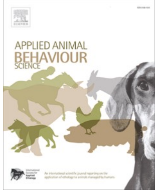
Applied Animal Behaviour Science 281 (2024) 106452

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim



Enjoy the silence: Preference and short-term effect of exposure to different acoustical stimuli in dogs

Cécile Guérineau, Miina Lõoke, Anna Broseghini, Paolo Mongillo *, Lieta Marinelli

Dipartimento di Biomedicina Comparata e Alimentazione, University of Padova, Viale dell'Università 16, Legnaro, PD 35020, Italy

ARTICLE INFO

Keywords:
Acoustic stimuli
Dog behaviour
Emotional response
Familiarity
Preference test

ABSTRACT

Prior research has demonstrated that animal vocalizations and music can elicit emotional responses in dogs, but their preferences for different acoustic stimuli remain underexplored. This study aimed to develop a methodology to assess dogs' preferences and behavioral reactions to various acoustic stimuli and examine the role of familiarity in shaping these responses. In the first experiment, 90 pet dogs were exposed to one of six types of sound stimuli: conspecific agonistic vocalizations, conspecific vocalizations recorded in positive contexts, classical music, relaxing music, dog-directed speech, and neutral background noise. The setup involved a room virtually divided into two areas, in which the dog could freely move. Sounds were turned on or off, depending on which of the two zones the dog was in, thereby giving subjects the possibility to choose whether to be exposed to the sound or not. Preferences were determined by relative amount of time spent in the sound versus quiet zone and behaviors were analyzed for emotional indicators. Dogs actively avoided agonistic vocalizations exhibiting increased attention-seeking behaviors toward their owners. No distinct preferences or aversions emerged for the other stimuli, although conspecific vocalizations in positive contexts and dog-directed speech elicited dogs' attention. Both types of music resulted in lower attention towards the sound compared to the neutral condition. In Experiment 2, the same procedure was used with 20 dogs, half of whom were routinely exposed to classical music at home, to test whether familiarity with classical music affected behavioral responses and preferences. Although no significant behavioral changes or preferences for classical music were observed, dogs with prior exposure spent twice as much time in the sound zone compared to those without, suggesting enhanced likability due to familiarity. These dogs also exhibited more relaxed behaviors, indicating that familiarity may influence emotional responses.

Overall, the study introduces a novel approach for evaluating dogs' preferences for acoustic stimuli. It revealed that none of the stimuli allegedly inducing positive emotions led to a clear preference. However, behavioral data suggest that familiarity can enhance the likability of specific sounds. These findings highlight the need for further investigation into how different soundscapes influence dogs' emotions and behavior over time, and whether dogs may inherently prefer silence. Moreover, the results underscore the importance of carefully considering acoustic enrichment strategies, particularly the role of familiarization in shaping dogs' responses to their auditory environment.

1. Introduction

Many sounds can evoke emotions in listeners. Acoustic features of speech have proven capable of carrying emotional content on their own (Sauter et al., 2010), conveying a variety of emotions to human listeners (Banse and Scherer, 1996; Gerdes et al., 2014). Acoustic features are so important they allow us to extract emotional information from sounds without an intelligible message, including vocalizations of other species (Filippi et al., 2017; Faragó et al., 2014), and even non-biological sounds, such as music (Schaefer, 2017). Moreover, acoustic attributes of speech and music that convey emotions, such as frequency spectrum, intensity and rate, can trigger the same emotional ratings when occurring in environmental sounds (Ma and Thompson, 2015). The ability of sounds and vocalizations to convey emotional messages to a receiver

---

* Correspondence to: Laboratory of Applied Ethology, Dipartimento di Biomedicina Comparata e Alimentazione, University of Padova, Viale dell'Università 16, Legnaro, PD 35020, Italy.

E-mail addresses: cecilechantalcatherine.guerineau@phd.unipd.it (C. Guérineau), miina.looke@unipd.it (M. Lõoke), anna.broseghini@phd.unipd.it (A. Broseghini), paolo.mongillo@unipd.it (P. Mongillo), lieta.marinelli@unipd.it (L. Marinelli).

https://doi.org/10.1016/j.applanim.2024.106452
Received 30 August 2024; Received in revised form 11 November 2024; Accepted 15 November 2024

extends to several animal species. According to a phenomenon known as motivation-structural rules, the acoustic characteristics of animal vocalizations inform the receiver of the signaler's motivational state (Morton, 1977; Manser et al., 2001; Fichtel and Hammerschmidt, 2003; Leavesley and Magrath, 2005; King et al., 2010; Leary, 2014). As a general rule, low-frequency and harsh sounds are used to convey aggressive meanings, whereas purer, high-pitched vocalizations convey fear or appeasement, as shown in several mammals (Briefer, 2012).

Emotional reactions to sounds have been also investigated in dogs. Through playback experiments it was shown that dogs express behaviours consistent with a negative emotional state when exposed to vocalizations characterized by negative valence, while approaching the owner were observed when dogs were exposed to sounds with positive valence (Huber et al., 2017). Dogs expressed more alertness and stress-related behaviours when hearing whining vocalization compared to an acoustically similar control sound (Quervel-Chaumette et al., 2016). Familiarity with the sound is also important for dogs. Dogs exposed to a familiar whine displayed more comfort-offering behaviours towards a familiar dog and a longer high cortisol level compared to when they were exposed to a stranger's whine (Quervel-Chaumette et al., 2016). In a cross-modal experiment, it was proven that dogs can integrate bimodal sensory emotional information, correctly matching happy/angry faces with the equivalent sound valence of both human and dog species (Albuquerque et al., 2016). Finally, functional MRI studies in dogs also highlighted specific brain sensitivity to vocal cues of emotional valence, recruiting the same brain regions to process affective vocalizations than human (Andics et al., 2014).

As for the role of auditory enrichment, research has explored its potential benefits across a wide range of species, showing varying effects on emotional states and welfare (for a review, see Snowdon, 2021). In dogs, most studies focused on the effect of music as an auditory enrichment in kenneled dogs (Wells et al., 2002; Kogan et al., 2012; Brayley and Montrose, 2016; Bowman et al., 2015, 2017) or within a veterinary hospital (Engler and Bain., 2017; King et al., 2022). Overall, the results are mixed, as some studies reported positive behavioural responses to classical music (Wells et al., 2002; Bowman et al., 2015), while other studies reported no effect (King et al., 2022) or dogs' preference for speech (Brayley and Montrose, 2016) or soft rock/reggae (Bowman et al., 2017) compared to classical music. Regarding positive effects of classical music on dogs in other contexts, Köster and colleagues (2019) found that, based on heart rate variability indices, dogs exposed to classical music were less stressed during veterinary training than those who were not. Additionally, classical music is thought to have benefits in a clinical context, as exposure to it was associated with a reduced need for sedation and a deeper depression of the central nervous system (Georgiou et al., 2023).

Preference tests have typically been used in the field of animal welfare, observing the animal actively choosing between presented alternatives and inferring that such preference is associated with better emotional states. When specifically referring to sounds, studies on preference between sounds and silence were carried out mainly on captive nonhuman primates (McDermott and Hauser, 2007; Ritvo and MacDonald, 2016; Wallace et al., 2017) while, to the best of our knowledge, no study assessed dogs' preference for acoustical stimuli. However, to understand if animals would prefer to avoid any acoustical stimulus is crucial (Ritvo and MacDonald, 2016; McDermott et al., 2007), and this is only possible by adopting a methodology in which the animal can decide when/if to turn the sound on and off.

To understand preferences for acoustic stimuli in dogs, we enrolled them in a preference test. In the first experiment, six acoustical stimuli, presumably eliciting different emotional states, were tested, including a neutral one to be used as a reference and dog aggressive vocalizations, known to be able to elicit negative emotions in dogs, to validate our procedure. As the scientific literature does not report any sound known to evoke positive emotions in dogs, four sounds potentially eliciting positive emotional states were tested (i.e., conspecific vocalization recorded in a positive context, classical music, relaxing music and dog-directed speech recording). Since familiarity has proven to be important in how subjects react towards sounds, we performed a second experiment to assess preference and behavioural reactions of dogs with or without prior regular exposure to classical music.

1.1. Experiment 1

The aim of the first experiment was to assess dogs' preferences for and behavioural reactions to exposure to different types of acoustic stimuli, including one background sound and one known to elicit negative emotions as a procedural validation. We also explored four additional sounds, thought to potentially evoke positive emotional responses.

