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You can judge a bearer by its bark: Dogs use sound to size up conspecifics

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Abstract

A variety of mammalian species use vocalizations to perceive the size of conspecifics. This ability may be an evolutionary adaptation shared by many mammalian species allowing them to detect the presence of a threat when visual resources are scarce or unavailable. Specifically, some mammals demonstrate prolonged attention to manipulated calls that suggest a larger conspecific compared to those suggesting a smaller conspecific. In humans this behavioral effect depends on the observer's size—perceptions of 'big' or 'small' may differ between individuals. We explored whether this generalizes to other species by manipulating formant dispersion of dogs' own barks to create synthetic barks that perceptually sounded either larger or smaller than the dog subject. We played these sounds to dogs and recorded how long they looked at the playback speaker. A univariate ANOVA revealed an effect of sound size ($F(2,22) = 4.724$, $p = 0.020$) such that dogs tended to look at the speaker longer in response to synthetic 'larger' dog sounds compared to synthetic 'smaller' sounds (Tukey post-hoc test, $p = 0.053$). Like humans, dogs may respond to novel barks by comparing the source's probable size to their own. We might expect to see this pattern of behavior in other mammalian species.

Keywords: dogs, sound, size, formant, conspecific, auditory

Introduction

The ability to detect the presence of a predator is a requisite feature of survival for many animals. If visual resources are scarce or unavailable (e.g. in poorly lit or densely packed areas), animals may rely on their ability to extract size related information from auditory cues in order to identify a possible threat such as large or threatening conspecifics. Despite a renewed interest across multiple disciplines (Plazak & McAdams, 2017; Taylor & Reby, 2010; Tsur, 2006), the ability to identify sound source size information, and the behavioral implications of perceiving this information, are not well understood.

A variety of species (e.g., domestic dogs: Taylor, Reby, & McComb, 2010; red deer: Reby et al., 2005; koalas: Charlton et al., 2011; panda bears: Charlton, Zhihe, & Snyder, 2010; alligators: Reber et al., 2017) perceive the size of a conspecific based on either natural or synthetic vocalizations manipulated to give the impression of a larger or smaller conspecific. In such experimental settings, synthetic vocalizations often manipulate formants of the vocalization's sound wave. Formants, particularly resonant bands of frequencies in a sound wave, may provide honest acoustic cues to an animal's size (Reber et al., 2017; Riede & Fitch, 1999; Taylor & Reby, 2010).

Auditory stimuli in these experiments are created by shortening or elongating the perceived vocal tract length (VTL) of a sound source to give the impression of smaller or larger animals. Since body size and vocal tract are positively correlated (Riede & Fitch, 1999), the synthetically elongated VTLs suggest an increase to the size of an animal, while shortened VTLs suggest a reduction in the animal's size. The psychoacoustic indicator of VTL is known as formant dispersion, the energy distance between particularly resonant bands of frequencies (formants) in a sound wave. Assuming a constant fundamental frequency, bigger animals tend to produce sound waves with shorter formant dispersion, whereas smaller animals produce sound waves with a larger space between formant frequencies (Taylor & Reby, 2010).

Source-filter theory (Fant, 1981) dictates that vocal tract resonances, rather than other auditory features such as glottal pulse rate (i.e., frequency), represents the most direct and honest auditory cue to body size (Taylor & Reby, 2010). VTL is anatomically constrained by an animal's skeletal structure, and VTL and formant dispersion are negatively correlated (Riede & Fitch, 1999; Taylor & Reby, 2010). Thus, manipulating the formant dispersion of a sound wave gives the perception of an elongated or reduced VTL, and as a result, a larger or smaller animal. Animals demonstrate sensitivity to this size-related cue by exhibiting longer periods of looking time in response to the vocalizations corresponding to large animals compared to those corresponding to small animals (Charlton et al., 2011; Charlton et al., 2010; Faragó et al., 2010; Reby et al., 2005; Taylor et al., 2010).

