More than noise?—Field investigations of intraspecific acoustic communication in dogs (*Canis familiaris*)

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ABSTRACT

Besides being a widely investigated behavioural phenomenon, barks of dogs often represent a factor of nuisance for people. Although some argue that dog barking has no or only minimal communicative function, it was shown recently that these acoustic signals carry various information that humans can decipher. However, apart from a few laboratory studies, until now no targeted research has been done about the communicative role of barks in the intraspecific domain. In this field experiment companion dogs were tested with bark playbacks at home, in a suburban environment. From a hidden sound system, placed near to the gate outside of the property, each subject was exposed to pre-recorded barks of an unfamiliar and a familiar dog. Barks for the playbacks were recorded in two different contexts: when the dog was either left alone or when it was barking at a stranger at the fence. We found differences in the behaviour of dogs depending on both the familiarity and context of the playback barks. The position of the dogs (near the house or near the gate) was mainly influenced by the context of the barks ($p = 0.011$), in a significant interaction with the familiarity of the barking dog ($p = 0.020$). Subjects stayed at the gate (nearest to the source of the sound) the longest when they heard an unfamiliar dog barking at a stranger ($p_{adj} = 0.012$). Meanwhile they stayed at the house mostly during the barks of a lonely unfamiliar dog ($p_{adj} = 0.001$). Dogs oriented more towards the house (where the familiar dog stayed during the experiment) when they heard the familiar dog's barking ($p = 0.019$). Subjects barked more often when they heard the 'stranger' barks, independently of the familiarity of the caller ($p = 0.035$). As a conclusion, dogs seemingly distinguished among the callers based on familiarity and between the contexts of the barks. This is the first study on companion dogs in their natural environment that found evidence that dogs are able to extract detailed information from the barks. The relevance of our findings for the management of excessive bark is discussed.

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1. Introduction

Barking is considered as the most typical vocalisation of dogs (Pongrácz et al., 2010, 2011). During the last decade barking drew a considerable interest from ethologists, and several studies dealt with the acoustic features (e.g. Pongrácz et al., 2006; Yin and McCowan, 2004), the possible function in communication (e.g. Lord et al.,

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2009; Pongrácz et al., 2005; Yin, 2002), and the evolution (Coppinger and Feinstein, 1991; Feddersen-Petersen, 2000; Pongrácz et al., 2011) of dog barks. Besides the biological relevance that inspires scientific interest, dogs' bark has less favourable features, too. Bark-related problems usually manifest themselves in the phenomenon called 'excessive barking' (e.g. Kobelt et al., 2003). Considering a vocalisation as excessive is obviously a relative decision, however it has a great relevance both in the veterinary diagnostics, like in the case of the symptoms of separation anxiety (e.g. Lund and Jørgensen, 1999); or probably even more commonly when the barking of a dog is becoming a nuisance. Nuisance barking is among the leading behavioural problems with dogs (e.g. Cross et al., 2009) that elicit considerable friction between inhabitants of any densely inhabited (mostly urban) areas (e.g. Fielding, 2008). In spite of the relevance of nuisance barks on the human and animal welfare and legislation, there are only very few empirical studies dealing with the biological characteristics and occurrence of dog barks as potential disturbance for the human living environment (see for example Flint et al., 2013). For a better understanding of the phenomenon of barking behaviour in dogs, it would be necessary to investigate the possible role of this vocalisation among field conditions, preferably in the natural environment of companion dogs in a (sub)urban habitat.

Hypotheses about the function and evolution of dog barks differ mostly in the extent and complexity of information that dog barks are supposed to carry. According to Coppinger and Feinstein (1991) it is unlikely that a single selective effect acted during the evolution of dogs that resulted in such diverse forms of bark signals. They argued that barks are 'meaningless' vocalisations, and have very little context-specificity (see also Lord et al., 2009). Other authors hypothesized that various barks may be connected to the contextually different situations they were produced in (Pongrácz et al., 2005, 2006; Yin and McCowan, 2004). Several studies seem to support the later notion by showing that dog barks have consistent situation-dependent acoustic features (e.g. Pongrácz et al., 2005; Yin, 2002).