2. Material and methods

2.1. Subjects

The sample for the first experiment consisted of 90 pet dogs recruited through the database of volunteers at the Laboratory of Applied Ethology in the University of Padua. 57 were purebred (9 Border Collies, 6 German Shepherds, 4 Lessinia and Lagorai Shepherds, 4 Golden Retrievers, 3 American Staffordshire Terriers, 3 Labrador Retrievers, 2 Huskies, 2 Australian Shepherds, 2 French Bulldogs, 2 Jack Russel, 2 Maltese, 2 White Swiss Shepherds, 1 American Akita, 1 Bernese, 1 Boxer, 1 Czechoslovakian Wolfdog, 1 Cavalier King Charles, 1 Chihuahuas 1 Cocker Spaniel, 1 English Bulldog, 1 English Setter, 1 Eurasier, 1 Italian Hound, 1 Belgian Malinois, 1 Pitbull, 1 Pug, 1 Schnauzer, 1 Shiba Inu) and 33 mixed-breed dogs. The sample consisted of 50 females and 40 males, 5.5 ± 3.0-year-old. The initial sample consisted of 99 dogs, but nine were excluded because they did not explore the both side of the room within the initial two minutes after the test started. Dogs were randomly assigned to one of six types of sound stimuli, ensuring an equal distribution of 15 dogs per type (see Table S1 for dog demographics by condition). The mean age of subjects did not differ among dogs exposed to different conditions (Kruskal-Wallis test: $H = 0.15$, $p = 0.2$) and sex was equally distributed within each group (Chi-square test: BN, RM, DDS: $\chi^2 = 0.6$, $p = 0.6$; AV, GV, CM: $\chi^2 = 0.07$, $p = 0.8$). For the subsample of dogs tested with classical music, information about the owner's genre preference and frequency of the dog's exposure to classical music was collected. Six dogs resulted regularly exposed, as their owners listened to classical music in the presence of their dog at least once a week, and nine were not.

2.1.1. Experimental setting

The experiments were carried out in a room (5.8 m x 4.7 m) virtually partitioned into two sections, one designated as the "sound" zone (SZ) and the other as "quiet" zone (QZ) (Figs. 1 and 2). Sounds were played when the dogs were in the SZ and paused when they entered in the QZ. The room was set up to reduce sound reflection and attenuate outside noise. To this aim, walls were covered with heavy curtains, and sound absorbing panels (model B, Zstyle, Corno di Rosazzo, Italy) were placed on the windows. The room was divided into two areas with the same surface size using a line drawn on the floor. Two panels, 150 cm tall, were positioned at one corner of the testing room to create an entrance across the diagonal line, to reduce the possibility of biases in dogs' behaviour due to the positioning of the actual entrance door. At the opposite corner, another panel was positioned to hide the sound producing equipment (custom-built speaker, powered by a custom-built amplifier based on a TA2024 amplifier chip). A chair for the owner was placed at 1 m from the speaker area, over the diagonal line and facing the entrance.

Five cameras were used to record all the tests, of which four (WV-CP310, Panasonic, Delhi, India) were used to cover the entire room, and one with pan-tilt-zoom capabilities (WV-CS570) was used to follow the

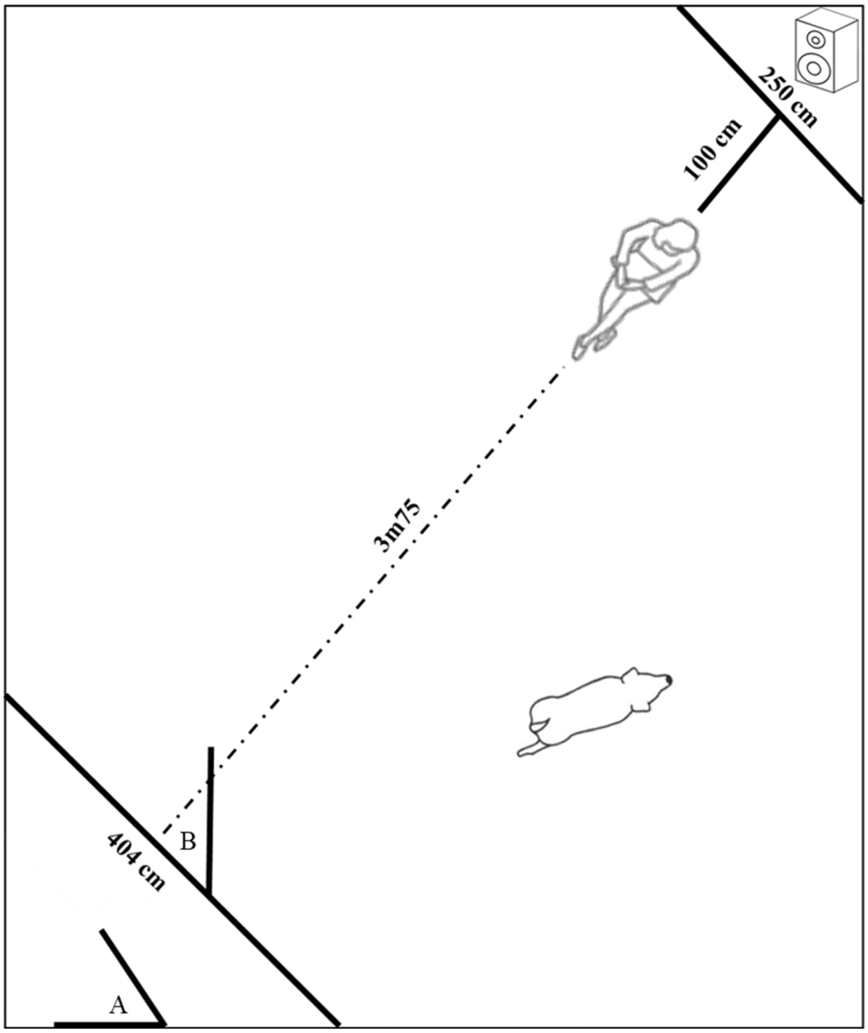


Fig. 1. Scheme of the experimental setup. Black thin lines represent the room. The thicker black lines indicate 150 cm tall panels and a dashed line illustrates the virtual separation of the two zones. "A" and "B" represent the entrance of the room and the entrance of the test area, respectively.

dogs throughout the test to obtain details of their movements and postures. The video recordings as well as the sound production were controlled from an adjacent room using two MacBook Pro laptops (Apple Computers Inc., Cupertino, CA, USA).

2.1.2. *Acoustic stimuli*

Six different types of sounds, henceforward referred to as conditions, were used: "Background Noise" (BN), "Angry Vocalizations" (AV), "Greeting Vocalizations" (GV), "Classical Music" (CM), "Relaxing Music" (RM) and "Dog-Directed Speech" (DDS). AV and BN were the only type of sounds for each of which we anticipated a distinct behavioural response. Specifically, we expected BN to act as a neutral stimulus, not eliciting behaviours related to any emotional state (i.e., no behavioural changes between being in the SZ or QZ) or preference (i.e., dogs spending equal time in both zones), and it was used as a neutral term to compare reactions upon exposure to other sound types. In contrast, AV was expected to elicit a negative emotional reaction with a clear avoidance behaviour (i.e., choosing the QZ). Besides providing a comparative term, verification of the assumptions linked to BN and AV would also provide support to the validity of the procedure, ensuring that dogs perceived the presumed neutral sound as neutral and understood how to avoid a clearly negative stimulus.

The effects of exposure to the other sound types were less predictable, although in general they were all assumed to possibly elicit positive emotional state, with variable levels of arousal, and were chosen to be representative of a variety of sounds to which dogs might be normally exposed to.

For each condition, except DDS, three different 10-minute audio tracks were created. Only one of such tracks was used for dogs exposed to any given condition; the tracks were allocated in a random fashion, balanced within condition (i.e., 5 dogs per track). For DDS, only one track was created, as it already included a variety of different sounds, and all dogs allocated to the DDS condition were exposed to this same track. The characteristics of the tracks within each sound type were similar (Table S2). Tracks for the six conditions were generated as follows:

BN: audio recordings were performed on the patio of a coffee bar. Recording lasted about 30 minutes, from which parts were selected by excluding sudden and loud sounds (e.g., car horns), to obtain a 10-minute track, which included sound of chatting people, bird chirping, distant traffic and other less defined, low intensity noise. Recordings performed in different days were used to create the three tracks.

AV: video and audio recordings of aggressive dogs were captured in a dog shelter. From such recordings, parts of audio were extracted, when both there was minimal background noise and the dog expressed clear aggressive behaviours directed towards a person, such as low and tense body posture and/or showing teeth. The selected parts of the recording were used to compose a 30 s clip, which was looped to create a 10-minute track. The three tracks were created starting from recordings of three different dogs.

