Should I whine or should I bark? Qualitative and quantitative differences between the vocalizations of dogs with and without separation-related symptoms

Pongrácz, Péter[1], Lenkei, Rita[1], Marx, András[1] and Faragó, Tamás[1,2]

[1] Department of Ethology, Eötvös Loránd University, Budapest, Hungary

[2] MTA-ELTE Comparative Ethological Research Group, Budapest, Hungary

Corresponding author:

Péter Pongrácz

Department of Ethology, Eötvös Loránd University

Pázmány Péter s. 1/c

1117 Budapest

Hungary

Email: peter.pongracz@ttk.elte.hu

Phone: +36 30 262 1284

Abstract

Separation-related disorder (SRD) is one of the most common behavioral problems of companion dogs, causing inconvenience and stress for dog owners and others living close by, as well as being considered as a major contributor to poor animal welfare. Although excessive vocalization is considered as one of the typical symptoms of SRD, until now there were no attempts to analyze and compare the vocal output of affected and non-affected dogs in a systematic, empirical test. In a three-stage outdoor separation experiment we investigated the vocal response of 25 family dogs with, and 20 family dogs without, owner-reported SRD symptoms to the (1) departure; (2) absence; and (3) return of the owner. After the analysis of the occurrence and onset latency of barks and whines, we found that contrary to the commonly held view of excessive barking being one of the trademarks of SRD, dogs with owner-reported SRD symptoms can be reliably characterized by the early onset and high occurrence of whines during the departure and 2 min long absence of the owner, while barks were affected mainly by the age of the dogs. Breed and neuter status may modify the vocal reaction to separation, we found that more purebred dogs barked sooner, while breed and neutering status affected the whines only during the departure of the owner, showing that more mixed breeds and intact dogs whined in this phase. This is the first study that targeted directly the vocal response of family dogs to separation from the owner, and according to the results, whines and barks reflect potentially different motivational/ inner states of dogs during a short isolation episode. Although the effect of other factors, such as sex, neuter status and breed cannot be ignored, the owner reported SRD status of dogs showed a high coincidence with the early onset of whining, which in turn proved to be a good indicator of high stress levels of dogs in this situation.

Keywords: dog, separation related disorder, vocalization, whine, bark

Introduction

Dogs became increasingly popular as pets/companion animals in the urbanized world in the last few decades (McConnell et al., 2011). The benefits of having a dog are well documented from the side of recreational and emotional aspects (Archer, 1997), as well as the safety and health of the owner (Cutt et al., 2007; Friedman et al., 1983). However, with a relatively large proportion of the population involved directly or indirectly in coexisting with dogs, demands of both human and animal welfare arise as well. As it is more and more common that companion dogs spend longer periods of time alone while their owners are not at home, the way dogs cope with situations of separation draws growing interest (Sherman and Mills, 2008). The apparent behavioral extremities in particular dogs accompanying the shorter-longer absence of the owner, form a rather coherent system of symptoms (destructiveness (King et al., 2000); inappropriate and unprovoked soiling in the building (Overall et al., 2001); hypersalivation (Sherman, 2008); and excessive vocalization (Schwartz, 2003)) which have been called ‘separation anxiety’ (Flannigan and Dodman, 2001; Simpson, 2000), or more recently separation-related disorder ‘SRD’ (Appleby and Pluijmakers, 2004). Such symptoms are not only burdening the co-existence between dogs and humans (Lindell, 1997), but represent a serious problem for the welfare of the animal, requiring veterinary (e.g. Gruen and Sherman, 2008; Herron et al., 2008; Simpson et al., 2007) or therapeutic intervention (King et al., 2000; Podberscek et al., 1999; Sherman et al., 2008; Takeuchi et al., 2000), and often resulting in the relinquishment of the dog to a shelter (Flannigan and Dodman, 2001; Marston et al., 2004; Takeuchi et al., 2001).

Based on the theory of dog-human attachment, being separated from the owner causes a manageable level of distress in each dog that belongs to a particular person or family (Topál

et al., 1998). During the diagnosis of SRD one should be able to distinguish between milder cases of symptomatic behavior and the signs of 'ordinary' attachment (e.g. Flannigan and Dodman, 2001; Parthasarathy and Crowell-Davis, 2006). Veterinarians, behavioral therapists and researchers often base their decision on surveying the owners with questionnaires, as it is usually the owner who experiences the response of his/her dog to separation (e.g. Overall et al., 2001; Podberscek et al., 1999; Takeuchi et al., 2000). Especially for reasons of confirming the presence of separation anxiety in particular canine patients, long-term video recordings may be taken in the home of the dog and evaluated later (e.g. Palestrini et al., 2010). Meanwhile this type of observation provides a valuable wealth of information about the occurrence of various behavioral elements of affected dogs, the process is somewhat awkward to perform and these studies usually lack the involvement of control groups of non-SRD dogs (e.g. Lund and Jørgensen, 1999; Palestrini et al., 2010). A different approach to testing of separation-related behaviors concentrates on inducing experimentally separation-related stress with a short isolation of the dog from the owner in a controlled environment (e.g. Borg et al., 1991; Konok et al., 2011)., There are promising results where simple behavioral tests (such as the 'separation & greeting' paradigm of Konok et al. 2011) could validate the reliability of owner-based questionnaires about SRD in dogs. On the other hand, the evaluation of these tests can be rather complicated because the observer/evaluator must record and analyze a rather high number of behavioral variables, which may be rather subtle and hard to distinguish (see for example Konok et al., 2011; Palestrini et al., 2005; Palmer and Custance, 2008; Prato-Previde et al., 2003). Vocalizations on the other hand theoretically offer a rather straightforward method for evaluating the status of dogs regarding their response to separation. Dogs often vocalize when they are isolated from or left alone by their owner (Kobelt et al., 2003), and there is ample evidence that SRD can be characterized by 'excessive' vocal behavior (Juarbe-Díaz, 1997).