However, perceptions of "big" and "small" may be subjective and dependent on the size of the observer (Plazak, 2016; Plazak & Silver, 2016). Human listeners may experience heightened levels of Electrodermal Activity (EDA) in response to synthetic singing tones generated from their own voice manipulated to simulate humans larger than themselves, compared to tones simulating humans smaller than themselves (Plazak & Silver, 2016). These stimuli, generated by manipulating the participant's own voice or vocalization, are known as *listener normalized stimuli.*

The present study aims to explore the extent to which effects of source normalized stimuli generalize to other species. We recorded domestic dogs' barking sounds, and manipulated the perceived formant dispersion of these sounds to represent four different sized versions of the sound source. We then presented these manipulated sounds back to the subject, and recorded the duration of time spent looking at the audio speaker presenting the stimuli. We hypothesized that dogs would demonstrate longer periods of looking time in response to their own barks manipulated to sound like a larger dog (by shortening formant dispersion and elongating perceived VTL) compared to those manipulated to sound like a smaller dog (by elongating formant dispersion and shortening perceived VTL).

Method

Participants:

Twenty-four domestic dogs were recruited via email (Mean age = 5.16 years, *SD* = 3.14; Mean weight = 52.19 pounds, *SD* = 28.33; 12 males) to a pre-existing database of dog owners. Our sample consisted of 2 Golden Retrievers, 2 Yellow Labs, 1 Bulldog, 1 Schnauzer, 1 German Shepard, 1 Pit Bull, 1 Border Collie, and 15 mixed breed dogs.

Stimuli:

Dog owners submitted audio recordings of their dog's bark as .wav files. We imported recordings into an open source sound editing software (Audacity) and edited the recordings at a sampling rate of 44100 Hz. Using Audacity, we extracted three individual barks from each recording and combined them into a loop with one second of silence between each bark. We created synthetic barks using the TANDEM- STRAIGHT vocoder (Kawahara, Takahashi, Morise, & Banno, 2009) through which we morphed the spectral envelope ratio of each dog's bark as to give the impression that the bark was produced by a larger or smaller dog. We used four spectral envelope ratio (SER) manipulations: "very small" (SER x 0.7143), "small" (SER x 0.833), "large" (SER x 1.2), and "very large" (SER x 1.4). These manipulations correspond to reductions and expansions of each dogs' body size by 20% and 40% (see supplementary online video). Sounds were played via an Apple MacBook Air laptop and a Sony STR-DH100 stereo receiver. Dogs were positioned approximately 5 meters away from two speakers that were 2 meters apart from each other. An experimenter was positioned behind a curtain out of the dog's view. Figure 1 depicts the testing area setup.

Procedure:

With the dogs in the testing area, we played their synthesized barks back to the dog subject. The testing session unfolded as a continuous flow of experimental and habituation trials (see supplementary online video). Experimental trials consisted of three manipulated barks, which were all modified to the same size, played on a loop with one second of silence between barks. Habituation trials consisted of a loop of unaltered barking sounds between each of the experimental trials. An experimenter observed the dog's responses through a slit cut in a curtain such that the experimenter was not visible to the dog. The experimenter initiated playback of the subsequent loop once the dog subject looked away from the sound source for three consecutive barks. The order of the four size manipulations was randomized, and dogs heard each size manipulation twice for a total of 16 trials (8 experimental trials and 8 habituation trails). An example ordering of trials is shown in Table 1. Behavioral observations were recorded via Sony Handycam HDR-CX220 camcorders, and analyzed at 30 frames per second using the open source software MPEG Steamclip. We recorded the duration of time that the dog looked at the speaker from which the sound originated. Testing sessions lasted between 5-13 minutes.

Results

Across all dogs, mean looking times for all trials combined was (M = 11.78 seconds, SD = 12.47 seconds; 95% CI [6.79, 16.77]). A repeated measures ANOVA revealed that dogs spent significantly different amounts of time looking at sounds corresponding to larger dogs, smaller dogs, and habituation sounds ($F[2, 22] = 4.724$, $p = 0.020$) such that dogs looked at the source of the sounds longer in response to sounds manipulated to sound like a larger dog (M = 17.35, SD = 21.03, 95% CI [8.93, 25.76]) compared to sounds manipulated to sound like a dog smaller than the subject (M = 11.69, SD = 14.41; 95% CI [5.92, 17.46]; p = 0.053). Compared to the habituation sounds (M = 6.30, SD = 4.89; 95% CI [4.34, 8.26], dogs also looked at both the larger and smaller sounds for a longer duration of time (relatively larger: p = 0.005; relatively smaller: p = 0.032). Figure 3 expresses mean looking times for each of the three sound types.