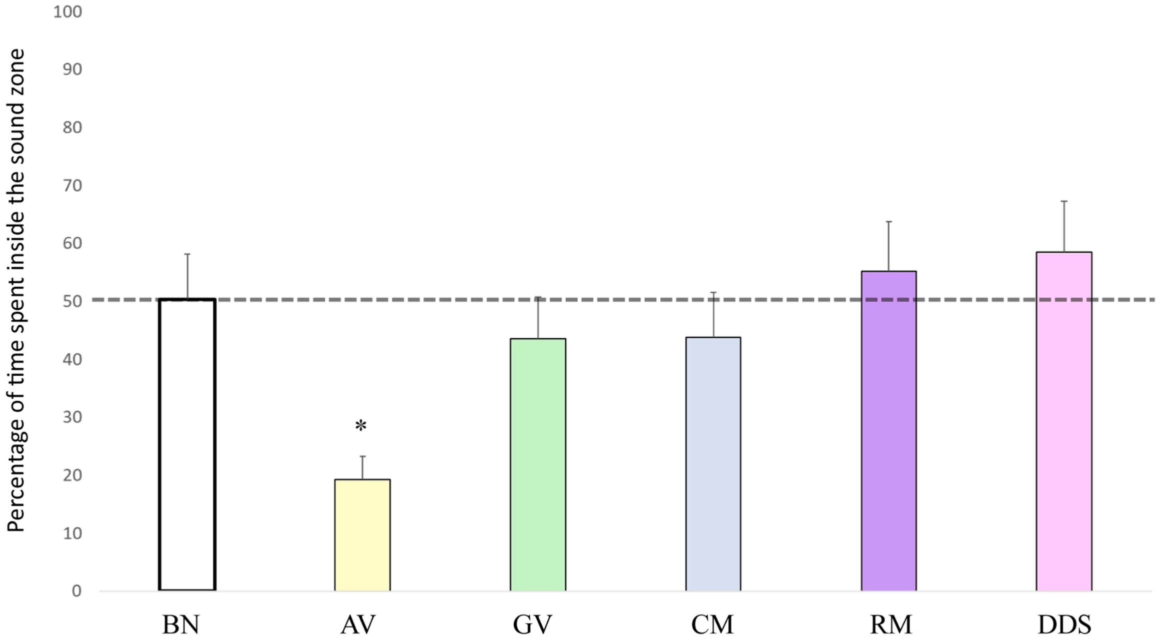


Fig. 2. Mean ± SE percentage of time spent by dogs in the SZ for each sound types. Grey dashed line represents 50 % level. Asterisk indicate a significant difference between a condition and the theoretical median of 50 % ($p < 0.001$, one-sample Wilcoxon signed-rank test).

GV: video and audio recordings of dogs reunited with their owners after a brief period of separation were performed. Parts of the audio were selected in which the dogs expressed clear motivation to reunite with the owner, i.e., running towards the owner and/or jumping on the owner and/or wagging their tail fast, while excluding parts in which the owner was talking. The selected parts of the recording were used to compose a 30 s clip, which was looped to create a 10-minute audio track. The three tracks were created starting from recordings of three different dogs.

CM: tracks were created by concatenating classical music pieces, selected amongst those rated as “Happiest” by children and adult humans (Flom et al., 2008; Siu and Cheung, 2017). One track consisted of about 3 minutes of the 4th movement of the 9th Symphony by Beethoven followed by about 7 minutes of the 1st movement of Concerto N°3 from Bach. One consisted of about 6 min of the Carnaval des animaux, by Saint-Saëns and about 4 min of Cakewalk by Debussy. The last track consisted of 10 min of Tombeau de Couperin by Ravel.

RM: A search of YouTube was performed to find audio tracks characterised by harmonic sounds, with frequency range centred at 432 Hz, known to have calming effect in humans (Calamassi and Pomponi, 2019) and natural sounds, such as water gurgling and bird chirping, known to have restorative efficacy (Ratcliffe, 2021). 10-minute excerpts were taken from three different tracks (youtu.be/ ZHWUdzggTiw; youtu.be/ 5PfAhZ0H9N0; youtu.be/ T4yVunChu-I).

DDS: female students were recorded while engaging in interactions with a human friendly dog, an approach that was proven able to produce naturalistic speech, eliciting appropriate reactions from dogs (Benjamin and Slocombe, 2018). Only people who had experience of living with or being around dogs were chosen. They were instructed to use a nurturing tone, akin to how they would greet their own dog and trying to capture the attention of the dog as much as possible. Segments of speech were selected from 17 women with clear intelligibility, whereby only segments with understandable speech were selected, potentially including sounds such as “Hey” or “Oh”. Segments containing commands like “Vieni qua” (“Come here”) or “Stai qui” (“Stay here”) were discarded, as well as any segments in which anything other than the women’s speech was present (i.e., dog’s vocalization, experimenter’s voice).

Dogs’ and human vocalizations were recorded with a camera (Canon, XA20, Tokyo, Japan) coupled with a wireless microphone (RØDE, Wireless Go, Sydney, Australia). The recorded material was digitalized with a 24-bit quantization and a 44.1 kHz sampling rate using Audacity ® software. The intensity played (see Table S2 for more details regarding the intensity sent for each sound) in the room was checked at 1-meter distance, using a sonometer (2250-S, Brüel and Kjaer, equipped with microphone Model Brüel and Kjaer 4144, Naerum, Denmark). The speaker was linked to an amplifier connected to a MacBook Pro laptop (Apple Computers Inc., Cupertino, CA, USA), which was used to start/end the sound.

2.1.3. *Experimental procedure*

Before the beginning of the procedure the dog was leashed and the owner was asked to sit on the chair, placing the dog along the middle line, between their legs if feasible. The experimenter gave instructions to the owner, closed the entrance to the test area and left the room, at which the owner unleashed the dog. This marked the start of the experiment and from this moment, the sound was played if the dog was in the SZ and stopped when the dog was in the QZ. The dog was considered in the SZ if at least one ear was in it, otherwise, it was considered in the QZ. The side of SZ was randomly allocated and counterbalanced within each condition. During the test dogs were allowed to explore the entire room and were not constrained in any way; however, dogs who did not explore both sides of the room within the initial two minutes were excluded from the experiment. The test lasted 10 minutes, from the moment the dog was unleashed. Owners were instructed to remain seated on the chair, read a magazine and not interfere with the behaviour of the dog. If the dog put the paw or jumped on the owner, the latter was allowed to pet the dog for about 5 s and then kindly push the dog away. If the dog returned, the same pattern was followed.

2.1.4. *Data collection and analysis*

Behavioural data were collected from video recordings using Observer XT software (version 12.5, Noldus, Groeningen, The Netherlands) with a continuous sampling technique on soundless videos, so that the observer was blind to the side where the sound was produced. Collected behaviours are listed in Table 1; briefly, they included data about dogs’ position in the room, motor activity, head’s orientation, ears and tail position and tail movement. Ear position could not be collected

Table 1
Category and description of behaviours recorded during the procedure. All variables were computed as states except stress behaviours, barking and growling. Behaviours belonging to the same category were mutually exclusive.

Category	Behaviour	Definition
Spatial location	Sound zone	At least one ear is inside the sound zone
	Quiet zone	Both ears are inside the quiet zone
Head Orientation	Oriented towards owner	The head is oriented towards the owner
	Oriented towards sound	The head is oriented towards the speaker location
	Oriented towards door	The head is oriented towards the exit door
Motor activity	Standing	Immobile standing posture
	Down	Immobile sitting or laying down posture
	Moving	Walking or running
Relevant behaviours	Soliciting owner	Actively touching with paw or muzzle the owner and/or emits vocalizations while clearly oriented towards the owner
	Proximity with the owner	Passively staying close (less than one arm distance) to any part of the body of the owner
	Try to open room entrance	Scratching and/or jumping and/or vocalizing towards the room entrance
	Try to reach sound	Scratching and/or jumping and/or vocalizing towards the speaker location
Stress behaviours	Scratching (event)	Scratching part of the body
	Lip licking (event)	Passing the tongue over the muzzle
	Shaking (event)	Vigorously shaking the entire body
	Yawning (event)	Opening the mouth and inhaling/exhaling air
Vocalization	Barking (event)	Vocalization of very short duration and low frequency.
	Whining	Cyclic vocalization, mouth closed
	Growling (event)	Throaty, rumbling vocalization
Tail position*	Tail up	The base of the tail is held above the horizontal line of the back
	Tail aligned	The base of the tail is aligned with the horizontal line of the back, the end of the tail facing the ceiling, aligned with the base of the tail or facing the floor
	Tail down	The base of the tail is under the horizontal line of the back, the end of the tail facing the ceiling or facing the floor
	Tail in between legs	The base of the tail is under the horizontal line of the back, the end of the tail in between legs
Tail movement	Tail moving	The tail is in movement
	Tail immobile	The tail is not moving
Ears position	Forward	Both ears are erected and held forward
	Backward	Both ears are directed backward, retracted into the neck

* If the dog was laying down or sitting, none of the described behaviours were coded.

for two dogs and tail position and movement for two dogs, for the dog's morphology impeded a reliable collection of these data. We also collected expression of stress behaviours, vocalizations and relevant behaviours expressed towards the owner, the speaker location and the room entrance. The collected data was used to compute the percentage of time the dogs expressed each behaviour relative to the time spend within SZ or QZ; for events (i.e., stress behaviours and vocalizations except whining), the frequency of occurrence per minute spent within either SZ or QZ was computed. Finally, frequency of changes in ear position was also calculated.

Data were collected by a second independent observer on 25 videos (25.7 % of the sample) to assess inter-observer reliability in the collection of the general behaviours (Intraclass Correlation coefficient from 0.73 to 0.99), the tail movement and position (Intraclass Correlation coefficient from 0.82 to 0.99), the ears movement and position (Intraclass Correlation coefficient from 0.85 to 0.88) and the time spent within each zone (Intraclass Correlation coefficient = 0.95).

