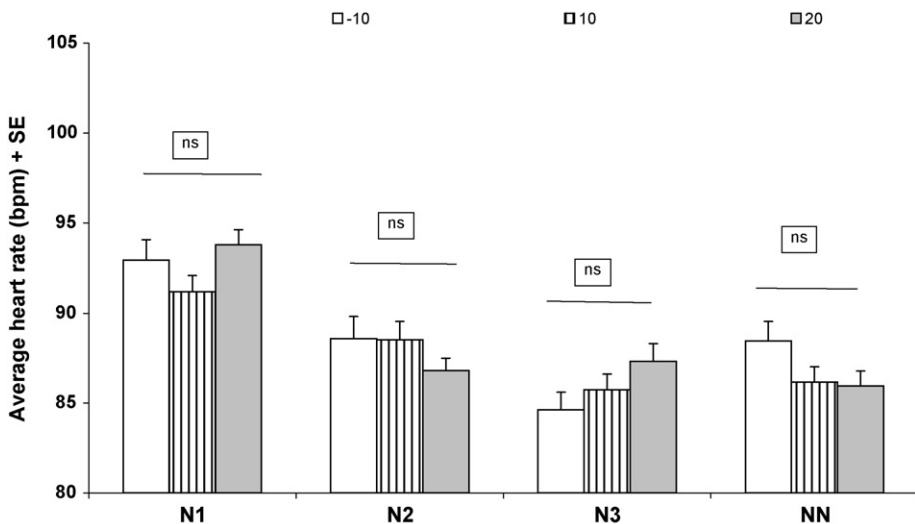

Fig. 2. Average cardiac changes of 14 dogs during a 10 s period preceding (−10), and two consecutive 10 s periods during (10 and 20), the noise playbacks.

Basic heart rate (i.e. before the first playback periods) of the dogs did not differ between the bark and noise conditions (paired t-test: $t_{(9)} = 0.79$; $p = 0.45$). Average heart rate for B1 (-10) was 94.3 (± 5.7) BPM and for N1 (-10) was 92.9 (± 5.4) BPM, respectively.

At first, changes of the cardiac responses during the first three playbacks (habituation) were analysed (by a 2-way ANOVA for repeated measures) separately in the bark and noise conditions (the two ways were ''sound'': which is the effect of the three playbacks; and ''time'': which is the three 10-s-long periods of time of data collection at every playback). In the bark condition, both the sound ($F_{(2,18)} = 31.07$, $p < 0.001$) and the time ($F_{(2,18)} = 21.55$; $p < 0.001$) had a significant effect on dogs' heart rate. We found also a significant interaction of the two factors: ($F_{(4,36)} = 3.29$; $p < 0.05$). These results show that during the three playbacks of the same kind of barking the heart rate of the dogs decreased, which shows the habituation. At the same time within each playback there was a significant effect of the time, which shows the effect of the barking sound itself, in comparison to the -10 s baseline.

For finer analysis of the effect of time, the average HRs during the 10 s long period before and the other two 10 s long periods during, each barking sounds were compared with each other within each playback event. We found a significant effect of time at each playback event: One-way ANOVA for repeated measures with SNK post hoc tests: (B1: $F_{(2,18)} = 15.94$; $p < 0.001$; B2: $F_{(2,18)} = 9.62$; $p < 0.01$; B3 $F_{(2,18)} = 6.27$; $p < 0.01$; B4: $F_{(2,18)} = 12.49$; $p < 0.001$, see Fig. 1). SNK post hoc test showed that the average heart rate of dogs increased significantly in both the habituation (B1, B2, B3) and dishabituation (B4) phases compared to the 10 s silent periods before them. B1 and B2 heart rates were higher in both 10 s periods during the sound playback which indicates a long lasting effect of barking. During B3, heart rates increased only in the first 10 s period, while in the second 10 s period it decreased to the previous, silent period level. It clearly reflects the dogs' habituation to the sound of 'Stranger' barks. The fourth, 'Alone' context (B4) barking had a longer lasting effect again. Heart rates remained high in both 10 s periods during the playback, which reflects the dogs' dishabituation to the sound of the barks in the ''new'' context.