Although vocal behaviors are often mentioned among the symptoms of SRD (see for a review Ogata, 2016), the detailed analyses of the vocal responses of dogs to separation are surprisingly rare, especially from the aspect of their possible applicability for diagnostic purposes regarding SRD. Authors mostly list different types of vocalizations (howls, barks, whines) as typical behaviors during separation (e.g. Horwitz, 2000), and in some cases they also provide a temporal analysis of the onset of vocal responses to separation. Lund and Jorgensen (1999) found for example that (along other SRD-related behaviors) whining reaches its peak intensity shortly after the owner's departure. However, until now by our knowledge no attempt was made for the qualitative comparison of vocal patterns in SRD and non-SRD dogs, with a specific interest towards the possible differences between the communicative content of different types of canine vocalizations. It is already known that dogs that were left alone by their owners either in a room (Yin, 2002) or on the street tied to a tree (Pongrácz et al., 2005; 2006; 2014) emit barks with clearly distinguishable acoustic structure (high fundamental frequency, high tonality, low pulse). Human listeners can recognize these barks significantly above chance level (Molnár et al., 2010; Pongrácz et al., 2005; 2011); and they also characterize the barks of isolated dogs as showing high levels of despair and fear (Pongrácz et al., 2005; 2006). Recently it was also found that barks that show the acoustic characteristics of the vocalizations recorded during separation cause especially strong nuisance effect among human listeners (Pongrácz et al., 2016). However, it has not been investigated yet whether patterns of isolation-related barking would differ between dogs with or without SRD. Besides the barks that can be considered as medium-to-long distance calls and if emitted in isolation, there are also other vocalizations that can be relevant in the analysis of SRD. In an earlier comparative work, Cohen and Fox (1976) listed whines and howls in addition to barking, as vocalizations typical to dogs being left alone. Although barks and howls definitely possess the intensity and duration to be detectable from larger distances,

117 one could hypothesize that the more elusive (i.e. less intense, and/or short distance) whines
118 could specifically signal the higher levels of distress in a dog affected by SRD. Some authors
119 characterize whines as a typical form of vocalization in dogs that experience frustration and
120 other negative inner states (Custance and Mayer, 2012; Palestrini et al., 2010). Moreover, the
121 similarity of their acoustic structure to the general pattern of infant distress calls (Lingle et al.
122 2012) suggest that these vocalizations can be the remnants of infant contact calls functioning
123 in the adult dogs as a distress vocalization signaling the negative inner state of the dog to the
124 owner. Accordingly, Lund and Jorgensen (1999) considered whines of SRD-dogs as
125 "attention-soliciting" behavior, which fits well to our hypothesis that meanwhile a large
126 proportion of dogs vocalizes during a separation episode, the emotional background of this
127 may differ between SRD and non-SRD dogs. According to this, subjects with separation-
128 related symptoms would emit mostly fear and distress-related vocalizations (including a
129 higher proportion of whines), non-SRD dogs could be rather characterized by vocalizations
130 related to protest and frustration (higher prevalence of barks).

131 In this paper we present the results of an experiment in which we compared the vocal
132 responses of dogs with or without owner-reported separation related problems during a short
133 outdoor separation episode. For the assessment of the SRD status of dogs, we used the
134 validated questionnaire of Konok et al. (2011). In that study, authors set up a short indoor
135 separation situation for the assessment of whether the owners are able to recognize (via the
136 completion of a questionnaire) their dog's separation related problems. The questionnaire
137 contained questions about the emotions of the owner when the dog is left alone and about the
138 general opinion of the owner about the stress level of the dog when it's left alone. It was
139 found that dogs with owner-reported SRD showed more stress-related behavior (e.g.:
140 vocalizing, physical contact with the door, rearing on the wall or the door), they spent less
141 time near the owner's chair during separation, and showed more intense greeting activity than

142 dogs without SRD. Non- affected dogs' activity decreased with increasing separation
143 duration, but dogs with SRD did not show this change in their separation behavior. Based on
144 these results, in agreement with Konok et al., we can conclude that the owners can report
145 reliably their dog's separation related problems.

146 Our question was whether the vocalizations of dogs with owner-reported SRD show
147 qualitative and quantitative differences compared to the vocalizations of dogs that do not
148 show SRD symptoms at home. We hypothesized that dogs with SRD will not only bark and
149 whine more abundantly than non-affected dogs (which could be expected based on the
150 literature (e.g. Lund and Jørgensen, 1999)), but we expected that whines will be the more
151 prevalent vocalization of SRD (compared to barks), because we hypothesized that whining is
152 the vocal manifestation of the negative inner state evoked by the absence of the attachment
153 figure of the dogs. We also tested for the possible effect of age, sex, neuter status and breed
154 (mixed or purebred) of dogs on their vocal responses. Although there are sporadic reports that
155 the dogs' breed may affect their response to separation (i.e. mixed breed dogs more often
156 show SRD symptoms – Takeuchi et al., 2001), and behavioral problems are in general more
157 common in intact males than in female dogs (Takeuchi et al., 2001), there are also other
158 indications that occurrence of SRD is independent of breed and dogs' sex (i.e. Flannigan and
159 Dodman, 2001; Wright and Nesselrote, 1987). Therefore we hypothesized that the actual SRD
160 status of a dog will have a stronger effect on the vocal responses to separation than the dogs'
161 sex or purebred status.

162

163 **Materials and methods**

164 Subjects

The subjects (N=45) were adult family dogs (older than one year, mean age: 4 ± years). Table 1 shows the breed and sex of the subjects. Dog owners were contacted and invited to the test on the basis of an online questionnaire about the vocal habits of dogs (https://goo.gl/forms/RBWgsY008Ru9rIs63) – we chose dogs where the owner had indicated that the dog vocalizes when left alone in a strange place. No other restrictions regarding the breed or sex of the dogs were made. Further assignment of the subjects into experimental groups was done with the help of another questionnaire (Konok et al., 2011) – see the next paragraph. Owners of the dogs were informed about the goals and circumstances of the experimental procedure a priori. Owners were present during the tests and we informed them that they can interrupt the experiment and withdraw their dog from participation if by their consideration the test was too stressful for their dog. The Animal Welfare Committee of the Eötvös Loránd University reviewed and accepted the protocol of the experiment (Ref. no.: PEI/001/1056-4/2015).