According to Feddersen-Petersen (2000) the highly variable ecological niche of domestic dogs and the increased complexity of their social life led to an increase of their communicative social interactions via the differentiation of their barks. Based on this hypothesis Pongrácz et al. (2005, 2006, 2011) and Molnár et al. (2006, 2010) conducted several playback experiments, where human listeners of different age, experience with dogs, and seeing abilities (i.e. sighted vs. sightless) were asked to rate the inner state of the barking dogs and categorize the context of the bark samples. In general, the results showed that humans could reliably identify the context of most dog barks, and rate the inner states of dogs with emotions corresponding to the context of the barks (e.g. high scores of aggression for barks directed towards a stranger at the gate or high scores of 'happiness' and 'playfulness' for barks emitted while playing).

For humans dog barks may serve as source of information about the dog's inner state, and indirectly about the context in which the bark was emitted, but this still does not answer the question whether dogs are able to extract this information from barks during intraspecific communication. Observations on feral dogs provide a good source of information here, as the social interactions of these animals are not restricted, altered, or channelled by humans, as in the case of companion or working dogs. Boitani et al. (1995) reported that feral dogs bark less and more rarely than dogs living with humans that could suggest that the primary function of barks is to communicate with humans. A study of ownerless village dogs in Ethiopia revealed that dogs barked more often when being alone than when being accompanied by other dogs (Ortolani et al., 2009) which could hint towards barks serving as a recruitment call (see also Lord et al., 2009). Unfortunately, no systematic experimental studies have been conducted on the vocal communication of feral dogs, which leaves open the question about the function of barks in intraspecific communication.

In a heart rate based habituation–dishabituation experiment Maros et al. (2008) found that dogs show dishabituation when hearing barks recorded in different contexts. In a behaviour (orientation) based habituation–dishabituation study Molnár et al. (2009) found that not only could dogs discriminate between barks recorded in different contexts but also between barks recoded in the same context but from different individuals. However until now no experiment was carried out to verify whether dogs react differently to barks recorded in different contexts outside a laboratory setup. Thus our first aim was to carry out a conceptual replication of these studies and to test if dogs react differently in their natural environment to bark playbacks of different contexts and from familiar versus unfamiliar individuals. Replication of previous results is essential before building on them in further experiments as this is the only way to ascertain if the phenomena to be studied is robust enough (see e.g. Bakker et al., 2012; Koole and Lakens, 2012).

While habituation–dishabituation experiments shed light onto the just-noticeable difference between stimuli, field playback experiments focusing on natural responses tell us about the just-meaningful difference (Nelson, 1988). The subjects' responses to playback experiments would therefore elucidate whether the perceived difference between stimuli is also relevant to the animals in their everyday environment (Fischer et al., 2013). Previous research has also shown that laboratory studies do not necessarily yield the same results as observations in natural environments (e.g. Anderson and Brown, 1984; Ladouceur et al., 1991), thus both of these approaches need to be used in order to obtain solid conclusions. Consequently we designed a field playback experiment to investigate how dogs react to pre-recorded barks of their canine home companions as opposed to barks of unknown individuals. We also wanted to see whether dogs showed different reactions to contextually different barks recorded in the 'being left alone' and the 'stranger approaches the gate' situations. We selected these two contexts because (1) it was found that the barks recorded in these are clearly distinct regarding their acoustic features (Pongrácz et al., 2005); (2) previous habituation–dishabituation experiments have shown that dogs can reliably distinguish between these contexts (Maros et al., 2008; Molnár et al., 2009); and (3) it

was reasonable to assume that dogs would react differently to territorial and distress barks (see the 'mobbing theory' of Lord et al., 2009). Testing dogs in their natural living environment (garden of the owner's house in a suburban area), enabled us to observe various different behaviours and if these behaviours would differ depending on how dogs interpret the played back vocalisations.