An initial set of analysis was used to verify that BN was a neutral sound. A one-sample Wilcoxon signed-rank test was performed to assess whether the percentage of time spent in the SZ was different from a theoretical median of 50 %. Then Generalized Estimating Equations (GEEs) were run to determine if there were differences in behaviours expressed by dogs when in SZ or in QZ, in the BN condition. The dependent variables for the models were the relative duration or frequency of expression of the different behavioural variables when the dog was in either zone of the room. Due to their rare expression, all stress related behaviours were summed up and analysed as a single behavioural variable. Models assumed a logarithmic link function and a Tweedie distribution (power parameter of 1.5). The zone the dog was in (QZ or SZ) was included as a fixed factor. The dog name was included as a random factor to account for repeated measurement in the same animal.

Once assessed that BN was in fact neutral, one-sample Wilcoxon signed-rank test was performed to assess whether the percentage of time spent in the SZ was different from a theoretical median of 50 % for the other sound category. Then, Generalized Linear Models (GLMs) were run to compare both the dog's preference for staying in the SZ/QZ and the expression of behaviours between other conditions and BN. The dependent variable for the models were the relative duration of time in which the dog stayed in the SZ and the relative duration of expression of the different behavioural variables. Models assumed a logarithmic link function and a Tweedie distribution (power parameter of 1.5). The sound category was included as a fixed factor. When a significant effect was found, post-hoc comparisons were performed with sequential Bonferroni-correction applied to assess whether there was any difference in behaviours expressed by dogs exposed to BN vs any other sound condition. Separate analyses were run for data obtained when the dogs were in the SZ and when they were in the QZ.

Statistical analysis was performed with SPSS (SPSS ver. 26, IBM, Armonk, NY, USA). All results are presented as mean values ± SE, unless otherwise stated.

2.1.5. *Ethical approval*

Ethical review and approval were waived for this study, due to the absence of any procedure involving pain or distress to the animals, and in accordance with relevant legislation for research involving animal research (Decreto legislativo 4 marzo 2014, n. 26 "Attuazione della Direttiva n. 2010/63/UE sulla protezione degli animali utilizzati a fini scientifici")

3. Results

3.1. *Background noise condition*

Results from the one-sample Wilcoxon signed-rank test revealed no significant difference between the percentage of time spent within the SZ (median = 61.8 %, mean ± SE = 50.3 ± 8.6 %, min = 2,8 %, max = 100 %) and the theoretical median of 50 % ($Z = 62.0$, $p = 0.9$). The GEEs resulted in no significant difference for any behaviours between SZ and QZ within BN condition (Table S3). Considering these results, BN was considered as neutral.

3.2. *Preference of all sounds' categories*

Results from the one-sample Wilcoxon signed-rank test revealed a significant difference between the percentage of time spent with the SZ and the theoretical median of 50 % in the AV condition ($Z = 1.0$, $p < 0.001$) but not in any of the other conditions (BN: $Z = 62.0$, $p = 0.9$; GV: $Z = 48.0$, $p = 0.5$; CM: $Z = 55.5$, $p = 0.8$; RM: 73.0, $p = 0.5$; DDS: $Z = 76$, $p = 0.4$)

3.2.1. *Behaviours inside the sound zone*

Table S4 reports results of the GLM assessing differences in preference for the SZ/QZ and expression of behaviours between the different conditions when in SZ, and Table 2 summarized the GLM with significant effect of the sound category. Mean ± SE of relative time or frequency of expression of behaviours where significant differences were found between conditions are reported in Fig. 3.

When exposed to AV dogs were oriented towards sound for longer time than when exposed to BN. Ears were kept forward for longer and changed position more often in AV than BN. Finally, dogs solicited more the owner when exposed to AV than BN.

When exposed to GV dogs were oriented towards the sound source for longer than when exposed to BN. Ears were kept forward and changed position more often in GV than BN. The tail moved for longer time in GV.

When exposed to CM dogs were oriented towards the sound source for shorter time than BN. Ears changed position less often when exposed to CM than BN.

When exposed to RM dogs were oriented towards the sound source for shorter time than BN. They were also oriented towards the entrance door for shorter time in RM than BN. Ears changed position less often in RM than BN.

When exposed to DDS dogs were oriented towards the sound source for longer than when exposed to BN. Ears were kept forward for longer in DDS then BN.

Significant effects of condition were also found for being in movement, being in proximity/contact with the owner, whining, expressing stress related behaviours or having ears in backward position. However, post-hoc comparisons did not reveal any significant differences between BN and other condition.

3.2.2. *Behaviours inside the quiet zone*

Table S5 reports results of the GLM assessing differences in preference for the SZ/QZ and in the expression of behaviours between the different conditions when in QZ. Table 2 summarizes the GLM with significant effect of the sound category. Mean ± SE of relative time or frequency of expression of behaviours where significant differences were found between conditions are reported in Fig. 4.

In the AV condition, dogs were oriented towards their owner when in QZ for a longer time than in the BN condition. In the CM condition, dogs spent less time in movement when in QZ than in the BN condition.

Significant effects of condition were also found for being in proximity/contact with the owner, soliciting the owner, ears held backward and the frequency of ears position changes; however, post-hoc comparisons did not reveal any significant differences between BN and other conditions for these variables.

Descriptive results (Mean ± SE) from all behaviours are available in supplementary material (Table S6 and Table S7).

4. Experiment 2

In the second experiment, we aimed to investigate how familiarity with classical music influenced dogs' preferences and behavioural responses towards this specific genre.

Table 2

Results of the generalized linear model reporting behaviours for which significant effect of the sound category where found, when the dog was in the in the sound or quiet zone.

Zone	Behaviours	χ^2	p
Sound Zone	Oriented towards sound	80.62	< 0.001
	Oriented towards door	11.86	0.037
	Soliciting owner	23.02	< 0.001
	Tail moving	17.27	0.004
	Ears forward	71.56	< 0.001
Quiet Zone	Oriented towards owner	15.47	0.009
	Movement	12.18	0.032

4.1. *Material and methods*

4.1.1. *Subjects*

The sample of the second experiment consisted of 20 dogs, including 10 dogs with regular exposure to classical music (E) and 10 dogs without (NE). Dogs were considered as regularly exposed when their owners listened to classical music in the presence of their dog at least once a week, with an average ± SD frequency of 2.6 ± 0.7 times per week for E dogs. Twelve dogs were purebred (2 German Shepherds, 2 Lessinia and Lagorai Shepherds, 1 American Staffordshire Terriers, 1 Bernese, 1 Chihuahua, 1 Golden Retriever, 1 Husky, 1 Schnauzer, 1 Weimaraner, 1 Pug) and eight mixed-breed dogs. The E dogs group had an average age of 8.0 ± 4.4 years, with 50 % being female, while the NE dogs group had an average age of 5.1 ± 2.7 years, with 70 % being female. Age did not differ among groups (Mann-Whitney U test: $U = 29.5$, $p = 0.2$) and gender was homogenous within each group (Chi-square test: E: $\chi^2 = 0.4$, $p = 0.5$; NE: $\chi^2 = 3.6$, $p = 0.1$).

4.1.2. *Experiment settings, acoustic stimuli and Experimental procedure*

The same experimental settings and procedure as Experiment 1 was used in this second experiment. The acoustic stimuli used were the background noise and CM compositions used in the Experiment 1, please refer to *2.1.3* for details of sounds for this category.

4.1.3. *Data collection and analysis*

The collection of the behavioural data and computation of percentage of time/frequency dogs expressed each behaviour relative to their time spent within SZ or QZ were analogous as Experiment 1. First, one-sample Wilcoxon signed-rank tests were performed to assess whether the percentage of time spent in the SZ was different from a theoretical median of 50 % for E and NE dogs. To investigate whether there was any difference in preference for staying in the SZ/QZ and in behavioural expression between dogs regularly exposed to CM (E; $N = 10$) and those non-exposed (NE; $N = 10$) GLM models were run. The models included the relative amount of time spent in SZ/QZ and the relative amount of time dogs expressed different behaviours as dependent variables. Models assumed a logarithmic link function and a Tweedie distribution (power parameter of 1.5). Exposure to CM (E or NE) was included as a fixed factor. Separate analyses were run for behavioural data obtained when the dogs were in the SZ and when they were in the QZ. Whenever a difference was observed, GLM models were run between the behaviour statistically different expressed in the Neutral condition from the first experiment and both groups of dogs (E or NE, analyzed separately). Models assumed a logarithmic link function and a Tweedie distribution (power parameter of 1.5). The different condition (Neutral, CM E/NE Dogs) was included as fixed factor.

Statistical analysis was performed with SPSS (SPSS ver. 26, IBM, Armonk, NY, USA). All results are presented as mean values ± SE, unless otherwise stated.

4.1.4. *Ethical approval*

The study was conducted in accordance with relevant legislation for research involving animals, and according to the type of procedure used, no formal ethical approval was required.