Experimental groups

Based on the owners' answers given to the questionnaire developed and validated by Konok et al. (2011), subjects were sorted into the SRD (N=25; 11 males and 14 females; 16 purebred and 9 mixed breed) or the non-SRD (N=20; 14 males and 6 females; 11 purebred and 9 mixed breed) group – see Table 1. Dogs were sorted to the SRD group if the owner answered 'yes' to the question "Does your dog have separation anxiety, or any behavioral problem in connection to being left alone?"

Experimental procedure

188 The setup of the testing environment is shown in Figure 1. Dogs were tested outdoors, at the
189 campus site of the Eötvös Loránd University, Budapest. The experiments were conducted
190 during daylight, on a flat, grassy area, with minimal to no disturbance from people passing by
191 in the distance.

192 The owner tethered the dog to a tree with a 1.5 m long leash, then he/she left the dog
193 (after saying a brief sentence such as: "Be good, I will be back soon" etc.) and walked away
194 in a straight line, until he/she disappeared behind the corner of a building 45 m away. We
195 gave a timer to the owners that they started when they left the dog. When 3 min had elapsed,
196 the owner reappeared from behind the building and walked back straightly to the dog. When
197 he/she arrived, they greeted and unleashed the dog and the test was over.

198 During the test, we recorded the behavior and vocalizations of the subjects with a
199 Panasonic HDC-SD10 video camera and a Sennheiser ME-66 shotgun microphone with K-6
200 power module connected to a Zoom H4n handheld audio recorder (PCM WAV 44.1 kHz, 16-
201 bit). The devices were placed on tripods and handled by two experimenters (MA, LR and
202 occasionally FT) who stayed with the dog but avoided any kind of interaction with the
203 subject, including eye contact as well. One of the experimenters indicated verbally on the
204 recordings the moment when the owner disappeared and again when he/she reappeared from
205 the building.

206

207 **Data analysis**

208 From the recorded audio and video material we extracted the latency of first occurrence and
209 the frequency of barks and whines. Extraction and analysis were performed by a researcher
210 who was not aware of the group assignment of the subjects. Data extraction was performed by
211 Solomon Coder (beta 15.03.15, copyright by András Péter). An independent coder reanalyzed

12 randomly chosen videos for reliability testing. The coded latencies (Pearson's correlation, barks - phase 1: $r=0.999$; $p<0.001$; phase 2: $r=1$; $p<0.001$; whines – phase 1: $r=0.892$; $p<0.001$; phase 2: $r=0.952$; $p<0.001$) and frequencies (Pearson's correlation, barks - phase 1: $r=0.86$; $p<0.001$; phase 2: $r=0.873$; $p<0.001$; whines – phase 1: $r=0.936$; $p<0.001$; phase 2: $r=0.918$; $p<0.001$) showed strong correlation between the two coders thus we accepted the coding to be reliable.

Both in case of barks and whines the occurrences and latencies were analyzed on a 0.2s time basis. We considered two series of barks or whines as separate units if at least 0.4 s pause separated them. Each test was divided to three phases: departure (owner walks away from the dog, until disappearance); absence (owner is behind the building); return (owner re-appears and walks back to dog). Barks and whines were coded separately within the three phases. We first measured an overall latency of vocalizations during the separation (departure and absence phase together). As the departure phase was qualitatively different from the real separation as the owner was still visible during this phase, we also calculated and analyzed the latencies for the departure separately. As in the return phase the majority of the subjects remained silent, we omitted it from further analysis. Frequencies were measured separately in the first two phases, however due to the high number of non-vocalizing dogs, models with Poisson or negative binomial distributions showed low level of fit, we therefore decided to use this data in a simplified way, marking only the presence or absence of whines/barks. For both types of vocalization the following fixed factors were used: SRD-status, sex, neutered/spayed vs. intact, and breed (purebred vs. mixed breed) and age. All analyses were performed in R (R Core Team, 2016).

The occurrence of barks and whines was analyzed with Generalized Linear Models with Binomial response with logit link (glm function of stats package). We performed model selection by step-wise combined elimination/addition of main effects (based on Akaike

Information Criterion, stepAIC function in MASS package). Latencies were analyzed with Cox-regression (coxph function of the survival package), followed again by the same model selection. In both cases results from the final models are reported (for details see Tables 2-3).

Results

Barks

We found a significant effect of age in case of the latency of barking: while the owner left and remained hidden from sight, older dogs started to bark later (cox-regression (LR test): $\chi2(1)=4.321$; p=0.037; AIC= 165.166), while during the departure phase only (cox-regression (LR test): $\chi2(2)=10.05$; p=0.006; AIC=102.33) we found the age (($\chi2(1)= 8.13$; p=0.004) and breed ($\chi2(1)= 4.14$; p=0.042) of the dog significantly affecting the latency of barks: younger dogs and purebreds bark sooner while the owner leaves.

In contrast, we found that only the age of the dogs had a significant negative effect on the occurrence of barking behavior (binom GLM (LR test): $\chi2(2)= 8.181$; p=0.016; AIC= 55.105). Older dogs barked significantly less during the departure of the owner (z=-2.109; p=0.035) (Figure 2). While the owner was not visible for the dog, we found only a non-significant trend effect of age (binom GLM (LR test): $\chi2(1)= 3.816$; p=0.051; AIC= 62.367).

