

A New Perspective on Barking in Dogs (*Canis familiaris*)

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The disparity in bark frequency and context between dogs (*Canis familiaris*) and wolves (*Canis lupus*) has led some researchers to conclude that barking in the domestic dog is nonfunctional. This conclusion attributes the differences primarily to genetic variation caused by domestication rather than to the influence of social environment on ontogeny. Other researchers, however, have concluded that vocal usage and response to vocalizations in mammals are strongly guided by social interactions. Closer evaluation of dog vocalizations with respect to social environment reveals developmental factors that lead to both frequent barking and barking in many contexts. Additionally, spectrographic analysis indicates that bark structure varies predictably with context, suggesting that barks can be divided into contextual subtypes and may be a more complex form of communication than given credit.

With 52 million pet dogs (*Canis familiaris*) in the United States alone, the dog is almost an essential part of family life in America. Ironically, only a handful of studies have focused on vocal communication of the domestic dog. One major contributing factor is that a number of ethologists consider domesticated dogs to be so altered by artificial selection that their vocalizations, especially their hallmark vocalization, the bark, lacks specific communication functions (Bradshaw & Nott, 1995; Coppinger & Feinstein, 1991; Fox, 1971).

The primary basis for this idea is the divergence in bark behavior between dogs and wolves (*Canis lupus*). Whereas wolves rarely bark (Mech, 1970; Scott & Fuller, 1965), with barks comprising only 2.3% of all vocalizations (Schassburger, 1987), dogs bark relatively frequently, some of them for hours on end. Additionally, although wolves bark primarily in two contexts—an alert and a territorial context (Joslin, as cited in Mech, 1970)—dogs bark in “virtually every behavioral context” (Coppinger & Feinstein, 1991, p. 125). Given this apparent lack of context specificity and the hypertrophied nature of barking in dogs, researchers might presume that barking is nonfunctional. However, doing so discounts the dynamic interactions between organism and social environment and the effects of these interactions on the ontogeny of vocal behavior (West, King, & Freeberg, 1997).

In the last 2 decades, developmental research has demonstrated the importance of social interactions in shaping the animal’s ability to communicate competently. For example, adult female brown-headed cowbirds (*Molothrus ater*) shape the song potency of juvenile males by selectively responding to certain structural elements of the songs, thus, reinforcing the production of these song elements. Adult males influence the juvenile males’ communicative ability at a higher organizational level, teaching them to

integrate singing with appropriate courtship maneuvers and therefore mate more successfully (King, West, & White, 2002; West et al., 1997). In mammals, it is at this higher organizational level that social companions most strongly influence vocal communication. That is, although in some cases social interactions can affect signal structure (McCowan, Doyle, & Hanser, 2002; Snowdon & de la Torre, 2002), in general, social interactions have a much more profound effect on the context in which an individual vocalizes and in how an individual responds to the vocalizations of others (Seyfarth & Cheney, 1997; Snowdon & de la Torre, 2002).

These concepts of vocal development apply not only to wild animals but also to their domestic counterparts. Researchers frequently assume that behavioral variation between wild and domestic animal populations is a direct reflection of change in genetic variation caused by the domestication process. However, in making this assumption, researchers forget that changes associated with the captive environment can lead to many important modifications in an animal’s behavioral development (Lickliter & Ness, 1990; West et al., 1997). For instance, when raised in the captive environment, domestic species such as Pekin ducks (*Anas platyrhynchos domesticus*) and laboratory rats may lack typical social or sexual displays exhibited by their wild counterparts; however, when raised in a more natural context, they develop the full range of species typical behaviors (Lickliter & Ness, 1990). Thus, the domestic phenotype results from a combination of genetic factors and environmental features of the captive setting.

Researchers would expect the same might hold true for domestic dogs. Dogs in Europe and the United States are typically deprived of their ancestral social environments during development. They are born into litters containing multiple pups but are often separated from their siblings and other conspecifics shortly after weaning. Thereafter, they live in households in which they frequently rely on humans for social relationships as well as for access to resources such as food, shelter, and exercise. According to the developmental research described earlier, such social changes have the potential to lead to changes in vocal habits.