Due to the exploratory nature of our study and the lack of previous experiments in the field it is hard to formulate any clear-cut hypothesis about the behaviour of the subjects. However we expected that if dogs differentiated among the bark playbacks according to familiarity and/or context, then their behaviour (position, orientation, vocalisation) would differ according to these dimensions. According to our knowledge our study is not only the first field experiment on the role of dog barks in intraspecific communication, but also the first report of non-feral dogs' reactions to dog barks in their natural habitat.

2. Methods

2.1. Subjects

Our subjects were 16 adult (mean age 4.0 years, range 1–12 years) companion dogs (9 females, 7 males), representing various breeds (6 Mudis, 3 Mixed breeds, 2 Great Danes, 1 Bichon-Havanese, 1 German Shepherd, 1 Malinois, 1 Pumi, 1 Tervuren) from 5 multi-dog households (2 to 4 dogs/household). Subjects lived in the suburban areas of different Hungarian cities, where they had access to the garden of the owner's house but were also allowed to enter the house. The dogs from the individual households did not know each other. Subjects were recruited on a voluntary basis from the Family Dog Project database.

2.2. Procedure

2.2.1. Bark recordings

Bark recordings were done as it is described by Pongrácz et al. (2005). Prior to the playback experiments we recorded barks from all participating dogs in two social contexts using a Sony Digital Audio Tape Walkman (type: TCD-D100) with a directional microphone (type: ECM-MS907). In the *Left alone* context the owner tied the leash of the dog to a tree in an unfamiliar place (outside the home environment) and walked away, out of sight of the dog.

The experimenter recorded the barks of the dog from a distance of 4–5 m for 3–4 min. In the *Stranger arrives* context an unfamiliar experimenter (Cs. M., male, age 22), appeared at the gate of the garden, where the dog lived. At this time the dog was alone in the garden, and the owner was asked to stay in the house. The experimenter recorded the barking of the dog from approximately 2 m distance after approaching the garden gate for about 2–3 min. The recorded material was transferred to a computer via a TerraTec DMX 6fire 24/96 sound card with a 16-bit quantisation and a 44.1 kHz sampling rate.

2.2.2. Playback experiment

Four experimental conditions were formed, based on the type of the bark playback the subjects were receiving.

Both '*Left alone*' and '*Stranger arrives*' barks were played back from '*Familiar*' (dogs living in the same household) and from '*Unfamiliar*' individuals (dogs living in a different household). Consequently the four conditions were: 'Alone-Familiar' (Al_Fam), 'Alone-Unfamiliar' (Al_Unf), 'Stranger-Familiar' (Str_Fam), 'Stranger-Unfamiliar' (Str_Unf). Each dog was tested once in each of the four conditions on separate days (with a minimum of four days in between). The order of the tests was randomly chosen for the individual subjects.

A total of 37 different bark sequences were created for the playbacks. Unfamiliar dog barks were selected randomly from an already existing pool of barks and from the barks recorded during the study. None of the unfamiliar dog barks was used more than three times (17 used once, 3 used twice and 3 used three times). Familiar dog barks for households with two dogs were selected so that the barks of one dog served as stimuli for the other dog, while in households with more than two dogs bark stimuli were selected so that each dog heard a different individual as familiar stimulus in the two contexts (unless some of the dogs did not bark during the bark recordings).

For each experimental condition 1 min long bark sequences were prepared from the recorded barks. Sequences were assembled of multiple segments, which were extracted from those parts of the original recordings that contained only barks (lacking background noise). Each segment's highest amplitude peak was normalized to 0 dB. The relative loudness of the individual barks within a segment was left unchanged to preserve the natural variability present in the vocalisations .

The number of individual barks were also not equalized in the playback sequences, therefore there was a variation in bark numbers across conditions (Al_Fam: 79 ± 31, Al_Unf: 69 ± 31, Str_Fam: 62 ± 27, Str_Unf: 54 ± 16). Comparing the number of barks between the conditions revealed that sequences in the 'Stranger' conditions contained significantly more barks than those in the 'Alone' conditions (Generalized Liner Model with Poisson distribution and log link: Context: $F_{(1, 60)} = 58.17$, $p < 0.001$; Familiarity: $F_{(1, 60)} = 1.68$, $p = 0.20$; Context × Familiarity: $F_{(1, 60)} = 1.93$, $p = 0.17$). The difference in the number of barks however is a natural property of barks emitted in these two contexts, and it is the consequence of the shorter interbark intervals in the 'Stranger' context (Pongrácz et al., 2005).