Whines

In the case of whine latencies, during the entire separation we found a strong effect of SRD status (cox-regression (LR test): $\chi2(1)= 4.699$; p=0.03; AIC= 238.498). Dogs with owner reported separation problems started to whine with two times higher probability than the non-SRD subjects (Exp(B)[95%CI]= 2.064 [1.061, 4.014]; p= 0.033) (Figure 3). During the

departure phase the final model showed a non-significant trend (cox-regression: $\chi 2(1)= 2.761$; p=0.097; AIC= 187.847).

In the case of the occurrence of whines, our final model was also significant (binomial GLM (LR test): $\chi 2(3)= 8.657$; p=0.034; AIC= 59.01) and showed significant effect of SRD (z= 2.091; p=0.037), neuter status (z= -1.974; p=0.048) and breed (z= 1.974; p=0.048) in the departure phase. Significantly more dogs with SRD whine than non-SRD dogs (Figure 4), and mixed and intact dogs also whine more. Similarly, the occurrence of whines was also affected significantly by the SRD status of the dogs during the absent owner phase (binomial GLM (LR test): $\chi 2(2)= 7.027$; p= 0.03; AIC= 41.094). Significantly more dogs with owner reported separation problems whined during the absence of the owner than non-SRD dogs did (z= 2. 168; P= 0.03).

Discussion

The experiments presented here revealed the complexity of vocal responses of dogs to an outdoor separation episode from their owners. Dogs with owner-reported symptoms of separation related disorder (SRD) vocalized differently than non-SRD dogs during the departure and the absence of their owners. Barks, as expected, were observed frequently in these phases of the experiment, however, this type of vocalization was not influenced by the SRD status, only by the age and breed of the dogs Whines on the other hand, were not only the other frequently encountered type of vocalization during the departure and absence phases of the experiment, but the occurrence and onset of whining gave an excellent match with the SRD status of the subjects. SRD-dogs start to whine sooner than dogs with no SRD symptoms, and more SRD-dogs whine than non-SRD dogs in both phases (departure and absence) of the separation test. Whining was additionally affected by the neuter status

283 (neutered/spayed dogs start to whine sooner, but eventually more intact dogs whined), and of
284 the breed (purebreds whine more).

285 The main goal of this study was to find out whether dogs with owner-reported SRD
286 symptoms vocalize differently than non-SRD dogs in a short episode of outdoor isolation
287 from the owner. Rather surprisingly, the results showed that excessive barking was not the
288 most typical form of vocalization in SRD-dogs. Abundant ('excessive') barking is one of the
289 main and most noticeable symptoms of separation-related behaviors based on both
290 questionnaire and descriptive surveys (Juarbe-Diaz, 1997; Kobelt et al., 2003; Lund and
291 Jørgensen, 1999; Parthasarathy and Crowell-Davis, 2006; Wells and Hepper, 2000). However,
292 in our experiment dogs that were reportedly affected by SRD did not bark more frequently or
293 sooner than the non-affected subjects. Instead, dogs' age was the most influential factor on the
294 onset and abundance of barks – younger dogs started to bark sooner and barked more than
295 older dogs did. It should be noted that our sample did not include juvenile dogs and had only a
296 moderate fraction of old subjects (over 10 years of age). Therefore the found pattern can be
297 considered as characteristic for the adult companion dogs. Our results can be explained with
298 ontogenetic reasons – younger dogs are considered more active and excitable than older ones
299 (Siwak et al., 2002; Vas et al., 2007), meanwhile older dogs might became more experienced
300 with shorter periods of isolation from their owner, therefore show less stress and start to bark
301 later and less than the younger dogs.

302 It is possible that barking becomes 'excessive' only after a longer separation from the
303 owner (see for example Lund and Jorgensen (1999)) – although in other experimental studies
304 researchers found behavioral differences between SRD and non-SRD dogs also relatively
305 quickly (e.g. Konok et al., 2011; Mendl et al., 2010). Earlier it was also found that dogs bark
306 readily when their owner leaves them alone on the street or in a park, therefore this particular
307 'alone' context was used regularly for collecting bark samples in many acoustic studies (e.g.

Maros et al., 2008; Molnár et al., 2009; Pongrácz et al., 2005; 2014). There is a possibility that the barks of SRD-affected dogs show qualitative differences compared to the non-SRD dogs. In a recent study (Pongrácz et al., 2016) we found that barks that show acoustic structure typical to dogs in separation elicit the strongest nuisance effect in human listeners. If the barking of SRD dogs is more annoying for the nearby audience, this can cause an over-representation of this behavior in the reports concerning symptoms of separation anxiety.

Regarding the role of other factors in determining the vocalization pattern of dogs during separation from the owner, the purebred status of the subjects had a somewhat contradicting effect to the findings of Takeuchi et al. (2001). They reported that mixed breed dogs were showing symptoms of SRD more often than purebred dogs, in contrast to our study where purebred subjects although barked sooner, but more mixed breeds whined than purebred dogs when the owner left them behind. As in our sample barking behavior had no connection with the owner reported SRD status, this also suggests that whining can be a better indicator of separation problems. Our results are in accordance with the recent findings of Turcsán et al., (2017), who found in a large-scale questionnaire study that mixed breed dogs exhibited more behavioral problems and they were less calm than purebreds – even if the samples were controlled for possibly influential demographic factors (like the neuter status or age of the dog when it was adopted by the owner).

Based on the literature, a dog's sex is not among those factors that commonly influence the onset of SRD symptoms (e.g. Wright and Nesselrote, 1987; Flannigan and Dodman, 2001). Although other types of behavioral problems, such as different forms of aggression, are reported more frequently in intact male dogs (e.g. Borchelt, 1983), separation anxiety is found to be rather typical for the spayed/neutered dog population (Flannigan and Dodman, 2001). Accordingly, in our study dogs' sex did not have a decisive effect on the vocal behavior of the subjects, while the neuter status had an effect on the occurrence of

333 whining: more intact dogs whined during the departure of the owner. The connection between
334 neuter status and the onset of SRD symptoms is rather controversial in the literature – while
335 Flannigan and Dodman (2001) found no effect of neutering on SRD, a later study (McGreevy
336 and Masters, 2008) mentioned that intact dogs showed a higher probability for SRD
337 symptoms than neutered/spayed ones. Regarding the results of our study, neuter status
338 affected dogs' vocal behavior only in the departure phase (when the owner was still visible).
339 Regardless of their sex, a higher proportion of intact dogs emitted whines than
340 neutered/spayed dogs during this phase.

