Scientific Review Article

NOISE TOXICITY AND HEALING SOUNDS: CURRENT UNDERSTANDINGS

Susan O Wagner DVM, MS, ACVIM
MedVet Medical & Cancer Centers for Pets
300 East Wilson Bridge Road Worthington, OH 43085
wagner.67@osu.edu
614-519-6560

ABBREVIATIONS
dB — Decibels
Hz — Hertz

Abstract

Bioacoustics is the study of sound in animals. It looks at the ways in which animals communicate as well as the positive and negative effects of environmental sounds. Music is the most common therapeutic use of sound, but other modalities such as chanting, tuning forks, and nature sounds have been employed by sound practitioners. Research in various species shows that noise can have a detrimental effect on physiology and behavior. Music studies reveal trends, but it is not clear as to what types of music work best for calming or enrichment and if any species differences exist. Further research with larger numbers of subjects may elucidate these points. We may also find that response to acoustic therapy is individualized, and an understanding of physical, emotional, environmental, and bioenergetic factors are needed to design an appropriate therapy plan.

Introduction

Sound is an important part of every animal's surroundings. This is especially true for those suffering from anxiety disorders. Most owners do not realize the significance of sound in their homes, and many veterinarians are not cognizant of the sonic environment exposure of their hospitalized patients.

Sound is a type of electromagnetic radiation. Its frequency, or pitch, is measured in hertz (Hz). One Hz is defined as one complete wave cycle per second. Humans hear frequencies of 20–20,000 Hz, and dogs hear between 40–45,000 Hz. Cats can hear frequencies up to 64,000 Hz (1, 2). Both dogs and cats can hear sounds that are much further away than humans can perceive (3).

The intensity or loudness of a sound is measured in decibels (dB). Hearing damage occurs instantly at 100 dB and can also be caused by prolonged exposure to levels above 85 dB. The dB of some common sounds are listed in ***Table 1*** (3).

Decibels for Common Sounds	
Whisper	30 dB
Traffic	70 dB
Conversation	40 dB
Lawn mower	90 dB
Dishwasher	60 dB
Rock concert	130 dB
Vacuum	80 dB
Garbage disposal	80 dB

Table 1.

Bioacoustics is the study of sound in animals. It looks at the ways in which animals communicate as well as the positive and negative effects of environmental sounds. Psychoacoustics is the discipline that studies the perception of sound in humans (4). This includes how people listen, their psychological responses, and the physiological impact of music and sound on the human nervous system. Research suggests that psychoacoustic concepts also apply to animals (5). The purpose of this article is to review the effects of sound and music on various animal species.

SOUND AND THE NERVOUS SYSTEM

The French otolaryngologist, Dr. Alfred Tomatis, is considered the father of psychoacoustics, as he was one of the first people to understand the effects of sound on the nervous system. Tomatis realized that sound is a nutrient for the body, thereby being useful to calm, stimulate, and balance the nervous system. Although beyond the scope of this article, Tomatis' principles are still being used in human acoustic therapy today (5).

A key neurologic concept important in sound awareness is the orienting response, which occurs when the nervous system becomes aware of a stimulus (6). Whether the individual is cognizant or not, the brain actively engages with any stimulus. In the case of hearing, the process quickly goes from passive hearing to active listening. If the stimulus is low level, the nervous system reverts back to its original state. More intense stimuli create startle and fight or flight responses. For example, animals experience sudden arousal when an unusual or loud sound is heard.

The orienting, startle, and fight or flight responses are all survival mechanisms which are especially meaningful in prey animals. The ear pinna on dogs, cats, and horses allow the reception of sound to occur on a much more sensitive level than in humans. While an orienting response may get an animal's attention but not elicit overt fear, negative consequences can still occur. Ongoing instinctive reaction to sudden noise can interrupt the animal's relaxed state. This can be especially significant in the veterinary setting when ill patients are not able to rest.

NOISE TOXICITY

Hearing loss and noise induced stress have been well documented in many species, including laboratory animals. While variability in hearing damage is seen among strains of mice, most are negatively affected by a loud environment (5, 7). Background laboratory noise routinely reaches 80 dB, with human activity transiently increasing intensity by up to 40 dB (8). Moreover, early exposure to noise accelerates age induced hearing loss (9).

Other noise related toxicities have been noted in both mice and rats. Stress hormones and blood pressure increase with intense sounds, and chronic noise exposure can produce increases in blood pressure that last for weeks after the environment is normalized (10). Birth defects have been documented in mice and rats when the mother was exposed to noise pollution during pregnancy. Behavioral changes were also seen in the offspring (11, 12).