4.2. *Results*

4.2.1. *Preference*

The GLM revealed a statistically significant effect of exposure to classical music on the percentage time spent in the SZ ($\chi^2 = 6.278$, $df = 1$, $p = 0.012$), with higher preference for the SZ by E (61.0 ± 8.8 %) compared to NE (35.1 ± 5.8 %, $p = 0.014$). The GLMs were not significant when comparing E or NE dogs to the dogs in the Neutral condition of the first experiment (E dogs: $\chi^2 = 1.084$, $p = 0.298$; NE dogs: $\chi^2 = 2.231$, $p = 0.135$). Results from the one-sample Wilcoxon signed-rank test revealed no significant difference between the percentage of time

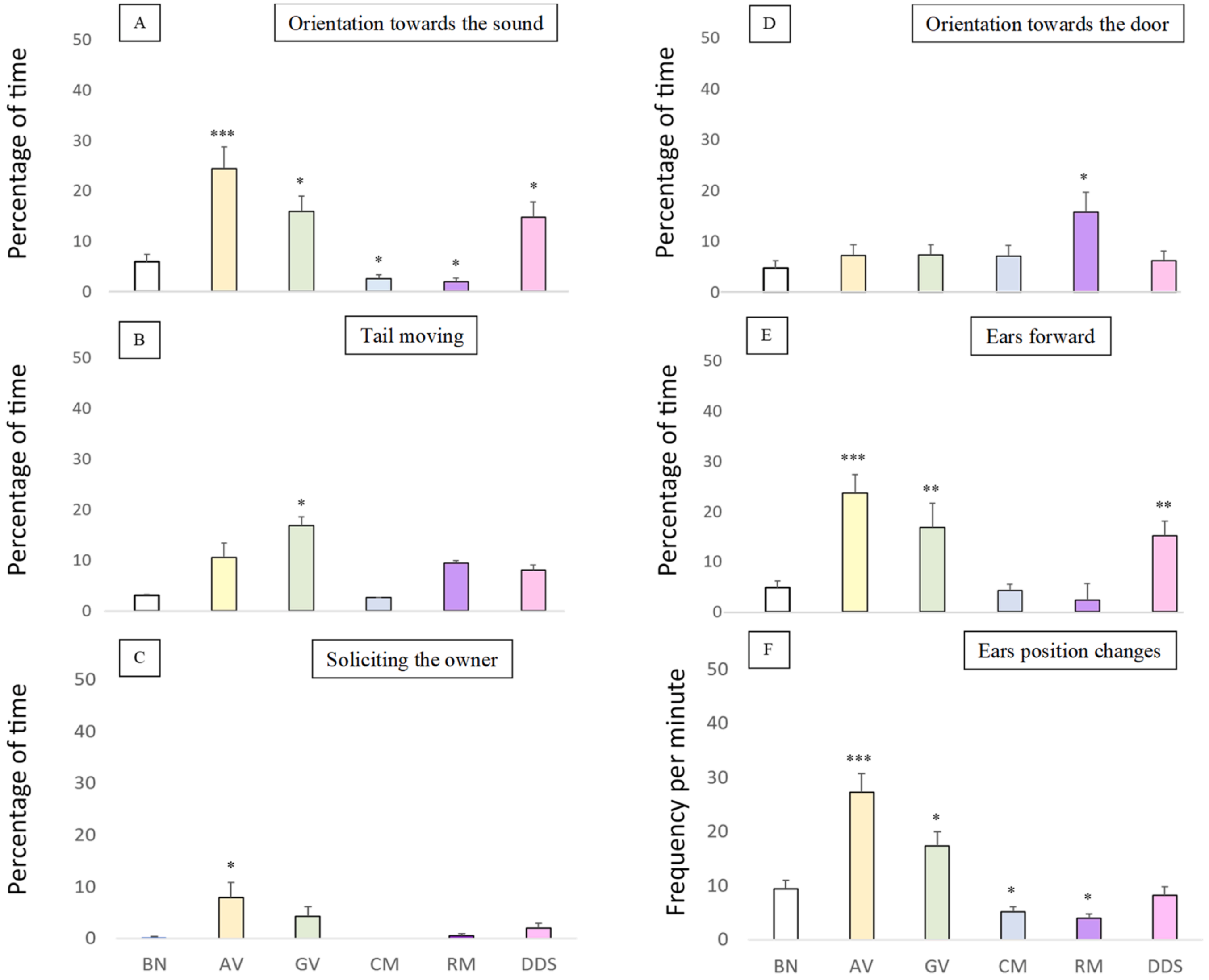


Fig. 3. Mean ± SE percentage of time oriented towards the sound (A), tail moving (B), soliciting the owner (C), oriented towards the entrance door (D), ears forward (E) and mean ± SE of the frequency per minute of ear position changes (F) within the SZ. Significant differences between BN and other types of sound are flagged by asterisks (*p < 0.05, **p < 0.01, ***p < 0.001, Bonferroni corrected post-hoc simple contrasts between BN and the other conditions, after generalized linear model).

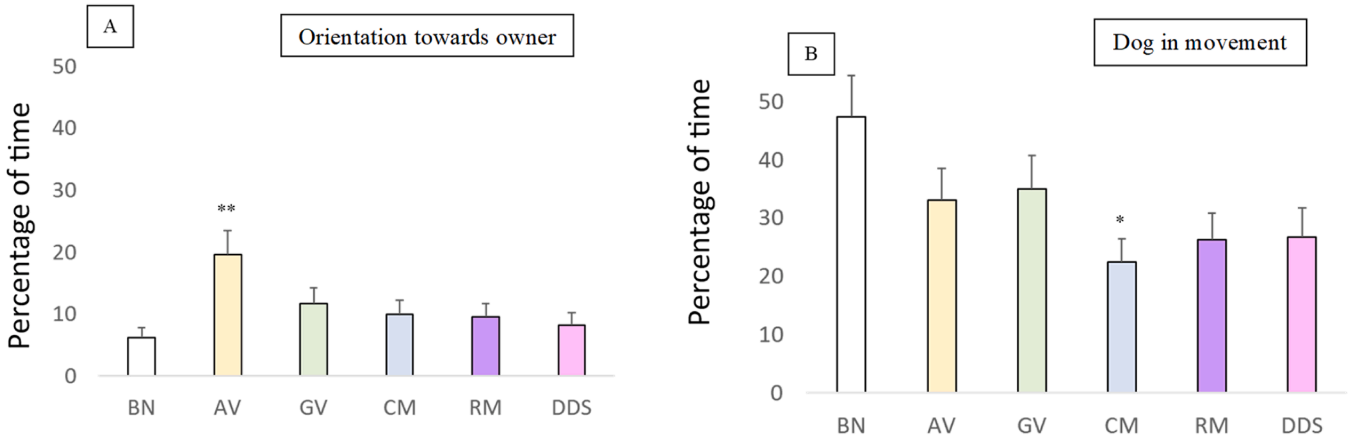


Fig. 4. Mean ± SE of percentage of time oriented towards the owner (A), in movement (B) inside the QZ within all sound types. Significant differences between “BN” and other types of sound are flagged by asterisks (*p < 0.05, **p < 0.01, post hoc comparison between “Neutral” and the other types after generalized linear model).

spent with the SZ and the theoretical median of 50 % in the both conditions (E: Z = 43, p = 0.1; NE: Z = 11, p = 0.1).

4.2.2. Behaviours inside the sound zone

summarizes the GLM parameters for behaviours expressed while in the SZ, for which a significant effect of familiarity was found. The complete results of the GLM assessing differences between E and NE when in SZ are available in the supplementary material (Table S8). Mean ± SE of relative time/frequency of expression of behaviours with significant differences between groups are reported in Fig. 5(a-c).

When exposed to CM, E dogs spent less time standing and more time laying down and/or sitting still than NE dogs. The tail was held down for longer time in NE than in E dogs. None of the GLM analyses run to observe any difference between E or NE and Neutral condition dogs regarding the aforementioned behaviours revealed any significant results (Table S9).

Table 3
Results of the generalized linear model analysis with significant effect of the Exposed/Non-Exposed variable.

