The acoustic and visual communication of the domestic dog (Canis familiaris) – analyses from multiple perspectives

Anna Bálint

Supervisor: Dr. Péter Pongrácz, Senior Lecturer
Department of Ethology, Eötvös Loránd University

1117 Budapest Pázmány Péter sétány 1/c

2014
Introduction

Many authors argue that communicative interaction— in a broad sense—is the transfer of information (a message) between the sender and a receiver (Simmons, 2003). Others emphasize mostly the influence of the signal on the receiver. According to this, signals of any kind that can modify the behavior of other organisms in a favourable way for the signaler, and have been evolved because of that effect (Maynard-Smith and Harper, 2003; Stegmann, 2013).

In highly social animals, like dogs, communication is a prevalent and often complex form of behavior. They exhibit a vivid communication mostly of the inner states and motivations, but cues referring to contextual or indexical information have also been found recently (Pongrácz et al., 2005; Faragó et al., 2010). These interactions take place on various communication channels, like the acoustic, visual, tactile, olfactory modality. These offer plenty of chance to examine the properties of communicative behavior (Håkansson and Westander, 2013; Miklósi, 200; Jensen, 2009; Serpell, 1995).

Since the natural habitat for dogs is the human social group (Miklósi és Topál, 2013), they represent a special case of frequent occurrence of both intra-, and interspecific communication. In this thesis we focused our experiments on the acoustic and visual modalities of the dog's communicative behavior, when we investigated communication behavior from the perspective of both the sender and the receiver.

Dogs have a very rich vocal repertoire, just as their closest wild relatives, the wolves, coyotes, or foxes. A number of studies were aimed to categorize or analyze these acoustic signals (Yeon, 2007; Yin and McCowan, 2004; Feddersen-Petersen, 2000; Cohen and Fox, 1976).

Growling is one of the most common vocalization types not only in dogs, but as well in other canines. It is used predominantly in close-range interactions (Cohen and Fox, 1976), and can also be subdivided to contextually different categories, such as defensive, threatening or playful (Faragó et al., 2010; Cohen and Fox, 1976). It has also been shown that dogs can...
Differentiate between contextually different growl types (Faragó et al., 2010a). Furthermore, it has been revealed, that growls carry size-related indexical cues via their acoustical structure (Riede and Fitch, 1999; Taylor et al., 2008), which is detectable not only to specifics (Faragó et al., 2010b), but to humans as well (Taylor et al., 2008; Taylor et al., 2010).

Dogs' vocal communication also shows remarkable differences compared to wild canine species. For example, unlike their closest relatives, they bark extensively. While wolves, or coyotes mainly bark in defensive or warning contexts, dogs use this vocalization under many different circumstances, both in dog-dog and in dog-human interactions (Pongrácz et al., 2009). Independent experiments showed, that contextually different barks had corresponding specific acoustic features (Pongrácz et al., 2005; Yin 2002). Furthermore, it has been revealed, that dogs are able to distinguish between contextually different bark types and different barking individuals (Maros et al., 2008; Molnár et al., 2009). According to other studies, humans were able to categorize barking types successfully, independently of their previous experiences with dogs (Pongrácz et al., 2006). Moreover, certain acoustical features of dog barking seem to carry emotional information to human listeners (Pongrácz et al., 2006).

Visual communication includes, for example, different body postures, movements, or morphological traits (Rosenthal and Ryan, 2000). In dogs and other canines, observational data have been gathered on different visual cues, used in communicative situations (e.g., Fox, 1971; Mech, 1970; Bekoff, 1977), which range from minor facial expressions to the complex, ritualized movements of playful interactions (Serpell, 1995).

Dogs are also well known to show a great sensitivity to human communicative cues. For example, they are responsive to the attention states of humans (Call et al., 2003), and they tend to commit perseverative search errors in visible displacement tasks if they are provided with human ostensive communicative cues (Topál et al., 2009). Dogs perform successfully in two-way choice tasks, where they have to follow various types of human-given pointing signals (Hare and Tomasello, 1999; Miklósi et al., 1998; Soproni et al., 2001).

In three studies (Study 1., Study 2.1 and 2.2) we analyzed how receivers perceive structural or contextual differences of acoustical and visual signals.
In the other two studies (Study 3 and 4) – now from the sender's point of view – we examined the structural change and variance of signals under modified or contextually different circumstances. We applied multiple different experimental methods, from classical behavior experiments, to utilizing video-projections, performing computational sound analysis, or using artificial intelligence techniques.