341 The main finding in our study was that dogs with SRD symptoms whined
342 significantly sooner than non-SRD dogs and more SRD-dogs also whined during the first two
343 phases of the test than subjects with no reported symptoms of SRD. In other words, dogs that
344 whined sooner and in the first two phases of the test were the ones that the owners
345 characterized as being affected with separation anxiety in the questionnaire. Whine is a well-
346 known manifestation of frustration and negative inner state in dogs (e.g. Custance and Mayer,
347 2012; Palestrini et al., 2010), however, as it is a relatively low-intensity sound, whining is
348 seldom noticed in the case of SRD-dogs, meanwhile the more robust (e.g. elimination,
349 destructive behavior) or longer distance (bark, howl) behaviors evoke stronger responses.
350 Although whining was found as being included to the vocal output of SRD-dogs in some
351 earlier studies (e.g. Lund and Jorgensen, 1999), the possible specificity of this type of
352 vocalization to separation-related problems has not been directly addressed so far. The lack of
353 attention-eliciting volume of dog whines warrants for the possibility of inaccurately diagnosed
354 separation-related symptoms in common veterinary practice, as dog owners concentrate
355 understandably on the more obvious symptoms. However, in case of need for quick
356 behavioral assessment, the early onset and dominant presence of whines may represent a
357 useful tool in determining the likelihood of a dog having problems with separation.

From the aspect of communicative relevance, barking can be considered as the behavioral stress response of dogs protesting against being isolated from their owner, especially when left alone at a strange place. Several studies showed that left alone dogs often bark and their barks are easy to recognize contextually (Pongrácz et al., 2005). Lund and Jorgensen (1999) found that left alone dogs with SRD symptoms react easily with barking to external stimuli, and importantly, they keep on barking longer time, with a more and more higher pitched bark that can be attributed to frustration. Wild relatives of dogs do not bark in isolation (Cohen and Fox, 1976; Tembrock, 1976), and according to a theory, parallel with domestication different acoustic variants of dog barking occupied several new communicative 'niches' related to dog-human communication (Pongrácz et al., 2010). As barks emitted in isolation are considered by human listeners mostly as 'fearful' and 'desperate' (Pongrácz et al., 2011; Molnár et al., 2010), we can assume that these vocalizations may in turn elicit helping/caregiving behavior from humans. Therefore when a dog barks when it is left alone at an unknown place it can be considered as an adaptive communicative behavior. Contrary to this, whining is a form of vocalization that occurs in similar circumstances in dogs and their close relatives (Tembrock, 1976), and can be considered as a footprint of negative inner states – distress is signaled not only in dogs, but even in human infants (Green et al., 2011; Johnson et al., 1975). The fact that in our study whining was characteristic to SRD dogs during the separation episode shows that these dogs may emit this kind of subtle vocalization rather as a symptom of their negative arousal (distress) than of any kind of communicative relevance. The function of such subtle, short-range vocalizations may be contact/comfort seeking in young puppies (Panskepp et al., 1978), therefore in adult dogs this stress-related behavior may be re-directed towards the owner.

In conclusion, we emphasize that the quickly emerging whining cannot be underestimated as a canine SRD-symptom, and additionally it is an easy to elicit and detect

behavioral response amid simple circumstances. Compared to dog barks that may convey a wide spectrum of inner states (from aggression to fear, frustration and joy), the emotional background of whines is simpler and more focused on negative states. Our results show that the abundance and early onset of whines correlates well with owner-reported SRD symptoms in family dogs, contrary to barking that appears both in SRD and non-SRD dogs during short outdoor separation episodes.

Acknowledgements

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (Grant Agreement No. 680040), the Stanton Foundation's Next Generation Canine Research Grant, the Office for Research Groups Attached to Universities and Other Institutions of the Hungarian Academy of Sciences and the Hungarian Academy of Sciences (MTA 01 031). The authors are thankful for the photograph and drawing on Figure 1 to Leéb Ádám, and to Celeste R. Pongrácz for proofreading the manuscript.

Literature cited

Appleby, D., Pluijmakers, J., 2004. Separation anxiety in dogs: The function of homeostasis in its development and treatment. Clin. Tech. Small. An. P. 19, 205–215.

Archer, J., 1997. Why do people love their pets? Evol. Hum. Behav. 18, 237–259.

Borchelt, P.L., Lockwood, R., Beck, A.M., Voith, V.L., 1983. Attacks by packs of dogs involving predation on human beings. Public. Health Rep. 98, 57.

van der Borg, J.A., Netto, W.J., Planta, D.J., 1991. Behavioural testing of dogs in animal shelters to predict problem behaviour. Appl. Anim. Behav. Sci. 32, 237–251.

Cohen, J.A., Fox, M.W., 1976. Vocalizations in wild canids and possible effects of domestication. Behav. Process. 1, 77–92.

Custance, D., Mayer, J., 2012. Empathic-like responding by domestic dogs (*Canis familiaris*) to distress in humans: an exploratory study. Anim. Cogn. 15, 851–859.

Cutt, H., Giles-Corti, B., Knuiman, M., Burke, V., 2007. Dog ownership, health and physical activity: A critical review of the literature. Health Place. 13, 261–272.

Flannigan, G., Dodman, N.H., 2001. Risk factors and behaviors associated with separation anxiety in dogs. J. An. Vet. Med. A. 219, 460–466.