Discussion

We hypothesized that dogs would demonstrate longer periods of looking time in response to their own barks manipulated to sound like a larger dog compared to their own barks manipulated to sound like a smaller dog. Our results supported this hypothesis. The longer periods of looking time in response to the larger sounds compared to smaller sounds is consistent with literature suggesting dogs attend to size-related cues in non-normalized stimuli (Taylor & Reby, 2010) and with literature suggesting that listener-normalized stimuli are salient for human listeners (Plazak & Silver, 2016). Further, this finding suggests that dogs may respond to barking sounds from an unknown sound source based on a calculation of the source's probable size in relation to their own. Although not one of our explicit hypotheses, we did find that dogs displayed significantly longer looking times in response to both the smaller and larger trials compared to the habituation trials. This result could be explained by the novelty of the manipulated barking sounds; dogs may look longer in response to manipulated barking sounds due to their sonic difference from unaltered barking sounds heard in everyday life. The novelty of the manipulated sounds, however, cannot account for the significantly different looking time durations between the larger and smaller sounds. Thus, our data are consistent with the hypothesis that dogs display longer looking times in response to larger sounds compared to smaller sounds.

In general, the ability to perceive the size of a conspecific based on their call may be an evolutionary adaptation shared by many mammalian species allowing them to detect the presence of a threat when visual resources are scarce or unavailable. Our research is limited in that we demonstrated this effect in only one nonhuman species. Thus, future research should investigate the degree to which other species attend to size-related manipulations using source-normalized stimuli. A second possible limitation of our study is that owners recorded their dog's bark outside of the lab, and thus we could not determine whether the barks submitted to us were agonistic or playful barks. It seems plausible that the effect of size on dogs' auditory perception may depend on other sonic features that affective state the intentions of the conspecific. Thus, future research should investigate the differences in bark context on dogs' responses to sound size manipulations.

Understanding how various species perceive sound source size may aid in our understanding of many auditory phenomena such as human music perception, human computer interactions, emotional speech perception abnormalities, etc. Our results are consistent with the hypothesis that behavioral responses to sounds of various sizes may be understood through a process of normalization relative to the size of the listener. That is, large or small sounds may be interpreted differently by dogs of various sizes.

Ethical approval: All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Compliance with Ethical Standards: Funding: This study was not funded by any grant.

References

Charlton, B. D., Ellis, W. A. H., McKinnon, A. J., Cowin, G. J., Brumm, J., Nilsson, K., & Fitch, W. T. (2011). Cues to body size in the formant spacing of male koala (phascolarctos cinereus) bellows: Honesty in an exaggerated trait. *Journal of Experimental Biology, 214*(20), 3414-3422. doi:10.1242/jeb.061358

Charlton, B. D., Zhihe, Z., & Snyder, R. J. (2010). Giant pandas perceive and attend to formant frequency variation in male bleats. *Animal Behaviour, 79*(6), 1221-1227. doi:10.1016/j.anbehav.2010.02.018

Fant, G. (1981). The source filter concept in voice production. *STL-QPSR*, *1*(1981), 21-37.

Faragó, T., Pongrácz, P., Miklósi, À, Huber, L., Virányi, Z., & Range, F. (2010). Dogs' expectation about signalers' body size by virtue of their growls. *PLoS ONE, 5*(12) doi:10.1371/journal.pone.0015175

Plazak, J. (2016). Listener-normalized musical affect: conceptualizing "felt" musical emotions. In V. Johnson, D. Zhao, H. Conrad (editors), "Proceedings of the 14th International Conference for Music Perception and Cognition." pp. 304-306.

Plazak, J., & McAdams, S. (2017). Perceiving changes of sound-source size within musical tone pairs. *Psychomusicology: Music, Mind, and Brain, 27*(1), 1-13. doi:10.1037/pmu0000172

Plazak, J. & Silver, Z. (2016). Inducing emotion through size-related timbre manipulations: A pilot investigation. In V. Johnson, D. Zhao, H. Conrad (editors), "Proceedings of the 14th International Conference for Music Perception and Cognition." pp. 276-278.

