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Attachment and communicative behaviour in dogs in connection with their cardiac activity

PhD thesis

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Introduction

Humans are very important factors of the social life of dogs (*Canis familiaris*). Human environment is their natural social environment. A dog's relationship to its caretaker is analogous to the child-parent attachment behaviour (Topál et al, 1989). Dogs are able to cooperate very efficiently with humans. They attend and follow the direction of humans' eyes (e.g. Soproni et al., 2001) but at the same time the continuous eye-contact (gaze) with a human may evoke their fear reactions (Vas et al., 2005). Their vocal repertoire has changed a lot in the course of domestication and one of their vocal signals, the bark, can easily be understood even by humans (e.g. Pongrácz et al., 2005).

Measuring heart rate parallel with behaviour can be one of the most popular indicator of an animal's inner state. Heart rate is affected by an individual's physical activity but also the psychical/cognitive state of the animal can have an impact on it (e.g. Wascher et al., 2008a). Analysis of heart rate variability can offer a further possibility to investigate the activity of the autonomic nervous system (von Borell et al., 2007).

Separation distress is reflected by changes of heart rate. Research on mother-infant attachment in humans resulted in surprising findings when the physiological background of the infants' behaviour was investigated in the scope of their attachment pattern. As some babies did not show overt distress during separation from their mother their physiological (e.g. cardiac) measures indicated arousal (Spangler and Grossmann, 1993). At reunion with the mother the vocally reactive babies' heart rate decreased (indicating the secure base effect of the parent) while those children displaying very little distress exhibited much longer elevations of heart rate (Sroufe and Waters, 1977). In case of dogs there are only a few studies that focus on behavioral responses considering physiological dimension during separation from the owner (e.g. Fallani et al., 2007). No information is available about the physiological background of the "secure base" effect of the owner in certain situations (e.g. in danger).

Heart rate measures can help to examine an animal's response to a conspecific's vocal signs (e.g. Bernston and Boysen, 1989). Humans can discriminate dog barks deriving from different situations (e.g. Pongrácz el al., 2005) but it has still remained a question if dogs are able to do it. We supposed that measuring heart rate can help us to find an answer.

Main objectives

First we wanted to test the applicability of ISAX heart rate (HR) measuring equipment developed for human psycho-physiological research on dogs. With the help of this equipment we aimed to follow up HR and heart rate variability (HRV) changes in dogs in different situations connecting to their attachment behaviour and communication.

1. The effect of body position and slow walk

Physical activity can have a pronounced effect on HR of animals. As in dogs such data are not available in previous studies we tested the following:

- Do different body positions (lying, sitting and standing) or movement (slow walking) affect cardiac parameters of dogs?

We supposed that:

1. Heart rate and HRV of dogs would be different during different body positions. We expected the lowest HR during lying.

2. Increasing physical activity would result in higher HR (and lower HRV) because of the higher energy demand.

2. The effect of attention

There are many experiments at the Department of Ethology in Eötvös Loránd University that aim to study the cognitive abilities of dogs. In many cases dogs have to be "attended" to something. Our next question was connected to the relationship between attention and cardiac activity.

- Does changing "attention" have any effect on HR and HRV? How does the orientation to a familiar object (connected to play/task) affect a dog's HR and HRV?

Considering scientific literature we supposed that orienting response to a given stimulus (favourite toy) will result in HR deceleration and HRV acceleration.

3. The effect of different social influences

Previous studies on HR changes in connection with separation from the owner were executed on freely moving dogs. In these experiments the effect of the animals' physical activity and separation stress on their HR was only indirectly separated from each other. According to these results we tried to find out the followings:

- Can we still demonstrate HR acceleration during separation in a situation where a dog's physical activity is controlled? How does separation affect HRV?

1. We assumed that when controlling a dog's movement we could still detect HR acceleration.
2. On the other hand, we also expected HRV deceleration because of stress in separation.

- Can the presence of a strange person who pets the dog counteract this change in HR?

1. We supposed that petting has a calming effect on dogs and can decrease stress during separation. It can also change (increase) HRV.
2. At the same time petting can be aversive so it could also have an opposite effect (e.g. increasing HR, decreasing HRV) on dogs.

In a separate series of experiments we wanted to examine the physiological effect of a threatening stranger approaching the dog. We were also interested in the effect of the owner in this potentially "dangerous" situation. The following questions revealed:

- Does the approach of a threatening stranger affect a dog's HR and HRV? How does the presence of the owner influence it?

1. According to our expectations threatening approach is aversive for dogs and results in HR acceleration and HRV deceleration.
2. We supposed that the presence of the owner decreases stress during a threatening approach in dogs compared to those who face to this potential danger alone. The "secure base" effect of the owner would be realised in less pronounced HR and HRV changes.