The experiments were conducted at the home environment of the subjects. All participants were middle class Hungarian families, living in single family houses, separated from the neighbours and the street by tall fences all around the garden. No other details of the house and the garden (e.g. the size of the house, the length and material of the fence) were controlled. Although all tests were conducted in quiet suburban areas, we could not fully control the environment outside the owner's house. As our subjects were most probably aware of what was happening on the street outside their garden (e.g. a car passing by), we controlled for the household as a nested variable in our models. These variations arising from the nature of the study ('field investigation') apart from ensuring the generalizability of

the results (e.g. the results would not only be true for a certain type of house and fence) also enabled us to test dogs in their natural environment (all subjects were used to hear barks regularly through the fence at their home environment).

Before the arrival of the experimenters to a particular test location, the owner was contacted by phone and he/she was asked to lock the dogs inside the house. In this way the test-equipment (cameras, playback device) could be placed and prepared along the fence and in the garden, and the experimenters could also hide so that the subject would not see them. The playback device (laptop, amplifier (HPB-602 350W) and speakers (a Genius SW-5.1 Home Theatre centre speaker) was placed outside of the garden, within 1 m distance from the fence. As the playback device and the experimenter was the same for all subjects and conditions, all sensory (e.g. olfactory) modalities were standardized.

As a next step the owner was again contacted via phone to let one of the dogs out to the garden, while at the same time locked the other dog(s) to the room furthest away from the garden. Thus only one dog was in the garden during the testing, and the other dog(s) of the household were isolated from the test subject as much as possible. The behaviour of the subject in the garden was recorded with two cameras which were mounted on tripods and pointed towards the gate and the area between the house and the gate. The cameras were started before the dog was released, therefore the dog did not encounter the experimenters during the playback tests. The playback was also started before the dog was released, however each sound file commenced with 3 min of silence, therefore the barks from the speaker started approximately 2 min after the dog was released and lasted for 1 min. One minute after the end of the playback the owner was contacted again via phone to call back the dog into the house. The owner was unaware of the exact aims and hypothesis of the study and was also blind to the experimental condition.

2.3. Data collection and analysis

From the video footage the behaviour of the subjects was manually coded using Solomon Coder beta (© 2013 by András Péter) and data was analyzed with IBM® SPSS® Statistics 21. The following behavioural variables were recorded: (a) *being near to the gate/being near to the house*, which was defined as either standing, sitting or laying within 1 m of the gate/house (duration, s); (b) *orienting towards the gate/orienting towards the house*, defined as head pointing in the direction of the gate/house irrespective of body orientation (duration, s); (c) *barking* (frequency). For all variables interrater reliability was determined by calculating the Intraclass Correlation Coefficient (ICC) based on the data of 20 randomly selected videos that were double coded by É. Sz. and an independent coder (*near gate*: $ICC_{(2,1)} = 1.00$; *near house*: $ICC_{(2,1)} = 1.00$; *orienting towards the gate*: $ICC_{(2,1)} = 0.93$; *orienting towards the house*: $ICC_{(2,1)} = 0.99$; *barking*: $ICC_{(2,1)} = 0.93$). Behaviours (being near to, orientation), which were directed towards irrelevant parts of the garden (not towards the gate and the house) were not coded.
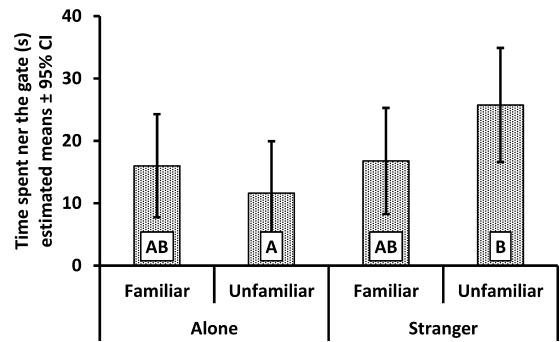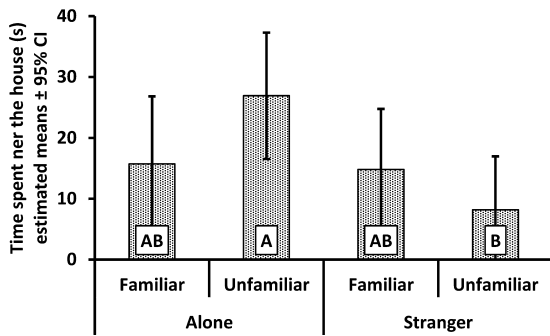