Aims and methods

Study 1. ‘Beware, I am big and non-dangerous!’ – Playfully growling dogs are perceived larger than their actual size by their canine audience. Play behaviour appears in diverse forms (Burghardt, 2005), where exaggerations and role reversals also commonly appear (Bekoff, 2004). In order to maintain the playful ‘mood’ and uphold the gamesome attitude of all the participants, it is important to utilize specific signals all over the course of play (Bekoff and Allen, 1998). Previous acoustical analysis showed that according to vocal parameters, playful growls seem to depict a larger body size than an agonistic (food-guarding) growl type (Faragó et al., 2010a). In this study, we investigated whether other dogs are sensitive to the indexical cues encoded in ‘play’ growls. We hypothesized that this size-manipulation can be the part of the complex play signalling system during canine play behavior. We applied a modified version of the ‘Looking Preference’ method used by (Faragó et al., 2010b). The subjects were presented with two dog pictures and a pre-recorded growl playback, collected either from a playful (PL, tug-of-war game) or an agonistic (FG, food-guarding) context (see Faragó et al., 2010). Thus, we had two experimental groups according to the two types of playbacks. The pictures were of two differently sized, but otherwise identical dogs in a sitting or standing position. The size (height at the withers) of one of the two pictures matched the size of the dog whose growl was coupled to the particular projection (‘sound-matching’). The other picture was either 30% larger or smaller. First, the dog pictures were projected for 10 s (‘Only Projection’ phase, OP), before the growl playback started. The pictures were visible for an additional 20 s after the growl (‘After Sound’ phase, AS) then the projection (and the test) ended. Each growl lasted approximately 2 seconds. We measured the dogs’ looking
In our next two studies, we examined dogs' performance in two-way choice tests, where they encountered visual cues.

**Study 2.1.** Owners fail to influence the choices of dogs in a two-choice, visual pointing task. First, we investigated how unintended signals given by humans affect dogs' choices in a pointing task. Unintentional cueing is known in animal behavior studies as the 'Clever Hans Effect' (CHE), but so far it was seldom investigated systematically in empirical experiments with dogs. In this study we were specifically interested in how owner given intended and unintended cues might influence the choice of dogs in a two-way choice test based on a human pointing gesture, therefore we systematically modified the owners' motivation for the dogs' success and their instructions for handling their dogs in our experimental groups. We used the so-called momentary distal pointing (Soproni et al., 2002; Gácsi et al., 2009a; Lakatos et al., 2009; Pongrácz et al., 2013), in which the subject observes a short (1-2 s) arm movement toward the indicated object, and the distance between the tip of the finger and the object is more than 50 cm (Miklósi and Soproni, 2006). We compared the performance of three experimental groups and a control group of dogs. In the three test groups the owners were either blindfolded, or highly motivated in the excellent performance of their dogs (Passive Clever Hans group) or requested to help their dogs (Active Clever Hans group) choosing the correct location. We predicted that if CHE has an important influence on two-way choice responses of dogs, then performance would decline for the blindfolded owner group (where the owner is not aware of the location of the 'correct' choice) and increase for those groups where the owners could help their dogs to follow the pointing cues.

**Study 2.2.** 'Do not choose as I do!' – dogs do not base their choice on another dog's gaze in a two-object choice task. In this experiment, we explored how dogs would act in a two-way choice test, if the signaler were a conspecific. We addressed specifically the question of gazing/gaze orientation as a possible visual communicative cue among dogs, since we know...
that this cue is effective in human–dog interactions (Hare and Tomasello, 1999; Miklósi et al., 1998; Soproni et al., 2001). We further examined whether dogs' choice is influenced by the size ratio of the signaler and the receiver dog, as well as the 'dominance status' of the subject (Pongrácz et al., 2008).

After watching a projected, life-sized video 'demonstration' of a dog, the subjects could choose between two, food-baited plates. The projected dog was sitting, and the directional cue was a short sequence of a head- and gaze turn demonstration, after which the dog was let to choose between the two plates. We tested our subjects in three different groups, according to the size difference of the subject and the projected 'demonstrator' dog. This way, we had a 'D-larger' group (the 'demonstrator' dog is larger than the subject), a 'D-equal' group (the 'demonstrator' and subject are about the same size), and a 'D-smaller' group (the 'demonstrator' dog is smaller than the subject).

We also assessed the 'dominance' status of those subjects that lived in a household with other dogs by means of a questionnaire developed by Pongrácz et al. (2008), to see whether this had an effect on the choice responses of the subjects.