Friedmann, E., Katcher, A.H., Thomas, S.A., Lynch, J.J., Messent, P.R., 1983. Social interaction and blood pressure: Influence of animal companions. J. Nerv. Ment. Dis. 171, 461–465.

Green, J.A., Whitney, P.G., Potegal,M., 2011. Screaming, yelling, whining, and crying: categorical and intensity differences in vocal expressions of anger and sadness in children's tantrums. Emotion. 11, 1124.

Gruen, M.E., Sherman, B.L., 2008. Use of trazodone as an adjunctive agent in the treatment of canine anxiety disorders: 56 cases (1995–2007). J. Am. Vet. Med. A. 233, 1902–1907.

Herron, M.E., Shofer, F.S., Reisner, I.R., 2008. Retrospective evaluation of the effects of diazepam in dogs with anxiety-related behavior problems. J. Am. Vet. Med. A. 233, 1420–1424.

426 Horwitz, D. F., 2000. Diagnosis and treatment of canine separation anxiety and the use of
427 clomipramine hydrochloride (Clomicalm). J. Am. Anim. Hosp. Assoc. 36, 107-109.

428 Johnson, J.E., Kirchhoff, K.T., Endress, M.P., 1975. Altering children's distress behavior
429 during orthopedic cast removal. Nurs. Res. 24, 404–410.

430 Juarbe-Diaz, S.V., 1997. Assessment and treatment of excessive barking in the domestic
431 dog. Vet. Clin. N. Am.-Small. 27, 515–532.

432 King, J.N., Simpson, B.S., Overall, K.L., Appleby, D., Pageat, P., Ross, C., Chaurand, J.P.,
433 Heath, S., Beata, C., Weiss, A.B., Muller, G., 2000. Treatment of separation anxiety in dogs
434 with clomipramine: results from a prospective, randomized, double-blind, placebo-controlled,
435 parallel-group, multicenter clinical trial. Appl. Anim. Behav. Sci. 67, 255–275.

436 Kobelt, A.J., Hemsworth, P.H., Barnett, J.L., Coleman, G.J., 2003. A survey of dog
437 ownership in suburban Australia—conditions and behaviour problems. Appl. Anim. Behav.
438 Sci. 82, 137–148.

439 Konok, V., Dóka, A., Miklósi, Á., 2011. The behavior of the domestic dog (*Canis familiaris*)
440 during separation from and reunion with the owner: A questionnaire and an experimental
441 study. Appl. Anim. Behav. Sci. 135, 300–308.

442 Lindell, E.M., 1997. Diagnosis and treatment of destructive behavior in dogs. Vet. Clin. N.
443 Am.-Small. 27, 533–547.

444 Lingle S, Wyman MT, Kotrba R, Teichroeb LJ, Romanow CA. 2012 What makes a cry a cry?
445 A review of infant distress vocalizations. Curr. Zool. 58, 698-726.

446 Lund, J.D., Jørgensen, M.C., 1999. Behaviour patterns and time course of activity in dogs
447 with separation problems. Appl. Anim. Behav. Sci. 63, 219–236.

448 Maros, K., Pongrácz, P., Bárdos, Gy., Molnár, Cs., Faragó, T., Miklósi, Á. 2008. Dogs can
449 discriminate barks from different situations. Appl. Anim. Behav. Sci. 114, 159–167.

450 Marston, L.C., Bennett, P.C., Coleman, G.J., 2004. What happens to shelter dogs? An
451 analysis of data for 1 year from three Australian shelters. J. Appl. Anim. Welf. Sci. 7, 27–47.

452 McConnell, A.R., Brown, C.M., Shoda, T.M., Stayton, L.E., & Martin, C.E., 2011. Friends
453 with benefits: on the positive consequences of pet ownership. J. Pers. Soc. Psychol. 101,
454 1239-1252.

455 McGreevy, P.D., Masters, A.M., 2008. Risk factors for separation-related distress and feed-
456 related aggression in dogs: additional findings from a survey of Australian dog owners. Appl.
457 Anim. Behav. Sci. 109, 320–328.

458 Mendl, M., Brooks, J., Basse, C., Burman, O., Paul, E., Blackwell, E., Casey, R., 2010. Dogs
459 showing separation-related behaviour exhibit a 'pessimistic'cognitive bias. Curr. Biol. 20,
460 839–840.
461 Molnár, Cs., Pongrácz, P., Faragó, T., Dóka, A., Miklósi, Á., 2009. Dogs discriminate
462 between barks: The effect of context and identity of the caller. Behav. Proc. 82, 198-201.
463
464 Molnár, Cs., Pongrácz, P., Miklósi, Á., 2010. Seeing with ears: sightless humans' perception
465 of dog bark provides a test for structural rules in vocal communication. Q. J. Exp. Psychol.
466 63, 1004–1013.

467 Ogata, N., 2016. Separation anxiety in dogs: What progress has been made in our
468 understanding of the most common behavioral problems in dogs? J. Vet. Behav. 16, 28-35.

469 Overall, K.L., Dunham, A.E., Frank, D., 2001. Frequency of nonspecific clinical signs in dogs
470 with separation anxiety, thunderstorm phobia, and noise phobia, alone or in combination. J.
471 Am. Vet. Med. Assoc. 219, 467–473.

472 Palmer, R., Custance, D., 2008. A counterbalanced version of Ainsworth's Strange Situation
473 Procedure reveals secure-base effects in dog–human relationships Appl. Anim. Behav.
474 Sci. 109, 306–319.

475 Palestrini, C., Previde, E.P., Spiezio, C., Verga, M., 2005. Heart rate and behavioural
476 responses of dogs in the Ainsworth's Strange Situation: a pilot study. Appl. Anim. Behav.
477 Sci. 94, 75–88.

478 Palestrini, C., Minero, M., Cannas, S., Rossi, E., Frank, D., 2010. Video analysis of dogs with
479 separation-related behaviors. Appl. Anim. Behav. Sci. 124, 61–67.