Fig. 1. Comparison of the time spent near the gate between the experimental conditions. Capital letters A and B mark the conditions that differ significantly from each other, according to the pair wise contrasts of the estimated means, conditions sharing the same letter(s) do not differ significantly.

The main analysis was carried out by Generalized Linear Mixed Models (GLMM). Household and subject was set as nested random effects, sequence of test was set as repeated effect and Context (Alone, Stranger), Familiarity (Familiar, Unfamiliar), and the Context × Familiarity interaction were set as fixed effects. In the case of the *near gate, near house, orienting towards the gate* and *orienting towards the house* variables (duration) we used a model with normal distribution and an identity link, in case of *barking* (frequency) we used a model with a Poisson distribution and a log link. After each analysis the residuals were tested for departure from normality with a Kolmogorov–Smirnov test with Lilliefors correction. The distribution of residuals did not differ significantly from normal in any of the cases. In case of significant interactions pair wise contrasts of the estimated means were calculated for both factors, and the resulting *p*-values were adjusted using the method of Hochberg (1988).

3. Results

In case of the *near gate* variable the GLMM found a significant effect of the factor Context ($F_{(1, 60)} = 5.98$, $p = 0.017$) and a significant interaction (Context × Familiarity: $F_{(1, 60)} = 4.45$, $p = 0.039$), but no effect of the factor Familiarity ($F_{(1, 60)} = 0.55$, $p = 0.46$) (Fig. 1). Contrasts of the estimated means revealed that the dogs spent significantly more time near the gate in the Stranger-Unfamiliar than in the Alone-Unfamiliar condition ($t(60) = 3.09$, $p_{adj} = 0.012$), however no significant differences were indicated between any of the other contrasted factors (Al_Fam vs. Str_Fam: $t(60) = 0.18$, $p_{adj} = 0.86$; Al_Fam vs. Al_Unf: $t(60) = 1.06$, $p_{adj} = 0.59$; Str_Fam vs. Str_Unf: $t(60) = 1.91$, $p_{adj} = 0.18$).

In case of the *near house* variable the test found a similar pattern with a significant effect of Context ($F_{(1, 60)} = 6.86$, $p = 0.011$), a significant interaction (Context × Familiarity: $F_{(1, 60)} = 5.75$, $p = 0.020$) but no significant effect of Familiarity ($F_{(1, 60)} = 0.36$, $p = 0.55$) (Fig. 2). According to the contrasts of the estimated means dogs spent significantly more time near the house in the Alone-Unfamiliar than in the Stranger-Unfamiliar condition ($t_{(60)} = 3.88$, $p_{adj} = 0.001$). The pairwise contrasts indicated no other significant differences (Al_Fam vs. Str_Fam: $t_{(60)} = 0.16$,

Fig. 2. Comparison of the time spent near the house between the experimental conditions. Capital letters A and B mark the conditions that differ significantly from each other, according to the pair wise contrasts of the estimated means, conditions sharing the same letter(s) do not differ significantly.

$p_{adj} = 0.88$; Al_Fam vs. Al_Unf: $t_{(60)} = 1.90$, $p_{adj} = 0.19$; Str_Fam vs. Str_Unf, $t_{(60)} = 1.43$, $p_{adj} = 0.32$).