With these ideas in mind, I propose that dogs are far from invalid subjects for vocal communication studies. On the contrary, the disparity in bark frequency and context between wolves and

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domestic dogs, as well as information on sources of selection that have shaped the evolution of domestic dogs, make dogs an especially interesting species to study. Environmental changes associated with domestic living conditions have played a major role in the evolution of domestic dogs through both artificial selection and development. Adopting the developmental perspective discussed earlier should contribute to a better understanding of dog vocal behavior by placing it in the context of the domestic social environment of dogs. Specifically, if context and bark structure covary, this suggests that dogs may perceive meaningful differences in their domestic contexts and may adjust their barking accordingly. In this article, I (a) look at the sources of selection favoring increased barking in dogs, (b) explore how the captive environment contributes to development of increased barking in dogs, (c) examine the prevalent assumptions leading to the idea that barking is nonfunctional or noncommunicative, (d) present data on the acoustic structure of dog barks in different contexts, and (e) offer a systematic approach for studying development and function of barking in dogs and wolves.

How Barking Became Prevalent

According to archaeological and mitochondrial DNA findings, dogs were domesticated from wolflike ancestors between 14,000 and 135,000 years ago (Clutton-Brock, 1995; Vila et al., 1997). During this time, either humans could have specifically selected dogs that barked more, for instance, as an alert function, or barking could have increased through indirect selection. That is, in selecting for some other trait such as tameness, humans could have inadvertently selected for barking (Coppinger & Feinstein, 1991). Indirect selection is supported by Dimitri Belyaev's (Trut, 1999) study of silver foxes (*Vulpes fulvus*). In this study, Belyaev started with fearful foxes and selected only for tameness. After 30 to 35 generations, most of the foxes were as tame as dogs. Additionally, a small percentage had floppy ears and piebald coat coloring, and many yipped like dogs when greeting humans (L. Trut, personal communication, March 9, 2000). These findings illustrate that selection for one behavioral trait can increase the prevalence of other traits and suggest that selection for tameness in dogs can, as a by-product, foster other doglike traits such as barking.

Regardless of how increased barking evolved, at some point humans directly selected for barking in some dogs and against barking in others. This selection still occurs today. For instance, livestock guarding breeds are specifically selected for their barking and vigilant behavior. Those that are not attentive make poor working dogs and are culled or removed from the breeding pool (Coppinger & Schneider, 1995). Some hunting breeds, such as bird dogs and sight-hunting hounds, are selectively bred to be silent while working. To reinforce this silence, people usually punish those dogs that do bark while hunting (Fox, 1971). Yet, in other breeds, barking is not a selection consideration. Racing sled dogs, such as Alaskan Huskies, are bred for physical ability and desire to run for long distances in harsh, cold conditions. Barking is not required for this activity; however, these dogs tend to bark in excitement as they are harnessed for daily practice sessions. Those left behind bark continuously, apparently in distress (Coppinger & Schneider, 1995).

In all of these cases, dogs bark more than wolves; however, because barking has not been systematically studied in dogs or

wolves, researchers can neither confidently state what the contextual differences are nor do they know the contribution of different selection and developmental factors. Early research on dog vocalizations by Scott and Fuller (1965) has indicated that humans can select for barking because bark threshold is likely inherited as a dominant allele; however, in addition to selection, interactions with environmental factors also alter the threshold. Closer evaluation of these interactions should reveal that different dog breeds not only have different bark thresholds but also have differing abilities to learn to bark in specific contexts. If this proves true, then certain environmental features could amplify breed differences in barking.

How the Captive Environment Contributes to Prevalent Barking

Once researchers start examining canid vocalizations within the appropriate contexts and considering the dog's *Umwelt* and social environment during ontogeny, they may realize that dogs probably should differ from wolves in their bark behavior. Dogs and wolves develop in two radically different social worlds, and even superficial investigation of the dog's captive environment reveals that many features of that environment can lead to both frequent barking and barking in many contexts.