Experiment / Zone	Behaviours	χ^2	p
Sound Zone	Standing	4.95	0.026
	Laying down or sitting down	7.18	0.007
	Tail down	4.55	0.033
Quiet Zone	Oriented towards door	5.43	0.020
	Proximity	5.14	0.023

4.2.3. Behaviours inside the quiet zone

Table 3 summarizes the GLM parameters for behaviours expressed while in the QZ, for which a significant effect of familiarity was found. Mean ± SE of relative time/frequency of expression of behaviours where significant differences were found between groups are reported in Fig. 5 (d, e). In the supplementary materials (Table S8) the complete results of

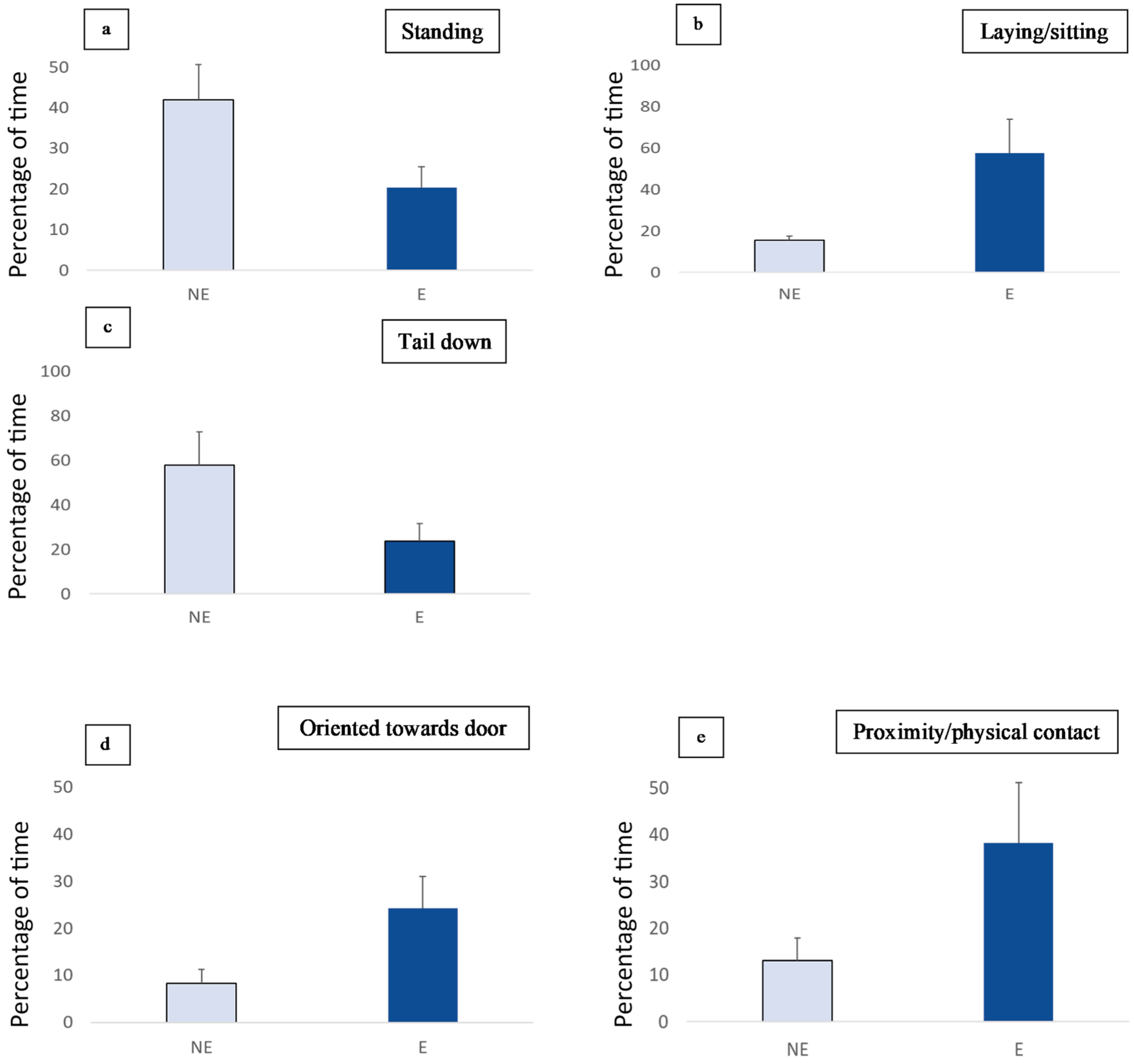


Fig. 5. Mean ± SE percent of time spent in behaviours for which a significant difference was found between dogs exposed (E) and not exposed (NE) to CM at home, when in the sound zone (a, b, c) or in the quiet zone (d, e). $P < 0.05$, generalized linear model.

the GLM on behaviours expressed by E and NE when in QZ are available. Experienced dogs spent more time oriented towards the door and in proximity/physical contact with the owner than NE dogs.

Descriptive results (Mean ± SE) from all behaviours are available in supplementary material (Table S10).

5. Discussion

The first aim of this study was to determine if dogs show a preference for and an emotional reaction to sounds potentially eliciting different emotional states. Only one of the sounds to which dogs were exposed determined both a clear choice and behavioural reactions: when exposed to a conspecific agonistic vocalization dogs chose to stay longer in the quiet area and showed owner-oriented behaviours. Regardless of preference, both conspecifics and human vocalizations were more effective in attracting dogs' attention than background noise, while the opposite was true for music.

Being the first implementation of a procedure to assess dogs' preference for acoustic stimuli, some of our results are relevant as an intrinsic validation of the procedure. Dogs exposed to a background noise, recorded in an urban environment, stayed in the sound or quiet zone for approximately the same amount of time, without difference in behavioural expression, confirming that not only the sound did not elicit any preference, but that it also did not draw any particular interest or produce any emotional reaction. It therefore seems appropriate to use this condition as a comparative term to evaluate the effect of other sounds. In agreement with previous findings (Faragó et al., 2010; Pongrácz et al., 2014), dogs clearly avoided agonistic conspecific vocalizations, by staying in the quiet zone for about 80 % of time, on average. In addition, dogs exposed to agonistic vocalizations expressed an increased orientation towards the sound source, ears kept for longer in a forward position, both clear signs of interest in the sound and consistent with the ability of aversive vocalizations to draw attention (Déaux et al., 2015). Dogs also showed more frequent changes in ear position, which is also related to auditory attention, as discussed in other mammals (Wathan and McComb, 2014; Reefmann et al., 2009). In the context of our experiment, acquiring more detailed information about the sound might have been particularly relevant, since vocalizations were the only cue about the presence, location and intentions of another dog. Emotional arousal would be another potential explanation for the frequent changes in ear position movements; however, ear movements are associated with positively valanced emotions in dogs (Bremhorst et al., 2019), and the clear avoidance of the sound suggests against this explanation. Moreover, while dogs showed no signs of fear (e.g., ears backward or tail down), exposure to the aggressive vocalizations condition significantly increased solicitation of the owner. While merely seeking proximity with the owner can be related to both affiliation and stress alleviation (Somppi et al., 2022), to actively seek human interaction might be more closely linked to distress. Interestingly, this condition was also the only one in which the dog oriented more towards the owner while in the quiet zone, potentially indicating a lasting emotional effect.

Conspecific vocalizations recorded in a positive context (i.e., reunion with their owner) induced longer orientation towards the sound source and forward position of the ears and more frequent changes in ear position than background noise. These responses were similar to what observed in dogs exposed to agonistic vocalizations, further supporting that, rather than being indication of an emotional reaction, they reflect both interest and the necessity to extract information about the sound. The only other behaviour that characterized exposure to the positive vocalizations was an increment in tail wagging. In the lack of a specific tail position, which characterizes emotional states (Siniscalchi et al., 2018), and of any fear- or stress related behaviour, the result seems to suggest that these vocalizations increased tail wagging as a generic increase in arousal.

Dog-directed speech only triggered attention-related behaviours, such as increased orientation towards the sound and ears in forward position. Interest towards this type of sound was expected, as it is known that dogs are sensitive to it (Benjamin and Slocombe, 2018). Exposure to this vocalization did not induce owner's directed behaviour, which might have been expected. However, dogs can clearly discriminate their owner's voice from that of other people (Gábor et al., 2019), besides the fact that, in our procedure, the vocalizations did not come from the owner's location, nor were they matching the owner's behaviour. More surprising was to observe no behaviour which could indicate an emotional response such as tail wagging, as previously observed in a training context (Fonseca et al., 2023). On the other hands, Benjamin and Slocombe (2018) argued that this type of vocalization might not be so relevant – at least for adult dogs – when the human speaker is not present. Moreover, a recent fMRI study showed activation of specific secondary auditory cortex regions after exposure to dog-directed speech, which are consistent with these stimuli's communicative relevance and attention-grabbing ability rather than their emotional valence (Gergely et al., 2023). Overall, it seems sensible to conclude that dog-directed speech *per se* elicits interest, but as such has no ability to induce an emotional response or preference in adult dogs.

Neither classical nor relaxing music elicited a preference by dogs. This seems relevant, especially because exposure to these types of music has been proposed as a form of enrichment in kennelled dogs (Wells et al., 2002; Kogan et al., 2012; Bowman et al., 2015). None of such studies, however, gave dogs the possibility to actively choose between music or silence, and in this sense, it is compelling that neither classical nor relaxing music produced any clear generalizable preference in dogs. On top of this, exposure to neither classical nor relaxing music induced any behavioural response indicative of an emotional reaction or interest. In fact, if anything, dogs paid less attention to the source of sound in both music conditions, compared to the neutral sound. Such lower attention could be due to the lack of potentially relevant component of sound, which, conversely, were present in the neutral sound (e.g. human chatting). A seemingly odd finding was that dogs were oriented for longer towards the door when exposed to the relaxing music. In the lack of a concomitant expression of signs of distress or attempts to reach the door, it is unlikely that such behaviour reflects dogs' motivation to leave the room. More likely, since relaxing music contained some bird chirping and other natural sounds, dogs might have turned to what was a potential origin of those sounds, i.e., the door leading outside.