Reber, S. A., Janisch, J., Torregrosa, K., Darlington, J., Vliet, K. A., & Fitch, W. T. (2017). Formants provide honest acoustic cues to body size in american alligators. *Scientific Reports, 7*(1). doi:10.1038/s41598-017-01948-1

Reby, D., McComb, K., Cargnelutti, B., Darwin, C., Fitch, W. T., & Clutton-Brock, T. (2005). Red deer stags use formants as assessment cues during intrasexual agonistic interactions. *Proceedings of the Royal Society B: Biological Sciences, 272*(1566), 941-947. doi:10.1098/rspb.2004.2954

Riede, T., & Fitch, T. (1999). Vocal tract length and acoustics of vocalization in the domestic dog (canis familiaris). *The Journal of Experimental Biology, 202*, 2859-2867.

Taylor, A. M., & Reby, D. (2010). The contribution of source-filter theory to mammal vocal communication research. *Journal of Zoology, 280*(3), 221-236. doi:10.1111/j.1469-7998.2009.00661.x

Taylor, A. M., Reby, D., & McComb, K. (2010). Size communication in domestic dog, canis familiaris, growls. *Animal Behaviour, 79*(1), 205-210. doi:10.1016/j.anbehav.2009.10.030

Tsur, R. (2006). Size-sound symbolism revisited. *Journal of Pragmatics, 38*(6), 905-924. doi:10.1016/j.pragma.2005.12.002

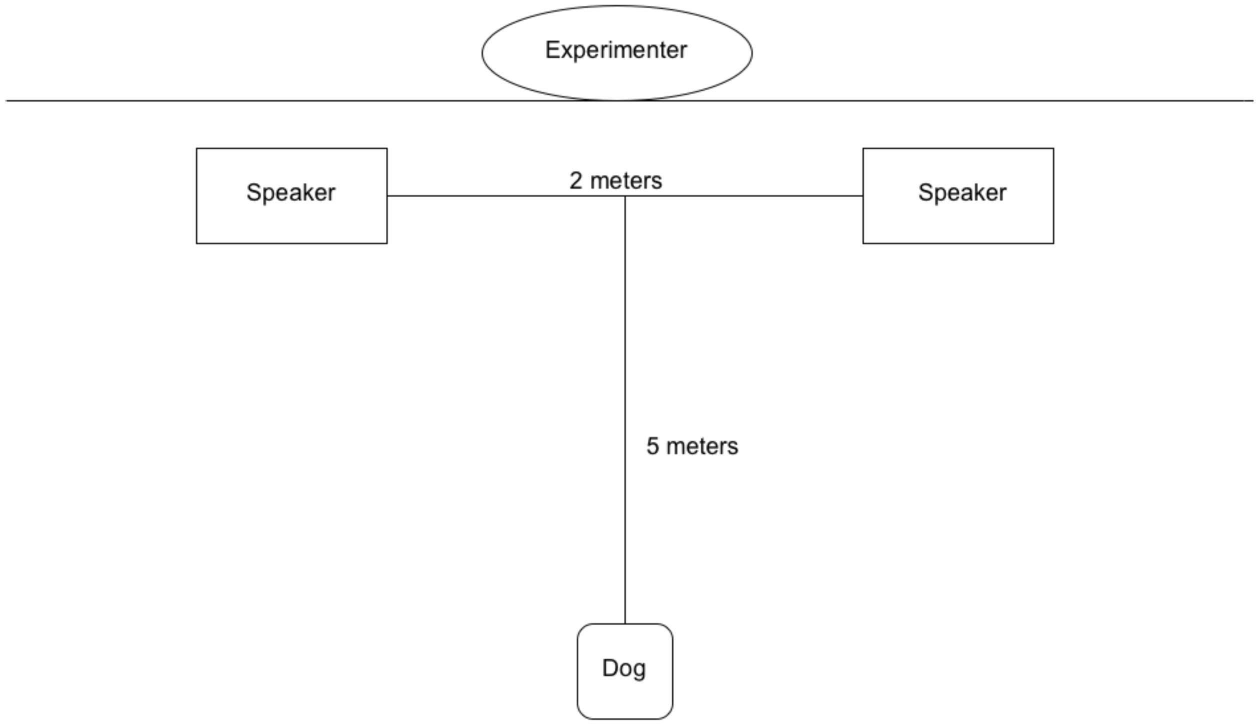

Figure 1: The layout of the testing area. Dogs were positioned 5 meters away from two speakers that were 2 meters apart from each other. An experimenter was positioned behind a curtain with a slit cut in it such that the experimenter could see the dog but the dog could not see the experimenter.