Study 3. Dogs' acoustic response to 'threatening strangers', according to the humans' gender and body size. The concept that emotions and affective states are mirrored in non-human and human vocal communication is a topic gaining a fast growing interest (Gogoleva et al., 2010). However, in canines, our knowledge on the vocal imprints of different affective states is rather scarce, with only a limited number of empirical studies.

In this experiment we analyzed the vocal reaction of dogs in a situation where the dog is encountering a 'threatening', unknown human ('threatening stranger', TS). The so-called 'Threatening Stranger' context is a dog–human interaction, where the dog (and its owner) are being approached by an unfamiliar person in a slow, stalking manner, who is steadily staring in the dog's eyes throughout the process. The method was developed by Vas et al., (2005), and used in a number of other studies since then (Klausz et al., 2014; Faragó et al., 2010). The main goal was to investigate whether particular aspects of the threatening human (sex, and/or body size) – which we hypothesized to affect the level of aggression/fear of the dog – have an effect on the acoustic al parameters of dogs' elicited vocal response. We presumed that different affective responses (e.g. fear/aggression) in the case of for example men, or a larger person, might be detected in dogs' vocalizations.
We used a within-subject experimental design, meaning all subjects were tested twice, with different experimenters in the 'TS' role. We had three experimental groups. These were the 'LargeMan-SmallMan' (LM-SM), 'LargeWoman-SmallWoman' (LW-SW), and 'Man-Woman' (M-W) group. We performed acoustical analysis on the recorded growl responses of dogs.

Study 4. Comparing supervised learning methods for classifying sex, age, context and individual Mudi dogs from barking. Many recent results suggest that dog vocalizations might carry a wide set of information (Pongrácz et al., 2005; 2006; Maros et al., 2008; Molnár et al., 2009). This raises interesting questions about the acoustic parameters that could be responsible for the finer details of the information content of vocal signals, e.g. dog barks. Moreover, the vocal correlates of certain individual characteristics of the signaler, e.g. sex or age, have never been tested previously by machine learning methods in dogs. The application of computerized methods, such as artificial intelligence, opens up the possibility for analyzing and testing massive amount of sound samples, and numerous variables, avoiding many technical and theoretical difficulties of the classical testing methods (e.g. playbacks).

We used the so-called k-Nearest Neighbors machine learning model (Fix and Hodges, 1951), learning from a comprehensive database of 800 barks corresponding to eight Mudi dogs in seven behavioral contexts. We also selected relevant features for the machine learning model with two methods, filter and wrapper (see Saeys et al., 2007). Similarly to Molnár et al. (2008), we classified barks into contexts and identified the barking individuals, but additionally, we also investigated whether barks encode information about the gender and age of the signaler. Also, we performed context classification per individual dog and the individual recognition task per each context. Therefore we had six different classification problems concerning sex, age, context, context per individual, individual and individual per context.

Results and Discussion

Study 1. In the PL growl playback group during the OP phase, dogs did not show preference for the 'larger picture', but in the AS phase they looked significantly longer at the 'larger picture'.
We found that dogs prefer to look at the larger dog picture than at a smaller one if they hear dog growls from a playful context. On the other hand, the size information conveyed by the 'food-guarding' growl seemed to depict the adequate size of the caller, which is a successful replication of the results of an earlier study (Faragó et al., 2010). We suggest that the acoustical 'size modification' in play growls might be a special feature of the playful vocalizations. Since growls are most suitable in short-range communication (Taylor et al., 2009), the obvious dichotomy between the acoustical and visual information may be an important factor in maintaining the 'non-serious' manner of play, even for a longer duration. Additionally, it is possible that during agonistic encounters the potential cost of advertising a larger body size would be too high to risk, thus it is more likely that signallers communicate their adequate body size.

Study 2.1. The mean number of correct choices was above the chance level in each group, and the ratio of individually successful dogs (those that choose correctly eight or more times) did not differ among groups. Thus, we found no evidence of the Clever Hans effect in any of our experimental groups, despite the fact that in one group the owners were strongly motivated to augment their dogs' performance (Passive Clever Hans group) and in another group the owners actively helped their dogs toward the indicated bowl (Active Clever Hans group). There was also no deterioration in the performance of dogs if the owners wore a blindfold and were not aware of the location of the 'correct choice'. Pointing gestures appear to have a strong effect on the choice of dogs in object-choice tasks, and the so-called 'Clever Hans Effect', theoretically caused by the owners doesn't seem to influence this. Our results further strengthen the idea that dogs might be predisposed to be responsive to socio-communicative interactions with humans.
improving their flexible adaptation to the human environment.