Although classical music had no clear effects on dogs' emotional state during playback, dogs who had listened to classical music during the experiment, were more likely to rest when in the quiet zone. Results of some earlier studies are consistent with a relaxing effect of classical music (Wells et al., 2002; Kogan et al., 2012), but do not investigate dogs' behavioural changes after exposure. However, there is evidence that some beneficial effects of music are exerted when silence is intermingled with it. This phenomenon has been highlighted in humans (Bernardi et al., 2006), but also in livestock animals (Crouch et al., 2019) with resting and rumination expressed during moments of silence after exposure to music.

A second experiment aimed at determining if familiarity with the acoustical stimuli plays a role in dog's preference or behavioural/emotional responses. Neither dogs who were used to listen to classical music, nor those who were not, showed a difference in time spent in the sound zone compared to the background noise. However, dogs used to classical music stayed in the sound zone for slightly more than 60 % of the time, compared to about 35 % of dogs not used to classical music. Clearly, experience did change the response to classical music of dogs and at least two different explanations could be raised for this phenomenon. On the one hand, it is possible that the mere exposure to a particular sound makes the latter more enjoyable (or tolerable). Exposure to a specific piece of music, or more generally to a genre, is an important factor in its likability in humans (Peretz et al., 1998 and references therein) and the same might be true for dogs. On the other hand, it is possible that dogs associated the playback of classical music with past pleasant situations, in the company of their owner. This second hypothesis would be supported by the differences in behaviours between the two groups of dogs. Indeed, when in the sound zone, dogs used to classical music expressed more relaxed behaviours compared to dogs not used to classical music. Moreover, when in the quiet zone they stood close to their owner, potentially mimicking their interaction with their owner when at home. It was somewhat surprising that dogs used to classical music were oriented towards the door for longer than dogs not used to classical music when in the quiet zone, as the behaviour could indicate dogs' desire to leave the room; however, a more detailed analysis of the videos revealed that this orientation co-correlated with laying at the side of the owner, whose chair was oriented towards the door, suggesting that the behaviour was a mere consequence of seeking proximity to the owner.

6. Conclusion

In conclusion, this study presents a simple and effective method to assess preferences and behavioural responses of dogs to acoustic stimuli. Dogs clearly avoided the aggressive vocalizations, supporting the ability of the procedure to induce a clear choice between being exposed to a sound or not, and to elicit behavioural responses consistent with a relatively long-lasting emotional state. None of the other sounds were chosen over silence, nor were they avoided. However, some of them were associated with changes in behaviour, indicating both interest and, potentially, an emotional response. In this sense, our procedure allows to expand the current knowledge about the various, nuanced ways in which acoustic stimuli affect dogs' emotions and behaviours.

Besides its use in research, the adoption of a procedure of this kind would be of utmost importance in determining the actual likability of music or of other acoustic stimuli by dogs – especially when promoting sounds as sources of enrichment – since current knowledge on the actual preference for specific acoustic stimuli over silence by dogs is lacking. It is possible that the ability to enjoy music is not typical of dogs. In fact, with one remarkable exception using non-western music in chimpanzees (Mingle et al., 2014), studies that offered animals the possibility to actively choose between music and silence, report a preference for the latter, or no preference for any of the two, in species ranging from rodents (Polston and Glick, 2011) to orangutans and gorillas (Snowdon et al., 2021), suggesting that the enjoyability of music might be an inherently human feature (Beccacece et al., 2021). Ecological reasons can likely explain why silence is more valuable than music, primarily the fact that music might mask potentially relevant sounds, e.g., prey, predators, conspecifics. This might be even more important when in a novel environment, such as the laboratory, where our experiment was conducted.

It was quite compelling to observe that none of the stimuli with a presumptive positive valence determined a clear preference for dogs. This does not negate that some these might still exert positive effects on dogs' affective states, but clearly prompts for exploring how these effects are exerted and for how long they endure. This seems especially relevant, considering that some of the stimuli resulted in behavioural changes that only became evident when playback was stopped. Overall, the results of the present study stimulate a deeper investigation on the time-scale of effects of exposure to classical music in dogs, including for instance the role of the context in which the exposure is realized, of the frequency and duration of exposure and of the entity and duration of effects after exposure.

CRediT authorship contribution statement

Paolo Mongillo: Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Anna Broseghini:** Validation, Investigation. **Lieta Marinelli:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Cécile Guérineau:** Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Miina Lõoke:** Validation, Investigation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The present study was supported by the University of Padova (PhD scholarship awarded to C.G. and post-doc grant number BIRD229302/22 awarded to M.L.) and the Italian Ministry of University and Research (PhD scholarship on Green Themes, DM 1061/2021, awarded to A.B.). We are very grateful to all the dog owners for volunteering their time, and a particular acknowledgment to Martina Violo and Nadia Guzzo for their dedication to hours of behavioural coding.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.applanim.2024.106452.

References

Albuquerque, N., Guo, K., Wilkinson, A., Savalli, C., Otta, E., Mills, D., 2016. Dogs recognize dog and human emotions. Biol. Lett. 12, 20150883. https://doi.org/10.1098/rsbl.2015.0883.

Andics, A., Gácsi, M., Faragó, T., Kis, A., Miklósi, Á., 2014. Voice-sensitive regions in the dog and human brain are revealed by comparative fMRI. Curr. Biol. 24, 574–578. https://doi.org/10.1016/j.cub.2014.01.058.

Banse, R., Scherer, K.R., 1996. Acoustic profiles in vocal emotion expression. J. Pers. Soc. Psychol. 70, 614–636. https://doi.org/10.1037/0022-3514.70.3.614.

Beccacece, L., Abondio, P., Cilli, E., Restani, D., Luiselli, D., 2021. Human genomics and the biocultural origin of music. Int. J. Mol. Sci. 22, 5397. https://doi.org/10.3390/ijms22105397.

Benjamin, A., Slocombe, K., 2018. Who's a good boy?!'Dogs prefer naturalistic dog-directed speech. Anim. Cogn. 21, 353–364. https://doi.org/10.1007/s10071-018-1172-4.

Bernardi, L., Porta, C., Sleight, P., 2006. Cardiovascular, cerebrovascular, and respiratory changes induced by different types of music in musicians and non-musicians: the importance of silence. Heart 92, 445–452. https://doi.org/10.1136/hrt.2005.064600.

Bowman, A., Scottish, S.P.C.A., Dowell, F.J., Evans, N.P., 2015. Four Seasons' in an animal rescue centre; classical music reduces environmental stress in kennelled dogs. Physiol. Behav. 143, 70–82. https://doi.org/10.1016/j.physbeh.2015.02.035.

Bowman, A., Scottish, S.P.C.A., Dowell, F.J., Evans, N.P., 2017. The effect of different genres of music on the stress levels of kennelled dogs. Physiol. Behav. 171, 207–215. https://doi.org/10.1016/j.physbeh.2017.01.024.

Brayley, C., Montrose, V.T., 2016. The effects of audiobooks on the behaviour of dogs at a rehoming kennels. Appl. Anim. Behav. Sci. 174, 111–115. https://doi.org/10.1016/j.applanim.2015.11.008.

Bremhorst, A., Sutter, N.A., Würbel, H., Mills, D.S., Riemer, S., 2019. Differences in facial expressions during positive anticipation and frustration in dogs awaiting a reward. Sci. Rep. 9, 19312. https://doi.org/10.1038/s41598-019-55714-6.

Briefer, E.F., 2012. Vocal expression of emotions in mammals: mechanisms of production and evidence. J. Zool. 288, 1–20. https://doi.org/10.1111/j.1469-7998.2012.00920.x.

Calamassi, D., Pomponi, G.P., 2019. Music tuned to 440 Hz versus 432 Hz and the health effects: a double-blind cross-over pilot study. Explore 15, 283–290. https://doi.org/10.1016/j.explore.2019.04.001.

Crouch, K., Evans, B., Montrose, V.T., 2019, April. The effects of auditory enrichment on the behaviour of dairy cows (Bos taurus). In Proc. Br. Soc. Anim. Sci. Annu. Conf. Poster available: ⟨https://pure.hartpury.ac.uk/ws/portalfiles/portal/14213326/Crouch_et_al_BSAS.pdf⟩ (accessed on 26 July 2024).

Déaux, É.C., Clarke, J.A., Charrier, I., 2015. Aggressive bimodal communication in domestic dogs, Canis familiaris. PLoS ONE 10, e0142975. https://doi.org/10.1371/journal.pone.0142975.

Engler, W.J., Bain, M., 2017. Effect of different types of classical music played at a veterinary hospital on dog behavior and owner satisfaction. J. Am. Vet. Med. Assoc. 251, 195–200. https://doi.org/10.2460/javma.251.2.195.

Faragó, T., Andics, A., Devecseri, V., Kis, A., Gácsi, M., Miklósi, Á., 2014. Humans rely on the same rules to assess emotional valence and intensity in conspecific and dog vocalizations. Biol. Lett. 10, 20130926. https://doi.org/10.1098/rsbl.2013.0926.

Faragó, T., Pongrácz, P., Range, F., Virányi, Z., Miklósi, Á., 2010. The bone is mine': affective and referential aspects of dog growls. Anim. Behav. 79, 917–925. https://doi.org/10.1016/j.anbehav.2010.01.005.