First, the captive environment provides more stimuli that warrant barking (Fox, 1971). Unlike wolves that live in large territories, dogs are confined to relatively small territories whose boundaries are frequently approached by intruders. Additionally, when dogs bark at potential intruders, their actions are frequently reinforced by the intruder's response. For instance, when postal carriers evoke barking by entering a dog's property and then leave while the dog is still barking, they reinforce the bark behavior. Moreover, because urban living has increased the number of dogs per given area, far greater than densities of wolf populations, there is more opportunity for social facilitation of barking. In fact, some researchers have proposed that social facilitation is one mechanism for increased barking in kenneled dogs (Fox, 1971).

Second, except for dogs that roam freely, most captive dogs rely heavily on humans to fulfill many of their needs. For instance, dogs may need to be let outside or to be let back in or may need to be taken for a walk or to be fed. Consequently, dogs may bark to attract their owner's attention, and owners may intentionally or unintentionally reinforce this vocal behavior through their response (Beaver, 1999).

These examples illustrate that an interplay between the dog's lower bark threshold coupled with the circumstances in which it lives can lead to what observers might deem as excessive or context-independent barking. When dogs are raised in a more wolflike setting, the results are different. In a study of free-roaming dogs in Italy, MacDonald and Carr (1995) noted that these dogs barked primarily in two situations. Like wolves that rally prior to hunting, dogs rallied in bark sessions prior to heading to the local dump site to scavenge. When the largest pack rallied from as far as 1 km away, other smaller packs responded by evacuating the dump site. These free-roaming dogs also barked during aggressive encounters with other packs. Rather than fighting, they engaged in barking matches until one group retreated. So in the more "naturalistic" setting, dogs barked in situations more similar to what has been reported in wolves, and these dogs did not bark

as frequently (D. MacDonald, personal communication, February 25, 2001) as human-owned dogs.

Questioning the Arguments for Nonfunctionality of Barking

Dramatic differences in vocalization threshold and contextual use would very likely draw considerable interest if they involved nondomesticated canids. When such differences involve barking in domesticated dogs, researchers argue that the highly repetitive nature, the use of this vocalization in many contexts compared with wolves, and the presence of concurrent visual signals all indicate that barking must be nonfunctional or just a nonspecific form of communication. For example, Coppinger and Feinstein (1991) described a livestock guarding dog that barked continuously for 7 hr with no other dog in sight or earshot for miles as evidence supporting nonfunctionality of barking. They also suggested that with the wide variety of contexts for barking, dogs would have to be "endowed with an extraordinarily subtle and powerful system of context-interpretation" (Coppinger & Feinstein, 1991, p. 125) for barking to be a specific form of communication. Fox (1971) stated that contextual variety indicates that barking must just function to attract attention so that receivers can attend to other cues for more specific information. These arguments seem reasonable; however, closer evaluation of social context in dogs and other animals reveals a different picture.

First, although dogs may bark repetitively in situations in which wolves would give a single bark, repetitiveness does not indicate nonfunctionality. Many animals regularly use vocalizations in a repetitive pattern that achieves a cumulative or tonic effect (Schleidt, 1973). This tonic communication can serve a number of functions. For instance, repeated cooing of female ring doves (*Streptopelia risoria*) cumulatively stimulates follicle growth leading to ovulation (Cheng, 1992). Songbirds sing repeated patterns for minutes to hours when attracting mates and defending territory. Even wolves use tonic communication. During the breeding season, male wolves solo howl for hours at a time with no detectable acoustic reply. This howling may function like a beacon (Schleidt, 1973) to attract females from neighboring packs (Klinghammer & Laidlaw, 1975).