480 Panksepp, J., Herman, B., Conner, R., Bishop, P., Scott, J. P., 1978. The biology of social
481 attachments: opiates alleviate separation distress. Biol. Psychiatry 13, 607-618.

482 Parthasarathy, V., Crowell-Davis, S.L., 2006. Relationship between attachment to owners and
483 separation anxiety in pet dogs (*Canis lupus familiaris*). J. Vet. Behav. 1, 109–120.

484 Podberscek, A.L., Hsu, Y., Serpell, J.A., 1999. Evaluation of clomipramine as an adjunct to
485 behavioural therapy in the treatment of separation-related problems in dogs. Vet. Rec. 145,
486 365.

487 Pongrácz, P., Miklósi, Á., Molnár, Cs., Csányi, V., 2005. Human listeners are able to classify
488 dog barks recorded in different situations. J. Comp. Psychol. 119, 136–144.

489 Pongrácz, P., Molnár, Cs., Miklósi, Á., 2006. Acoustic parameters of dog barks carry
490 emotional information for humans. Appl. Anim. Behav. Sci. 100, 228–240.

491 Pongrácz, P., Molnár, Cs., Miklósi, Á., 2010. Barking in family dogs: An ethological
492 approach. Vet. J. 183, 141–147.

493 Pongrácz, P., Molnár, C., Dóka, A., Miklósi, Á., 2011. Do children understand man's best
494 friend? Classification of dog barks by pre-adolescents and adults. Appl. Anim. Behav.
495 Sci. 135, 95–102.
496
497 Pongrácz, P., Szabó, É., Kis, A., Péter, A., Miklósi, Á., 2014. More than noise?—Field
498 investigations of intraspecific acoustic communication in dogs (*Canis familiaris*). Appl.
499 Anim. Behav. Sci. 159, 62–68.

500 Pongrácz, P., Czinege, N., Haynes, T.M.P., Tokumaru, R.S.T., Miklósi, Á., Faragó, T.,
501 2016. The communicative relevance of auditory nuisance: Barks that are connected to
502 negative inner states in dogs can predict annoyance level in humans. Interact. Stud. 17, 19–40

503 Prato-Previde, E., Custance, D.M., Spiezio, C., Sabatini, F., 2003. Is the dog-human
504 relationship an attachment bond? An observational study using Ainsworth's strange
505 situation. Behaviour. 140, 225–254.

506 R Core Team 2016. R: A language and environment for statistical computing. R Foundation
507 for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

508 Schwartz, S., 2003. Separation anxiety syndrome in dogs and cats. J. Am. Vet. Med. Assoc.
509 222, 1526–1532.

510 Sherman, B.L., 2008. Separation anxiety in dogs. Compendium. 30, 28–31.

511 Sherman, B.L., Mills, D.S., 2008. Canine anxieties and phobias: an update on separation
512 anxiety and noise aversions. Vet. Clin. N. Am.-Small. 38, 1081–1106.

513 Simpson, B.S., 2000. Canine separation anxiety. Comp. Cont. Educ. Pract. 22, 328–339.

514 Simpson, B.S., Landsberg, G.M., Reisner, I.R., Ciribassi, J.J., Horwitz, D., Houpt, K.A.,
515 Kroll, T.L., Luescher, A., Moffat, K.S., Douglass, G., Robertson-Plouch, C., 2007. Effects of
516 reconcile (fluoxetine) chewable tablets plus behavior management for canine separation
517 anxiety. Vet. Ther. 8, 18.

518 Siwak, C.T., Murphey, H.L., Muggenburg, B.A., Milgram, N.W., 2002. Age-dependent
519 decline in locomotor activity in dogs is environment specific. Physiol. Behav. 75, 65-70.

520 Takeuchi, Y., Houpt, K.A., Scarlett, J.M., 2000. Evaluation of treatments for separation
521 anxiety in dogs. J. Am. Vet. Med. A. 217, 342–345.

522 Takeuchi, Y., Ogata, N., Houpt, K.A., Scarlett, J.M., 2001. Differences in background and
523 outcome of three behavior problems of dogs. Appl. Anim. Behav. Sci. 70, 297–308.

524 Tembrock, G., 1976. Canid vocalizations. Behav. Process. 1, 57–75.

525

526 Topál, J., Miklósi, Á., Csányi, V., 1998. Attachment behaviour in dogs: a new application of
527 Ainsworth's (1969) Strange Situation Test. J. Comp. Psychol. 112, 219–229.

528 Turcsán, B., Miklósi, Á., Kubinyi, E., 2017. Owner perceived differences between mixed-
529 breed and purebred dogs. PLOS ONE, 12:e0172720.

530 Yin, S., 2002. A new perspective on barking in dogs (*Canis familaris*). J. Comp. Psychol.
531 116, 189.

532 Vas, J., Topál, J., Péch, É., Miklósi, Á., 2007. Measuring attention deficit and activity in dogs:
533 a new application and validation of a human ADHD questionnaire. Appl. Anim. Behav.
534 Sci. 103, 105-117.

Wells, D.L., Hepper, P.G., 2000. Prevalence of behaviour problems reported by owners of dogs purchased from an animal rescue shelter. Appl. Anim. Behav. Sci. 69, 55–65.

Wright, J.C., Nesselrote, M.S., 1987. Classification of behavior problems in dogs: distributions of age, breed, sex and reproductive status. Appl. Anim. Behav. Sci. 19, 169–178.