Fichtel, C., Hammerschmidt, K., 2003. Responses of squirrel monkeys to their experimentally modified mobbing calls. J. Acoust. Soc. Am. 113, 2927–2932. https://doi.org/10.1121/1.1548158.

Filippi, P., Congdon, J.V., Hoang, J., Bowling, D.L., Reber, S.A., Pašukonis, A., Hoeschele, M., Ocklenburg, S., de Boer, B., Sturdy, C.B., Newen, A., Güntürkün, O., 2017. Humans recognize emotional arousal in vocalizations across all classes of terrestrial vertebrates: Evidence for acoustic universals. Proc. R. Soc. B: Biol. Sci. 284, 20170990. https://doi.org/10.1098/rspb.2017.0990.

Flom, R., Gentile, D.A., Pick, A.D., 2008. Infants' discrimination of happy and sad music. Infant Behav. Dev. 31, 716–728. https://doi.org/10.1016/j.infbeh.2008.04.004.

Fonseca, M.G.B., Hilário, H.O., Kotrschal, K., Range, F., Virányi, Z., Duarte, M.H.L., Pereira, L.C.G., Vasconcellos, A.D.S., 2023. The power of discourse: associations between trainers' speech and the responses of socialized wolves and dogs to training. Animals 13, 1071. https://doi.org/10.3390/ani13061071.

Gábor, A., Kaszás, N., Miklósi, Á., Faragó, T., Andics, A., 2019. Interspecific voice discrimination in dogs. Biol. Futur. 70, 121–127. https://doi.org/10.1556/019.70.2019.15.

Georgiou, S.G., Sideri, A.I., Anagnostou, T.L., Goulestou, P.G., Tsioli, V.G., Galatos, A.D., 2023. Effect of classical music on depth of sedation and induction propofol requirements in dogs. Vet. Sci. 10, 433. https://doi.org/10.3390/vetsci10070433.

Gerdes, A.B., Wieser, M.J., Alpers, G.W., 2014. Emotional pictures and sounds: a review of multimodal interactions of emotion cues in multiple domains. Front. Psychol. 5, 1351. https://doi.org/10.3389/fpsyg.2014.01351.

Gergely, A., Gábor, A., Gácsi, M., Kis, A., Czeibert, K., Topál, J., Andics, A., 2023. Dog brains are sensitive to infant-and dog-directed prosody. Commun. Biol. 6, 859. https://doi.org/10.1038/s42003-023-05217-y.

Huber, A., Barber, A.L., Faragó, T., Müller, C.A., Huber, L., 2017. Investigating emotional contagion in dogs (*Canis familiaris*) to emotional sounds of humans and conspecifics. Anim. Cogn. 20, 703–715. https://doi.org/10.1007/s10071-017-1092-8.

King, T., Flint, H.E., Hunt, A.B., Werzowa, W.T., Logan, D.W., 2022. Effect of music on stress parameters in dogs during a mock veterinary visit. Animals 12, 187. https://doi.org/10.3390/ani12020187.

King, L.E., Soltis, J., Douglas-Hamilton, I., Savage, A., Vollrath, F., 2010. Bee threat elicits alarm call in African elephants. PLoS ONE 5, e10346. https://doi.org/10.1371/journal.pone.0010346.

Kogan, L.R., Schoenfeld-Tacher, R., Simon, A.A., 2012. Behavioral effects of auditory stimulation on kenneled dogs. J. Vet. Behav. 7, 268–275. https://doi.org/10.1016/j.jveb.2011.11.002.

Köster, L.S., Sithole, F., Gilbert, G.E., Artemiou, E., 2019. The potential beneficial effect of classical music on heart rate variability in dogs used in veterinary training. J. Vet. Behav. 30, 103–109. https://doi.org/10.1016/j.jveb.2018.12.011.

Leary, C.J., 2014. Close-range vocal signals elicit a stress response in male green treefrogs: resolution of an androgen-based conflict. Anim. Behav. 96, 39–48. https://doi.org/10.1016/j.anbehav.2014.07.018.

Leavesley, A.J., Magrath, R.D., 2005. Communicating about danger: urgency alarm calling in a bird. Anim. Behav. 70, 365–373. https://doi.org/10.1016/j.anbehav.2004.10.017.

Ma, W., Thompson, W.F., 2015. Human emotions track changes in the acoustic environment. Proc. Natl. Acad. Sci. 112, 14563–14568. https://doi.org/10.1073/pnas.1515087112.

Manser, M.B., Bell, M.B., Fletcher, L.B., 2001. The information that receivers extract from alarm calls in suricates. Proc. Roy. Soc. Lond., Ser. B: Biol. Sci. 268, 2485–2491. https://doi.org/10.1098/rspb.2001.1772.

McDermott, J., Hauser, M.D., 2007. Nonhuman primates prefer slow tempos but dislike music overall. Cognition 104, 654–668. https://doi.org/10.1016/j.cognition.2006.07.011.

Mingle, M.E., Eppley, T.M., Campbell, M.W., Hall, K., Horner, V., de Waal, F., 2014. Chimpanzees prefer African and Indian music over silence. J. Exp. Psychol. Anim. Learn. Cogn. 40, 502. https://doi.org/10.1037/xan0000032.

Morton, E.S., 1977. On the occurrence and significance of motivation-structural rules in some bird and mammal sounds. Am. Nat. 111, 855–869. ⟨https://www.jstor.org/stable/2460385⟩ (accessed on 26 July 2024).

Peretz, I., Gaudreau, D., Bonnel, A.M., 1998. Exposure effects on music preference and recognition. Mem. Cogn. 26, 884–902. https://doi.org/10.3758/BF03201171.

Polston, J.E., Glick, S.D., 2011. Music-induced context preference following cocaine conditioning in rats. Behav. Neurosci. 125, 674. https://doi.org/10.1037/a0024341.

Pongrácz, P., Szabó, E., Kis, A., Péter, A., Miklósi, A., 2014. More than noise? —Field investigations of intraspecific acoustic communication in dogs (*Canis familiaris*). Appl. Anim. Behav. Sci. 159, 62–68. https://doi.org/10.1016/j.applanim.2014.08.003.

Quervel-Chaumette, M., Faerber, V., Faragó, T., Marshall-Pescini, S., Range, F., 2016. Investigating empathy-like responding to conspecifics' distress in pet dogs. PLoS ONE 11, e0152920. https://doi.org/10.1371/journal.pone.0152920.

Ratcliffe, E., 2021. Sound and soundscape in restorative natural environments: a narrative literature review. Front. Psychol. 12, 570563. https://doi.org/10.3389/fpsyg.2021.570563.

Reefmann, N., Kaszàs, F.B., Wechsler, B., Gygax, L., 2009. Ear and tail postures as indicators of emotional valence in sheep. Appl. Anim. Behav. Sci. 118, 199–207. https://doi.org/10.1016/j.applanim.2009.02.013.

Ritvo, S.E., MacDonald, S.E., 2016. Music as enrichment for Sumatran orangutans (*Pongo abelii*). J. Zoo. Aquar. Res. 4, 156–163. https://doi.org/10.19227/jzar.v4i3.231.

Sauter, D.A., Eisner, F., Calder, A.J., Scott, S.K., 2010. Perceptual cues in nonverbal vocal expressions of emotion. Q. J. Exp. Psychol. 63, 2251–2272. https://doi.org/10.1080/17470211003721642.

Schaefer, H.E., 2017. Music-evoked emotions—current studies. Front. Neurosci. 11, 600. https://doi.org/10.3389/fnins.2017.00600.

Siniscalchi, M., d'Ingeo, S., Minunno, M., Quaranta, A., 2018. Communication in dogs. Animals 8, 131. https://doi.org/10.3390/ani8080131.

Siu, T.S.C., Cheung, H., 2017. Infants' sensitivity to emotion in music and emotion-action understanding. PloS ONE 12, e0171023. https://doi.org/10.1371/journal.pone.0171023.

Snowdon, C.T., 2021. Animal signals, music and emotional well-being. Animals 11, 2670. https://doi.org/10.3390/ani11092670.

Somppi, S., Törnqvist, H., Koskela, A., Vehkaoja, A., Tiira, K., Väätäjä, H., Surakka, V., Vainio, O., Kujala, M.V., 2022. Dog–owner relationship, owner interpretations and dog personality are connected with the emotional reactivity of dogs. Animals 12, 1338. https://doi.org/10.3390/ani12111338.

Wallace, E.K., Altschul, D., Körfer, K., Benti, B., Kaeser, A., Lambeth, S., Waller, B.M., Slocombe, K.E., 2017. Is music enriching for group-housed captive chimpanzees (*Pan troglodytes*)? PloS ONE 12, e0172672. https://doi.org/10.1371/journal.pone.0172672.

Wathan, J., McComb, K., 2014. The eyes and ears are visual indicators of attention in domestic horses. Curr. Biol. 24, R677–R679. https://doi.org/10.1016/j.cub.2014.06.023.

Wells, D.L., Graham, L., Hepper, P.G., 2002. The influence of auditory stimulation on the behaviour of dogs housed in a rescue shelter. Anim. Welf. 11, 385–393. https://doi.org/10.1017/S0962728600025112.