When analyzing the *orienting towards the gate* variable the GLMM found no significant effect of Context ($F_{(1, 60)} = 0.00$, $p = 0.99$), Familiarity ($F_{(1, 60)} = 0.17$, $p = 0.69$), or an interaction (Context × Familiarity: $F_{(1, 60)} = 0.35$, $p = 0.56$). However dogs *oriented towards the house* significantly more when they heard a familiar dog bark, than when they heard an unfamiliar dog (Familiarity: $F_{(1, 60)} = 5.85$, $p = 0.019$) (Fig. 3), but the test found no significant effect of Context ($F_{(1, 60)} = 3.67$, $p = 0.06$) or a significant interaction (Context × Familiarity: $F_{(1, 60)} = 1.26$, $p = 0.27$).

According to the GLMM test the frequency of *barking* was significantly influenced by the factor Context ($F_{(1, 60)} = 4.65$, $p = 0.035$) but not by Familiarity ($F_{(1, 60)} = 0.51$, $p = 0.48$) or the interaction of the two factors (Context × Familiarity: $F_{(1, 60)} = 0.02$, $p = 0.90$) (Fig. 4).

4. Discussion

In a series of playback tests we found that companion dogs vary their behaviour depending on the identity of the caller and the context of the vocalization in their natural habitat. To discuss our main findings, we will go through shortly a set of alternative hypotheses that can explain the different possible outcomes of the experiment.
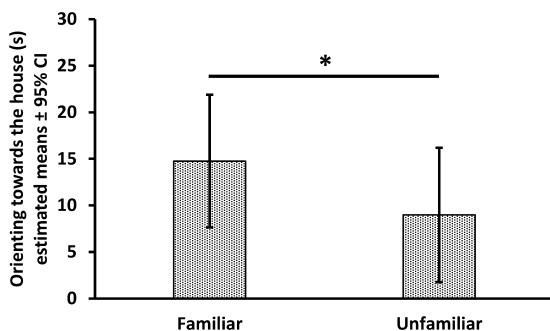
Fig. 3. Comparison of the time spent orienting towards the house between the Familiar and Unfamiliar conditions. Solid horizontal lines above the graph mark the results of the GLMM for the factor Familiarity (* $p < 0.05$).
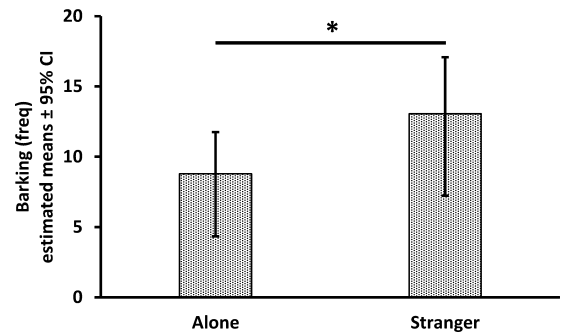
Fig. 4. Comparison of the frequency of barking between the Alone and Stranger conditions. Solid horizontal line above the graph marks the results of the GLMM for the factor Context (* $p < 0.05$).

The first possibility is that dogs can only differentiate barks (as it was shown in previous studies, i.e. Molnár et al., 2009) but do not associate them with certain individuals or contexts (null hypothesis). In this case we would expect dogs to show heightened reaction to those barks that are most unfamiliar to them. It is reasonable to assume that dogs hear the barks of their home companions most often and the 'stranger' bark is the most prevalent when being in the garden. Therefore we would expect dogs to show increased orientation towards the sound source at the gate and also to spend most time in the vicinity when they hear an unknown dog barking and when they hear the 'alone' bark type. In contrast with this hypothesis, the strongest response (staying near to the gate, leaving the vicinity of the house) was elicited by the unfamiliar dogs' 'stranger' barks. Dogs showed the weakest reaction to the 'left alone' barks of the unfamiliar dogs, as this type of playback elicited the least approach to the gate (to the source of the sound), and the dogs remained near to the house. This shows that dogs discriminated between the unfamiliar barks based on their context.

An alternative hypothesis is that dogs are not only able to differentiate barks of known and unknown individuals but also associate the known barks with the right individuals. In this case we expect dogs to show a heightened reaction to barks of unknown individuals (looking towards and approaching the gate) and at the same time barks of the known individual would elicit orientation towards the house (where the other dogs are during the experiment). Supporting this prediction, we found that dogs oriented towards the house most often when barks of their canine home companion were played back. However, as we mentioned it earlier, dogs did not react with the same level of interest to the barks of the unknown individuals, but rather differentiated between them context-dependently.