Study 2.2. Our results showed that dogs did not follow the gaze of the projected dog in any of our size-related experimental groups ('D-larger', 'D-equal', 'D-smaller'). The 'dominance' status of the subjects did not affect their choices, the 'dominant', 'subordinate' and 'single' dogs chose between the plates independently of the demonstration. However, 'single' dogs showed a left side preference along the ten trials. The first choice had a strong effect on the subsequent choices in the whole sample. It turned out that dogs chose significantly more the side of their first choices in the next nine trials, regardless of the firstly chosen side being 'demonstrated' or not, that is, side preference formed very quickly in dogs in this experimental set-up.

We hypothesized that dogs' responsiveness to human directional cues (e.g. in human pointing experiments) is due to the special socio-communicative abilities they developed during the domestication process and is also dependent on individual experiences, acquired during their ontogeny (Miklósi et al., 2004; Udell et al., 2008). Consequently, while a cue might be relevant in dog-human communicative situations, a phenotypically similar alternative may not play the same role in their intraspecific communication. Also, companion dogs may interact more with humans than with other dogs, and this experience might facilitate to learn about human-originated communicative cues. Furthermore, we found that dogs showed a strong side-preference in all groups, which was determined by the side of their first choices. Although it is known that dogs are inclined to show lateral biases, it is noteworthy, that if provided with an adequate external cue, this tendency does not manifest itself, as seen in human pointing experiments.

Study 3. Since we had a large set of acoustical variables, we first performed a Principal Component Analysis, in which we gained four components ('Intensity', 'Pitch', 'Dynamics', 'Tonality'). Our results showed that if the TS was a male, dog growls had smaller 'Pitch' and 'Dynamics' values. We also found that 'Pitch' and 'Dynamics' were lower in the growl of larger dogs. Based on the variables assigned to the 'Pitch' component, the results suggested that growls had lower fundamental frequencies and narrower 'formant dispersions' ('df') when encountering men TSs. Lower fundamental frequency is usually related to more aggressive
Motivational states (Owings and Morton, 1998), while narrower 'df' refers to a larger body size (Taylor and Reby, 2010). Additionally, the variables associated with the 'Dynamics' component suggested that growls were shorter, and the extreme values of pitch and intensity were reached sooner in time when encountering men TSs. According to findings of affective vocalizations in other species, this indicates a higher motivational and arousal state of dogs when facing man 'threateners'. Our finding that the growls of larger dogs had usually lower 'Pitch' values is in accordance with previous findings that larger animals usually vocalize at lower frequencies and also have more closely spaced formants (Taylor and Reby, 2010), while the lower 'Dynamics' values in case of larger dogs might indicate a more highly aroused (e.g. more aggressive) motivational state of larger dogs, when being approached by a threatening human.

Study 4. The best of the models in this study was able to predict dog sex in 85.13% of the cases. The age of the dog categorized as young, adult and old, was inferred correctly in 80.25% of the cases. Determining the context of the dog bark was successful in 55.50% of the bark cases. A model for each of the eight dogs with two or more different contexts has been induced from the barks associated with this specific dog. Model accuracy ranged from 38.24% to 100%. The individual identification, a hard classification problem with eight possible categories, has produced up to 67.63% accuracy in the best model. When the dog identification was performed within each context, the accuracies of the best models were in the interval [64.89%, 100%]. In almost all cases, the wrapper feature subset selection strategy has provided the best results. We followed an alternative approach to the analysis of the communicative roles of vocalizations by focusing on the acoustical characteristics of the signal. A solution for two prediction problems, sex and age - never approached by machine learning methods previously in dogs - has been presented, and has been categorized by high success rates (85.13%, 80.25%). The results of the classification of bark contexts (55.50%) are an improvement compared to the results of Molnár et al. (2008), where for 6 possible contexts the best model yielded a 43% success rate. The detection of consistent cues related to certain individual (e.g. sex, age), or contextual features might serve as important clues to recipients that are able to perceive them. For example, if dogs are sensitive to sex-, age-, or individual specific information of
cal's, this might contribute to their observed discriminative capability of different conspecific vocalizations. Attributes such as sex or age might be relevant features in a highly social species, such as dogs, since they may be relevant in determining mate-choice, reproductive status, fighting potential, etc. (e.g. Mech, 1999). Furthermore, the flexibility of such computerized techniques makes the methods and results directly applicable and comparable to other species.

Publications in referred journals