For more detailed analysis of the dishabituation, we compared the +10 s and +20 s heart rates of B1 and B3 phases with the corresponding heart rate data of B4 (new bark) phase with paired t-tests. We found that both +10 s and +20 s measurements were significantly lower in the B4 phase than in the B1 phase (+10: $t_{(9)} = 4.76$; $p < 0.01$; +20: $t_{(9)} = 4.10$; $p < 0.01$). However, when we compared B3 phase to B4, the +20 s measurement was significantly higher in the B4 phase (+10: $t_{(9)} = 0.85$; $p = 0.41$; +20: $t_{(9)} = 2.77$; $p < 0.05$). These data show that although the new bark (B4) did not elicit as strong a heart rate increase as B1, the new bark sound had a stronger effect on the dogs' heart rate than B3—in other words the heart rate showed a dishabituation effect.

In the noise condition, we initially analysed the first three playbacks separately. Heart rate was affected by the sound (2-way ANOVA for repeated measures ($F_{(2,18)} = 29.15$, $p < 0.001$), but not by the time ($F_{(2,18)} = 0.58$; $p = 0.57$). The interaction of the two factors was not significant ($F_{(4,36)} = 2.53$; $p = 0.06$). These results show a general decrease of dogs' heart rate during the noise-habituation period. However, as the time did not have a significant effect on the heart rate of dogs within the individual noise playback sessions, there were no significant differences between the -10, +10 and +20 periods either, which means that we did not find any effect of the individual noise playbacks on the heart rate (see Fig. 2).

For analysing a possible dishabituation in the noise condition, we compared the +10 s and +20 s heart rates of N1 and N3 phases with the corresponding heart rate data of N4 (new noise) phase with paired t-tests. We found that both +10 s and +20 s measurements were significantly lower in the N4 phase, than in the N1 phase (+10: $t_{(9)} = 3.76$; $p < 0.01$; +20: $t_{(9)} = 5.89$;

$p < 0.001$). When we compared N3 phase to N4, neither of the measurements differed significantly (+10: $t_{(9)} = 1.64$; $p = 0.14$; +20: $t_{(9)} = 0.19$; $p = 0.87$). These data show that the new bark (N4) did not elicit as strong of a heart rate increase, as N1, and the new noise had the same effect on the dogs' heart rate as N3—in other words the heart rate showed no dishabituation effect in the case of mechanical noises.

4. Discussion

We chose the two types of bark sounds for our study that had the strongest effect on human listeners in our earlier studies (Pongrácz et al., 2005, 2006; Molnár et al., 2006). Barks from the ''Stranger'' and from the ''Alone'' situation have markedly different acoustic features, and our study here showed that dogs may have the capability to differentiate between them. The heart rate (HR) measurements showed that (1) dogs habituate to repeated bark playbacks from the same situation; (2) they dishabituate when we play back a bark sample from a different situation and (3) samples of two different mechanical noises did not result in dishabituation.

We know of only one study testing the effects of barks in dogs (Heffner, 1975). Dogs on their conspecifics were first trained to be able to categorize different sound samples into ''dog'' and ''not-dog'' categories. After the subjects had mastered this task reliably, they were given new sound samples and had to categorize them again into the two previous categories. Although no experimental results were reported, Heffner suggested that dogs have the capacity for ''classifying sounds into different categories''. However, there is another possibility; that dogs can react and recognize dog vocalizations without any training. With measurement of the changes of the HR in dogs, we showed that dogs can differentiate between bark samples from two situations, whereas they habituated to the (different) samples from the same situation. Since we did not get similar results in the case of mechanical noises, it is possible that the effect we found with the barks was not caused by simple acoustic similarities and dissimilarities. Of course, as we did not compare acoustically the mechanical noises to each other, there is a chance that dogs did not show dishabituation to the new noise, because it was not different enough from the other noise.

This experiment has shown that dogs have the capacity for distinguishing between different barks. Whether they react differently in a more natural environment and whether they recognize the same situation as humans do, requires further investigation.

5. Conclusion

Dog barking has been considered a meaningless vocalisation for decades. Recently we found that humans understand the emotional and referential content of dogs' bark. Now, with measuring the heart rate of dogs during a habituation–dishabituation test, we showed that they can discriminate between dog barks, recorded in different situations. This experiment can be the first step to investigate the capacity of dogs as receivers during communicating with barks.

Acknowledgment

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