Dogs also exhibit negative effects from noise. In one study, sound blasts increased heart rate and salivary cortisol levels and elicited postural signs of anxiety (13). Consistent ambient levels of 85 dB are reported to create anxiety in canines (14). Brain Auditory Evoked Response (BAER) was used to measure hearing loss in kenneled dogs housed at a facility in which background noise often reached 100 dB. All 14 dogs studied had hearing loss within 6 months (15).

Wildlife are not immune to noise pollution. Global efforts have increased to protect cetaceans from modern sound technology. Sonar often reaches over 200 dB and can disrupt normal communication among whale populations and create behavioral changes (16). Sea lions, dolphins, and other marine life are also affected by human induced sound (17–21).

HEALING SOUNDS

While noise toxicity can have far-reaching detrimental effects, sound can also be used for healing. Much of the discipline of positive sound therapy is based on the psychoacoustic principles of resonance and entrainment. Resonance describes the effect of 1 frequency on another. The vibration of sound causes a change in the frequency of a cell, muscle, or organ. Entrainment is the process by which periodic rhythms cause major body pulse systems (heart rate, brain waves, and breath) to naturally speed up or slow down (22). Through these acoustic processes, sound causes a physiologic effect on the body.

Pattern identification is another component of psychoacoustics and is related to the complexity of sound. When a new pattern is introduced, the nervous system engages the orienting

response. The focus of the brain turns to this sensory input with active listening. Once the pattern has been processed, the brain returns to a passive hearing state. While pattern identification appears to be relevant in animals, it is not known whether more complex psychoacoustic properties such as intervals and harmonies influence them (23).

Music is the most common therapeutic use of sound, but other modalities such as chanting, tuning forks, and nature sounds have been employed by sound practitioners. Music therapy has been well studied in humans. It has been shown to be useful for many conditions, including neurologic rehabilitation, dementia, and pain (5, 24, 25). Music also improves quality of life and assists with concentration and relaxation (26).

Sound therapy has been studied in a variety of animal species. Cows were more likely to come into the milking parlor if they were signaled by music (27). An increase in growth rate was seen in chickens exposed to music, and stress was reduced in layer chicks when sound was used for enrichment (28, 29). A pilot study in horses suggested that eating decreased when jazz was played, but increased with country music (30).

Music therapy and sound enrichment are low cost, easy modalities to enrich the lives of captive animals. Whether it be a short term stay in a veterinary clinic or shelter, or long term captivity in a sanctuary or zoo, sound can play a key role in enhancing the welfare of these animals. Wells found that the quality of life for Asian elephants and gorillas was improved through auditory enhancement. Gorillas showed a tendency toward relaxation and a reduction in stress behaviors with rainforest sounds and classical music (31). Elephants had a significant decrease in stereotypic behaviors with classical music (32).

Dogs also respond well to environmental enhancement with sound. Classical music decreased stress behaviors in kenneled dogs better than heavy metal, pop, and conversation (33). Heart rate variability, a measure of stress, also improved with classical music in kenneled dogs. This change was still measurable after 9 days of music therapy, meaning the dogs did not habituate to the music (34). And yoga music was effective in reducing stress behaviors in the veterinary setting (35).

Four types of psychoacoustically arranged classical music were tested by Leeds, Spector, and Wagner. Results suggested that all classical music does not have the same effect on behavior in dogs. Varying the instrumentation and tempo produced differences in results, with slower tempos and simpler sounds having the greatest calming effect (5). In the second phase of the research, music with the most calming effect was tested against normal classical music. Twice as many anxiety behaviors were reduced with the psychoacoustically arranged work (5).

Work has also been done with cats. In a study of young, middle-aged, and older felines, results showed that they preferred music with frequencies and tempos similar to what is heard in feline communication. The young and older cats responded more than the middle-aged subjects (5). Psychoacoustic principles that stimulate the nervous system have been used for enrichment in cats, but data is not yet available on its efficacy (36).

Environmental sound is important even when the individual is not cognizant of the surroundings. A study of 12 cats showed that respiratory rate and pupil diameters changed depending on whether classical music, pop, or rock was played during spay procedures. Classical music had the most positive effects, pop was intermediate, and heavy metal caused increased respiratory rate and pupil diameters, indicating a stress response (37, 38).