Table 1

Example of trial ordering

Trial Number	*Stimulus type*
1	Habituation
2	Very Large
3	Habituation
4	Small
5	Habituation
6	Very Small
7	Habituation
8	Large
9	Habituation
10	Very Small
11	Habituation
12	Large
13	Habituation
14	Small
15	Habituation
16	Very Large

Table 1: A possible ordering of trials. Habituation trails always occurred on odd numbered trails. The ordering of experimental trials (on even numbered trails) was randomized.

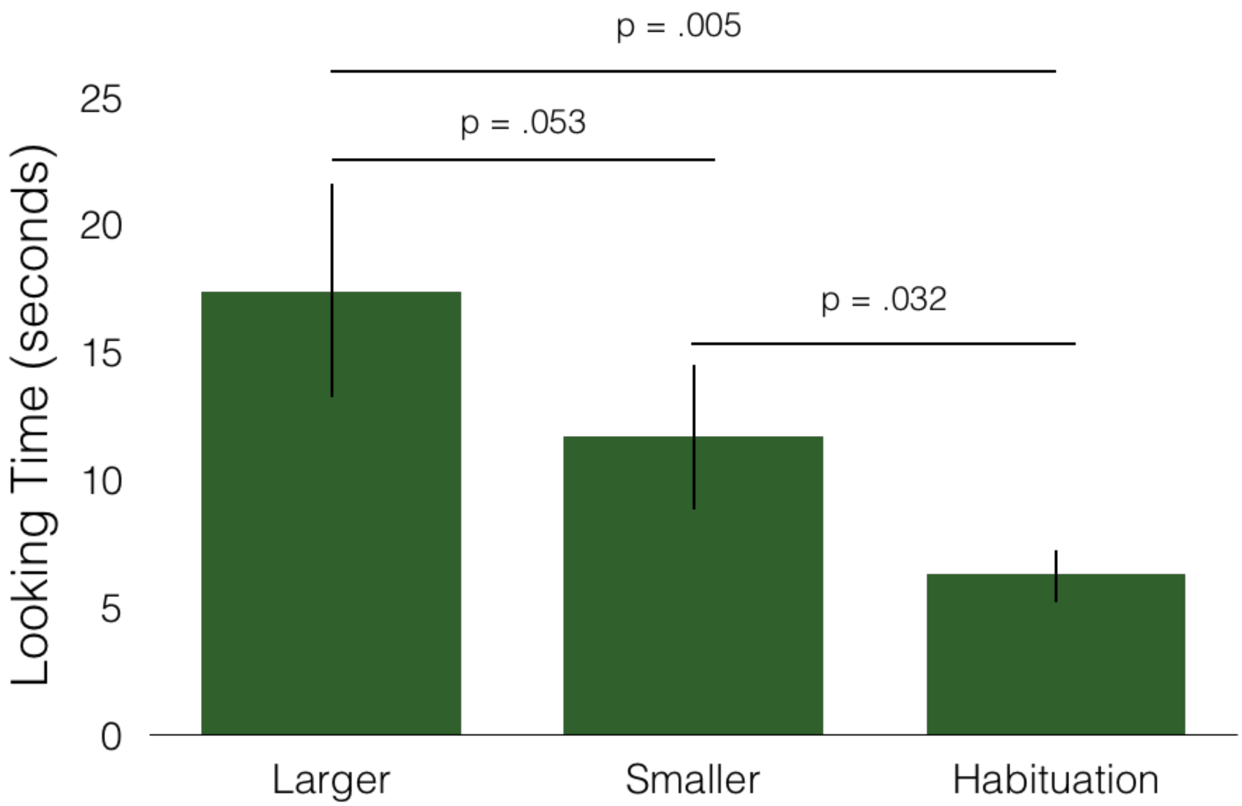

Figure 2: Mean looking times and standard deviations for each of the three stimuli types, larger (M =17.35 SD = 21.03), smaller (M = 11.69 SD = 14.41), and habituation (M =6.30 SD = 4.89). Dogs looked in response to larger sounds for a longer duration of time compared to smaller sounds (p = 0.053) and habituation sounds (p = 0.005). Dogs also looked longer in response to smaller sounds longer compared to habituation sounds (p = 0.032).