Table 1 – Basic information of the dogs participating in our study. All dogs were family pets. SRD-status was established on the basis of a questionnaire, completed by the dog owners.

name	breed	age (month)	breed status	sex	neuter status	SRD status
Berci	mixed	153	mixed	male	neutered/spayed	non-SRD
Bogyó	Pumi	33	purebred	male	intact	non-SRD
Barka	English Cocker Spaniel	39	purebred	male	neutered/spayed	SRD
Plútó	mixed	26	mixed	male	neutered/spayed	SRD
Foltos	Beagle	76	purebred	female	neutered/spayed	non-SRD
Bolygó	mixed	23	mixed	female	intact	SRD
Miro	Beagle	47	purebred	male	intact	non-SRD
Appia	Transylvanian Hound	52	purebred	female	neutered/spayed	SRD
Brownie	Basset Hound	32	purebred	male	intact	SRD
Csikó	Whippet	54	purebred	male	neutered/spayed	SRD
Tappancs	Tibetan Terrier	80	purebred	female	intact	SRD
Helyes	Greyhound	73	purebred	male	neutered/spayed	SRD
Joda	mixed	129	mixed	male	neutered/spayed	non-SRD
Pimpa	mixed	51	mixed	female	neutered/spayed	non-SRD
Remi	Mudi	64	purebred	female	neutered/spayed	SRD
Csicsi	Mudi	39	purebred	female	intact	SRD
Borisz	Borzoi	39	purebred	male	intact	SRD
Mása	mixed	40	mixed	female	neutered/spayed	non-SRD
Nelson	Groenendael	131	purebred	male	intact	SRD
Bob	Border Collie	116	purebred	male	intact	non-SRD
Mazsola	mixed	69	mixed	female	neutered/spayed	non-SRD
Mila	Border Collie	54	purebred	female	intact	non-SRD
Guszti	Bichon Havanese	68	purebred	male	intact	non-SRD
Panna	Sheltie	51	purebred	female	intact	SRD
Athos	Bordeaux dog	66	purebred	male	intact	non-SRD
Brúnó	mixed	10	mixed	male	intact	non-SRD
Agima	Groenendael	82	purebred	female	neutered/spayed	SRD
Zsömi	mixed	29	mixed	male	neutered/spayed	SRD
Fickó	Hungarian Vizsla (wirehaired)	47	purebred	male	neutered/spayed	non-SRD
Dijon	Hungarian Vizsla (wirehaired)	47	purebred	male	intact	non-SRD
Monty	mixed	73	mixed	male	neutered/spayed	SRD
Fredó	Yorkshire Terrier	60	purebred	male	intact	non-SRD

Tessa	mixed	85	mixed	female	neutered/spayed	SRD
Panka	Dachshund	22	purebred	female	neutered/spayed	SRD
Szusi	mixed	12	mixed	male	intact	non-SRD
Szláva	Russian Black Terrier	22	purebred	female	intact	SRD
Lotte	Boxer	10	purebred	female	intact	non-SRD
Kefír	mixed	15	mixed	female	intact	SRD
Velúr	mixed	20	mixed	male	neutered/spayed	non-SRD
Ashley	Yorkshire Terrier	30	purebred	female	neutered/spayed	SRD
Ori	mixed	76	mixed	male	neutered/spayed	SRD
Zara	Hungarian Vizsla	21	purebred	female	neutered/spayed	SRD
Chandler	mixed	51	mixed	male	neutered/spayed	SRD
Koda	mixed	113	mixed	male	neutered/spayed	non-SRD
Mignon	mixed	34	mixed	female	neutered/spayed	SRD

Table 2 – The details of the final cox-regression models. Significant effects highlighted with bold.

		Overall separation			
Barks	*coef*	*exp(coef)*	*se(coef)*	*z*	*Pr(>|z|)*
age	-0.013937	0.98616	0.007239	-1.925	0.0542
Whines					
SRD	**0.7246**	**2.0639**	**0.3394**	**2.135**	**0.0328**
		Departure phase			
Barks					
breed	-1.21598	0.29642	0.63912	-1.903	0.0571
age	**-0.03390**	**0.96667**	**0.01423**	**-2.382**	**0.0172**
Whines					
SRD	0.6597	1.9343	0.4085	1.615	0.106

547 Table 3 – The details of the final binomial models. Significant effects highlighted with bold.

Departure phase				548
Barks	*Estimate*	*Std. Error*	*z value*	*Pr(>|z|)*
(Intercept)	1.33148	0.87336	1.525	0.1274
breed	-1.14504	0.77558	-1.476	0.1398
age	**-0.03347**	**0.01587**	**-2.109**	**0.0349**
Whines				
(Intercept)	4.511e-16	5.974e-01	0.000	1.0000
neut	**-1.723**	**8.729e-01**	**-1.974**	**0.0483**
breed	**1.723**	**8.729e-01**	**1.974**	**0.0483**
SRD	**1.647e+00**	**7.876e-01**	**2.091**	**0.0365**
Absence phase				
Barks				
(Intercept)	1.15144	0.63135	1.824	0.0682
Age	-0.01869	0.01028	-1.818	0.0690
Whines				
(Intercept)	1.4283	0.6469	2.208	0.0272
sex2	-1.6243	0.9433	-1.722	0.0851
SRA1	**2.1702**	**1.0008**	**2.168**	**0.0301**

549

550

551

552 **Figure captions**

553 Figure 1 – On the left: schematic arrangement of the outdoor testing area. On the right: actual
554 photograph of a subject (tethered to a tree) with the video camera and the shotgun microphone
555 in the foreground. Photo credit: Leéb Ádám.

556

557 Figure 2 – The occurrence of barks during the departure phase. Older dogs bark less likely
558 while the owner leaves them. The dots represent the individuals, the blue line is the binomial
559 fit with the confidence intervals.

560

561 Figure 3 – The occurrence of whines as a function of their latencies during the entire
562 separation event (owner leaves, then stays out of sight of the dog). SRD dogs start to whine
563 with significantly higher chance, and sooner than non-SRD dogs. Red line: non-SRD dogs;
564 Blue line: SRD dogs. The graph shows how the cumulative ratio of whining dogs changes
565 over time in the tested sample.

566

567 Figure 4 - The occurrence of whines during the departure of the owner. Significantly more
568 SRD dogs whine than non-SRD dogs already when the owner leaves but is still visible.