Second, although dogs bark in many contexts, dogs may bark in the same types of contexts as wolves. Wolf experts frequently state that wolves bark primarily in an alert context and a territorial context; however, closer evaluation of the literature reveals that wolves bark in far more contexts than usually reported. Schassburger (1987) documented that in addition to the alert and territorial contexts, wolves bark in other circumstances including protest, prey hunting, and pair behavior. Furthermore, when researchers consider other barklike sounds, such as woofs, huffs, yips, and combined sounds such as bark howls, researchers realize that wolves may also bark to contact other pack members and in a group cohesive function (Schassburger, 1987). The problems with comparing dog and wolf barking, though, is that (a) many studies describe vocalizations phonetically without using spectrographic analyses, (b) classifications of vocalizations and contexts are inconsistent between researchers, and (c) context is rarely rigorously documented in either wolves or dogs. Thus, to make a valid comparison, researchers must systematically study both structure

and context of barking in both wolves and dogs using the same standards and definitions.

Third, in analyzing vocal communication, researchers must remember that animals participating in vocal communication also use nonvocal contextual cues to guide their behavior (West et al., 1997). For instance, Seyfarth and Cheney (1997) observed that adult vervet monkeys (*Cercopithecus aethiops*) responded appropriately to juvenile alarm calls by looking for the appropriate class of predator but relied additionally on visual cues prior to taking action. Thus, animals incorporate many contextual cues in interpreting vocal signals. Consequently, when studying canid communication, researchers must look at signals within the contexts of canids prior to making conclusions about the signals' function.

An Approach for Testing the Importance of Context

Although careful consideration reveals many reasons why barking might be a functional communication with specific uses in different contexts, with current information, researchers cannot draw objective conclusions. Covariation between context and bark structure would suggest that dogs perceive meaningful differences among their domestic contexts and adjust their barking accordingly. In many species, animals distinguish a number of subtly different context-specific call subtypes within each broad acoustic class, and playbacks verify that these subtypes elicit different behavioral responses (Fischer, Hammerschmidt, & Todt, 1995; Rendall, Seyfarth, Cheney, & Owren, 1999). It follows that if barking in dogs has specific functions, then the acoustic parameters of dog barks should vary predictably with context, and researchers should be able to classify barks into context-specific subtypes. In this article, I address the first hypothesis, which is that acoustic parameters vary specifically with context. Results regarding the second hypothesis, which is that researchers can classify barks into subtypes, are presented in a subsequent article (Yin & McCowan, 2002).

Method

In this study, I recorded barking from 10 adult dogs (*Canis familiaris*) of six different breeds (2 Australian cattle dogs, 2 Australian shepherds, 3 German shorthair pointers, 1 dachshund, 1 Springer spaniel, 1 mixed breed) in three different test situations: a disturbance situation in which a stranger rang the doorbell, an isolation situation in which the dog was locked outside or in a room isolated from its owner, and a play situation in which either two dogs or a human and a dog played together.

Barks were recorded using a Sony DCR VX2000 digital video recorder (nondirectional microphone) with 16-bit, 44,000-Hz sampling. Barks were analyzed in Cool-Edit Pro (Huber, 1998) with macros written by Brenda McCowan.¹ The program took 60 sequential frequency measurements and 60 sequential amplitude measurements of the dominant frequency (the frequency band in which the most energy is concentrated) in a frequency by time spectrogram. For each bark, this program calculated mean frequency and duration. Results on 4,672 barks were analyzed in SAS (SAS Institute Inc., Cary, NC) using mixed effects analysis of variance (ANOVA) in which context was the fixed effect and dog identity was the random effect. Pairwise comparisons were made using the least squares

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Table 1
Means and Standard Deviations for Bark Frequency and Duration

Variable	Disturbance		Isolation		Play	
	M	SD	M	SD	M	SD
Frequency	686	139	860	228	840	158
Duration (ms)	345	75	247	24	272	51

means test with a Bonferroni correction to determine which contexts were different from each other.