<u>4. The effect of a species-specific vocalization</u>

So far, we have no scientific evidence about the effect of species-specific vocalizations on dog HR. On the other hand, besides behaviour physiological responses can also inform us about the functional role of different vocal stimuli on the animal. It is still doubtful whether dogs are able to differentiate barking recorded in different situations. We tried to answer the following questions:

- Does barking sound ('Stranger arrives') affect a dog's HR? Is there any difference between reactions provoked by a species specific vocalization or by a "indifferent noise"?

1. We hypothesized that a dog will react to the bark of an other dog differently than to a presumably indifferent, mechanical noise. We supposed that the

‘Stranger arrives’ bark will evoke a dog’s defensive reaction and will result in HR acceleration. This kind of bark was also perceived more aggressive by humans.
2. In case of mechanical noises we expected HR deceleration because of the orienting response. No detectable HR change was presumable in this situation.

We also wanted to find out if dogs (similarly to humans) would be able to differentiate barks recorded in different situations.

- Does a dog show physiological habituation with repeated playbacks of barks from the same situation? Do they show dishabituation (changing HR) when they are exposed to a new type of bark?

1. According to our expectations dogs would habituate to repeated presentation of a similar type of bark.
2. In addition we supposed that dog HR would change if they perceive the bark from a different situation (with a biological meaning for them). On the other hand we did not expect HR changes in the control situation, in which two types of mechanical noise were presented.

Methods

Older than 1.5-year-old family dogs were involved in our experiment. Animals lived with their owners (in the same household: garden or indoor) and the owners regularly spent time with them (e.g. walking or training in dog schools). Medium sized (min. 15 kg) dogs were recruited since they were required to carry the recording equipment. Subjects of research belonged to different breeds.

Tests were carried out in a 3.5×5.5 m empty experimental room at the Department of Ethology, Eötvös Lóránd University. Experimental room was visually separated from the corridor and from other rooms.

A telemetric system (ISAX – Integrated System for Ambulatory Measurement and Spectral Analysis of Heart Period Variance) was used to measure the cardiac activity of dogs (Láng and Horváth, 1996). ISAX was originally developed for human psycho-physiological research and it has not been used for dogs before. The equipment was attached to the animal 30 minutes before the start of the experiment. Before electrodes were attached the fur of the dogs was shaved off in three circles of about 5 cm in diameter. The 3 ECG electrodes (Metec Austria S50 LG Ag/AgCl) were then connected to the recording equipment, which was mounted in a pocket of a specially designed harness fastened on the dog. R waves of the recorded ECG were detected using

a special software and R-R intervals (heart period, ms) were measured and stored.
We excluded those parts of our cardiac measures in which errors were visually identified. Behaviour of the dogs was video recorded. For each dog the phase of video recording and heart rate recording was synchronised in accordance with the requirements of a particular experiment. Then R-R averages and standard deviations of R-R (SDNN) were calculated. The experimental procedure contained three main tests:

1. In the first test, divided into 2 episodes including several phases, 14 dogs were involved. During the observation the subject, the owner and the experimenter controlling the camera stayed in the experimental room. In the first episode (according to a predetermined protocol) the owners were asked to command their dog to take up different body positions or to walk for 1–2 minutes. During the test the owner showed a favourite ball to the dog two times for at least 30 s. At the end of this episode the owner left the experimental room and the dogs stayed with the experimenter for 4 more minutes (2×2 min.) and she petted the animals for 2 minutes. The experiment was repeated later on with at least 3 days between the first test and the repetition. In the repetitions the order of the phases was changed.

In data processing we compared the given R-R intervals (30 or 40 s) measured during the below mentioned phases:
- influence of the body positions or slow walk: “*lying”* vs “*sitting”* vs “*standing* vs *walking”*
- influence of orientation at the ball: “*sitting”* vs “*sitting with the ball”*
- influence of separation and stroking: “*standing”* vs “*separation”* vs “*separation and stroking”*

2. In the second test the influence of separation and threatening stimulus on heart rate of the subjects (n=30) was measured in a modified Stranger Situation Test (Topál et al., 1998). The test consisted of six episodes. In the experiment the dog stayed in the room with or without its owner according to a predetermined protocol and in both cases a threatening stranger (Vas et al., 2005) approached the separated dog or the dog together with the owner. As we wanted to eliminate the impact of asymmetrical order of the episodes two different sequences were applied with different order of the episodes. Each dog took part in a test just for one time. During data processing 15 s long R-R intervals were compared.