While research in sound therapy is promising, variability among studies does exist. In a more recent study of Lowland gorillas, only natural sounds reduced stereotypic behavior; classical or rock music did not (39). Similarly, a study in kenneled dogs did not show a difference between psychoacoustically arranged classical music when compared to other types of music. Normal classical music did best at reducing stress, and heavy metal increased stress induced behaviors (40).

Conclusion

Music is just one aspect of the vast array of sounds affecting the complicated auditory and nervous systems in animals and humans. When we consider species and individual differences in communication, sensory processing, and adaptation, it is not surprising that music research is revealing trends but no definitive answers.

While it is clear that noise has a detrimental effect on many species, the effects of music are not as apparent. We may be witnessing challenges similar to studying any complementary modality. For example, subjects in an acupuncture study may all have the same clinical disorder but require very different points due to their underlying nature and imbalances. They all receive acupuncture, but a set of points that helps one individual may not be appropriate for the other. In our conventional mindset of controlling every variable (i.e., all subjects receive the same acupuncture points), we may make incorrect conclusions from the data.

Conversely, further research with larger numbers of subjects may show us that species variation does exist, and we may find that one species prefers nature sounds while another requires classical music. But if we apply holistic concepts to acoustic therapy, we are more likely to find that an understanding of physical, emotional, environmental, and bioenergetic factors are needed to design an appropriate therapy plan. Truly effective sound therapy may need to be prescribed on a case by case basis.

References

1. Heffner HE. Hearing in large and small dogs: Absolute thresholds and size of the tym-panic membrane. Behav Neurosci 1983;97:310-318.
2. *www.lsu.edu/deafness/HearingRange.html*
3. *www.pawscrossed.co.uk*
4. Leeds J. The Power of Sound: How to Manage Your Personal Soundscape for a Vital, Productive, & Healthy Life. Rochester Vermont: Healing Arts Press, 2001:95.
5. Leeds J, Wagner SO. Through A Dog's Ear: Using Sound to Improve the Health & Be-havior of Your Canine Companion. Boulder, Colorado: Sounds True, 2008.
6. Leeds J. Sonic Alchemy: Conversations with Leading Sound Practitioners. 4th ed. San Rafael, California, InnerSong Press, 2005:33-44.
7. Ohlemiller KK, Wright JS, Heidbreder AF. Vulnerability to noise-induced hearing loss in 'middle-aged' and young adult mice: a dose-response approach in CBA, C57BL, and BALB inbred strains. *Hear Res.* 2000;149:239–247.
8. Lauer AM, Bradford JM, Ziwei JH, et al. Sound levels in modern rodent housing rooms are an uncontrolled environmental variable with fluctuation mainly due to human activi-ties. *Lab Anim* (NY). 2009;38(5):154-160.
9. Kujawa SJ, Liberman MC. Acceleration of age-related hearing loss by early noise expo-sure: Evidence of misspent youth. *J Neurosci.* 2006;26(7):2115-2123.
10. Cook RO, Nawrot PS, Hamm CW. Effects of high-frequency noise on prenatal develop-ment and maternal plasma and uterine catecholamine concentrations in the CD-1 mouse. *Toxicol Appl Pharmacol.* 1982;66:338–348.

11. Kimmel CA, Cook RO, Staples RE. Teratogenic potential of noise in mice and rats. *Toxi-col Appl Pharmacol.* 1976;36:239–245.

12. Nawrot PS, Cook RO, Staples RE. Embryotoxicity of various noise stimuli in the mouse. *Teratol.* 1980;22:279–289.

13. Beerda B, Schilder MBH, van Hooff JARAM, et al. Behavioural, saliva cortisol and heart rate responses to different types of stimuli in dogs. *App Anim Behav Sci.* 1998;58:365-381.

14. Herron ME, Shreyer T. The pet-friendly veterinary practice: a guide for practitioners. *Vet Clin North Am Small Anim Pract.* 2014;44(3):451-481.

15. Scheifele P, Martin D, Clark JG, et al. Effect of kennel noise on hearing in dogs. *Am J Vet Res.* 2012;73(4):482-489.

16. Erbe C, Reichmuth C, Cunningham K, et al. Communication masking in marine mam-mals: A review and research strategy. *Mar Pollut Bull.* 2016;Feb 15;103(1-2):15-38.

17. Miller PJ, Kvadsheim PH, Lam FP, et al. First indications that northern bottlenose whales are sensitive to behavioral disturbance from anthropogenic noise. *R Soc Open Sci.* 2015 Jun 3; 2(6):140484.