Results and Discussion

A mixed effects ANOVA plus pairwise comparisons revealed that the mean frequency (see Table 1) of disturbance barks was significantly lower than those of isolation and play barks, $F(2, 17) = 77.52, p < .01$; however, contact and play barks did not differ significantly from each other. Bark duration (see Table 1) was significantly longer for disturbance barks than for contact and play barks, $F(2, 17) = 99.27, p < .01$; however, isolation and play barks did not differ significantly.

Mixed effects ANOVA also revealed a significant dog-context interaction in the case of both mean bark frequency, $F(16, 158) = 6.29, p < .01$, and mean bark duration, $F(16, 158) = 18.63, p < .01$; however, in the case of bark frequency, only 1 of the 10 dogs varied in a direction opposite that of the others (see Figure 1), and in the case of bark duration, only 2 of the dogs varied in a direction opposite the others (see Figure 2). In both cases, the variation in the opposite direction was relatively small.

These changes in mean frequency and duration with context are consistent with Morton's motivation-structural rules, which state that birds and mammals use harsh, low-frequency sounds in hostile situations and higher frequency, more tonal sounds when they are approaching in a friendly or appeasing manner (Owings & Morton, 1998).

The results are also consistent with McConnell's (1990) findings that short, rapidly repeated sounds correlate with increased

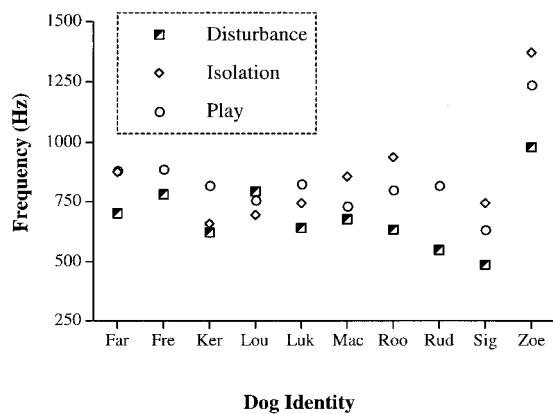


Figure 1. Average mean frequency for individual dogs in different contexts.

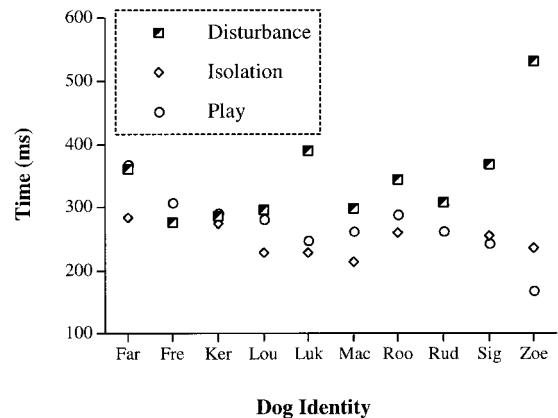


Figure 2. Average bark duration for individual dogs in different contexts.

motor activity. The disturbance test situation calls for the highest arousal level in the dog. As expected, the disturbance barks were often repeated rapidly—so rapidly that they were sometimes fused into *superbarks*, which consisted of two to four barks. As a result, disturbance bark durations were longer than isolation or play bark durations.

Overall, the differences indicate that the acoustic structure of barks does vary predictably with context. On average, barks are lower in pitch and longer in duration in the disturbance situation than in the isolation and play situations. Additionally, further analysis shows that a combination of predictive variables, such as the two shown, reliably discriminates the three contexts (Yin & McCowan, 2002). The fact that barks were context specific for different dogs, even though these dogs came from diverse developmental environments, strongly suggests that barks serve specific functions. However, to confirm that the barks have different functions in different contexts, researchers must perform playback studies and observe the response of the receiver as well as the barking dog's response to the receiver. This investigation indicates that evaluating vocal communication of dogs in the context of the domestic social environment can lead to a rich area of study—one in which researchers can look at the long-term sources of selection as well as the influence of both heterospecific and conspecific interactions on the ontogeny of barking in dogs.

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