Impact of the below mentioned factors on HR and HRV were taken into consideration:

- influence of the owner's presence – "*with the owner"* vs "*without the owner"* (separation)
- influence of threatening stimulus – *"before the threat*" vs *"during the threat"* vs *"after the threat"*
- influence of reactivity – *"vocally reactive"* vs *"vocally non-reactive"* dogs

3. In the third test the impact of species-specific vocalisation, the barking sound was observed by a so-called habituation-discrimination method in which the playback of a sound sample resulted in the habituation of the animal (orientation response disappeared). A new sound sample resulting in the dishabituation (repeated orientation) of dogs shows that the animal is able to distinguish a new sound from well-known sounds (Sproul et al., 2006). In the tests "barking at a stranger" (which could easily be distinguished also by humans) sound sample was applied to achieve habituation of the subjects. This sound was played back three times where each sample was 25 s long. The new sound sample (the 4th sound: "alone") derived from a dog which was tied to a tree by its leash. The acoustic parameters of the two different barking types were different (Pongrácz et al., 2005). We used sound samples of mechanical noises as control which were supposed to be neutral for the dogs (n=14) in the already-mentioned protocol. Each dog was exposed to playbacks of both sound samples.

Comparisons were drawn of the behaviour observed before and after the playback events. We also analysed the HR of our subjects

- 10 sec before playback events
- during playback events.

With the two recording periods during each sound playback we were able to detect possible changes created by long lasting effects of the sound.

Results and discussion

1. Our study demonstrated that HR of dogs was affected by changes in posture for at least a 1–2 min long period. Heart rate was the lowest during lying and significantly increased with increased motor activity, e.g. slow walking. On the other hand, we did find significant differences in HRV during different body positions and walking.

With regard to HR and HRV high inter-individual variability and stable individual consistency were found.

These results highlight the importance of considering physical activity of individuals when psychological and cognitive processes are studied by measuring HR.

2. Increased attention (orientation towards the favorite toy) of dogs resulted in highly repeatable changes in HR (both in direction and in degree) at an individual level. We suppose that these individual differences originate from a different evaluation of a situation. In case of about half of our subjects we observed HR deceleration, which could be the result of the orienting response. In some other dogs the effect of a general sympathetic arousal during preparation for a given action (e.g. play) could induce HR increase.

Moreover, increased attention (orientation to the ball) resulted in a remarkable increase in HRV in all animals. We suppose that the increased parasympathetic effect due to a deeper and more regular respiration causes this phenomenon.

According to our result HR could be a good indicator of elevated ‘‘attention’’ in dogs.

3. During separation – opposite to our expectations – we could not find HR elevation. Interestingly, petting of separated dogs increased HR. Further systematic tests could clear up possible aversive effects of an unknown person on dogs.

In both tests, when dogs were separated from their owners an increased HRV was found. In our opinion it reflected an enhanced orientation towards the owner but during petting by the experimenter HRV decreased again. In the second experiment, when dogs were left alone in the room, an increasing HRV was only typical for behaviorally reactive (vocalizing) dogs.

According to our results, we can claim that separation for 2-3 minutes is not appropriate to reveal physiological stress in dogs when measuring HR. On the other hand, petting by the experimenter during separation could decrease a dog’s orienting response. In this situation, increased HR – beyond its aversive effect – could be the result of stress appearing due to separation.

4. In the modified version of the Strange Situation Test the approach of a threatening unfamiliar person caused HR increase and HRV decrease. These changes were only typical for behaviorally reactive (vocalizing) dogs. The presence of the owner also affected the subject’s cardiac activity. “Threatening” during separation induced a more increased HR compared to the other situation

where the owner sat beside the dog. This clearly demonstrates the “secure base” role of the owner on the animal.

Test order, whether the dog encountered the threatening stranger first with or without its owner, also proved to be important. When threatened first with their owner, next time in separation they had a less pronounced HR reaction.

Different cardiac responses of vocalizing and non-vocalizing dogs indicate that working on group averages can mask significant individual differences in animals. These differences can also reflect individual coping strategies.

5. We could also prove that dogs – similarly to humans – can differentiate barks from different situations. Upon hearing the first barking sound, the heart rate of dogs increased significantly followed by a habituation (HR deceleration) when the same bark was played back for the second and third time. The fourth, different bark caused dishabituation (elevation) of heart rate. Sample of mechanical noise did not show HR acceleration.

On the other hand, behavioural responses (orientation) did not reflect that dogs could differentiate the two types of barking.

According to our results HR measurement in dogs can be a useful complementary indicator when it comes to evaluating species-specific vocalizations.

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