The next alternative is that dogs associate the barks with the appropriate context. In this case we would expect that dogs show the strongest reaction to 'stranger' barks (approaching and orienting towards the gate) as this type of bark signals a potentially more threatening situation and at the same time dogs would bark more in response to these barks if barks serve as a recruitment call. Our results confirm partly this hypothesis, as the dogs approached the gate mostly when they heard the 'stranger' barks, and also reacted with a heightened level of barking to this

type of vocalisation. These findings are in accordance with the hypothesis that dogs are able to associate the barks recorded in the 'stranger' context with the situation itself (higher level of threat); and it can be assumed also that the more frequent barking of the subjects upon hearing 'stranger' barks may refer to recruitment calls (Ortolani et al., 2009) in such a 'defence' context. However, we found also that dogs did not react similarly to all the 'stranger' barks. Contrary to the reaction elicited by the unfamiliar dogs' 'stranger' barks, the contextually similar vocalisations of the familiar canine companions elicited much weaker reaction, which suggests that dogs discriminate these barks on the basis of familiarity as well. From the above detailed analysis of different hypotheses, we can conclude that dogs are able to associate both the context of barks and the individuals, and react accordingly to the content and familiarity of the calls.

The pattern of the subject's behaviour is in line with the findings of earlier laboratory experiments (Maros et al., 2008; Molnár et al., 2009) showing that dogs can differentiate between individuals and contexts on the basis of barks. More importantly, the present experiment has shown that the information contained in barks also guides dogs' behaviour in their everyday environment. Furthermore we show that certain behavioural reactions reflect differentiation between bark contexts, while others reflect differentiation between familiar versus unfamiliar dogs. While barking can be also informative for humans (e.g. Pongrácz et al., 2005, 2006) our findings support the idea that it can be just as relevant in dog–dog communication. This result has important relevance regarding our understanding and the possibilities to manage excessive and nuisance vocalisation in dogs. The indication that barks most probably serve as means of communication among dogs lessen the possibility that nuisance barking is merely a 'nonsense vocalisation', without function, or being an unspecific product of the dog's heightened arousal levels (e.g. Tod et al., 2005). We showed that dogs show the strongest reactions to unfamiliar dogs' 'Stranger' (alarm) vocalisations, including response-barking, therefore one useful way to lessen the occurrence of potentially disturbing noise levels would be the prevention of these type of barks. By isolating the dogs from the sight of normal everyday passing-by traffic on the street in front of the yard, or keeping them in a part of the house where the sound of such traffic is less prevalent seems to be an advisable first step towards reducing the bark-inducing stimuli. Regarding the other issue often connected to excessive barking, 'Left alone' barks may show contextual relationship to the vocalisations occurring in canine patients with separation anxiety symptoms. Our results showed that 'Left alone' barks elicited weaker and different response of the subjects compared to the 'Stranger' barks. One could assume that this type of vocalisation might be less meaningful for a canine audience, compared to humans, who can effectively recognize this context from playbacks of barks (Molnár et al., 2010; Pongrácz et al., 2005). It is the task for further research to investigate the acoustic and functional relationship between the 'everyday' barks of dogs left alone for shorter periods of time and the excessive vocalisations of dogs suffering of separation anxiety. Our results showed

that this type of barking may be more relevant for humans than for the dogs, and its disturbing nature might stem from the common acoustic features of human and non-human animal distress vocalisations (Faragó et al., 2014).

In this study we found evidence that dogs show context and individual specific responses to barks of familiar and unfamiliar dogs. These results supply further knowledge about the communicative function of these vocalisations, which had their role in interspecific (dog–human) communication emphasized earlier. Although it is undeniable that barks changed quantitatively and qualitatively during the domestication, and humans are able to interpret them reliably, in this study we provided further evidence that dog barks convey information about the signaller's identity and most probably its inner state in interspecific communication as well.

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