18. Visser F, Cure C, Kvadsheim PH, et al. Disturbance-specific social responses in long-finned pilot whales, Globicephala melas. *Sci Rep.* 2016;Jun29;6:28641.

19. Au WWL, Pack AA, Lammers MO, et al. Acoustic properties of humpback whale songs. *J Acoust Soc Am.* 2006;120(2):1103-1110.

20. Buckstaff KC. Effects of watercraft noise on the acoustic behaviour of bottlenose dol-phins,Tursiops truncatus, in Sarasota Bay, Florida. *Mar Mamm Sci.* 2004;20(4):709-725.

21. Costa DP. A bioenergetics approach to developing the PCAD model. In: Popper AN,Hawkins T. (Eds), The Effects of Noise on Aquatic Life: Advances in Experimental Medicine and Biology. Springer Verlag New York, 432-426.

22. Leeds J. The Power of Sound: How to Manage Your Personal Soundscape for a Vital, Productive, & Healthy Life. Rochester Vermont: Healing Arts Press, 2001:33-43.

23. Zhang MU, Ho RC. Personalized reminiscence therapy M-health application for patients living with dementia: Innovating using open source code repository. *Techno Health Care* 2016; Oct 22.

24. Orentin M, Quintame V, Yelnik A, et al. Experimental feasibility pilot study: Music ther-apy and rehabilitation care follow a stroke. *Ann Phys Rehabil Med.* 2016;59S:e48.

25. Espi-Lopez GV, Ingles M, Ruesces-Nicolau MA, Moreno-Segura N. Effect of low im-pact aerobic exercise is combined with music therapy on patients with fibromyalgia: A pilot study. *Complement Ther Med.* 2016;Oct 28:1-7.

26. Shin YN, Chien WH, Chiang HS. Elucidating the relationship between work attention performance and emotions from listening to music. *Work.* 2016; Sep 27. DOI: 10.3233/WOR-162408.

27. Uetake K Hurnik JF, Johnson L. Effect of music on voluntary approach of dairy cows to an automatic milking system. *Appl Anim Behav Sci.* 1997;53:175-182.

28. Gvaryahu G, Cunningham DL, van-Tienhovern A. Filial imprinting, environmental en-richment, and music application effects on behavior and performance of meat strain chicks. *Poult Sci.* 1989;68(2):211-217.

29. Davila SG, Campo JL, Gil MG, et al. Effects of auditory and physical enrichment on three measurements of fear and stress (tonic immobility duration, heterophil to lympho-cyte ratio, and fluctuating asymmetry) in several breeds of layer chicks. *Poult Sci.* 2011;90:2459-66.

30. Houpt K, Marron BS, Seeliger BS. A preliminary study of the effect of music on equine behavior. *J Eq Vet Sci.* 2000;20(11):691-737.

31. Wells DL. A note on the effective auditory stimulation on the behavior and welfare of zoo-housed gorillas. *Applied An Beh Sci.* 2006:327-332.

32. Wells DL, Irwin RM. Auditory stimulation as enrichment for zoo-housed Asian elephants (Elephas maximus). *Anim Welfare.* 2008;17:335-340.

33. Wells DL, Graham L, Hepper PG. The influence of auditory stimulation on the behavior of dogs housed in a rescue shelter. *Anim Welfare.* 2002:385-393.

34. Bowman A, Scottish Spca, Dowell FJ, et al. "Four Seasons" in an animal rescue centre: classical music reduces environmental stress in kenneled dogs. *Phys & Beh.* 2015;143:70-82.

35. Boardman K. Managing canine patient's stress through music therapy: part one. *Vet Nurses Times.* 2014;6:26-27.

36. Snowdan CT, Teie D, Savage M. Cats prefer species-appropriate music. *App Anim Beh Sci* 2015;166:106-111.

37. *www.ThroughACatsEar.com*

38. Mira F, Costa A, Mendes E, et al. Influence of music and its genres on respiratory rate and pupil diameter variations in cats under general anesthesia: contribution to promoting patient safety. *J Feline Med Surg.* 2016;18(2):150-159.

39. Robbins L, Margulis SW. The effects of auditory enrichment on gorillas. *Zoo Biol.* 2014; 33 (3):197–203.

40. Kogan LR, Schoenfeld-Tader R, Simon AA. Behavioral effects of auditory stimulation on kenneled dogs. *J Vet Behave.* 2012;7:268-75.