BIOACOUSTIC RESEARCH & DEVELOPMENT (BARD)
CANINE RESEARCH SUMMARY

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Justification

Sound is an important part of an animal's surroundings. Many guardians don't realize the significance of sound in their homes, and most veterinarians are not cognizant of the sonic environment their hospitalized patients are exposed to.

Sound consists of waves of energy. How fast a wave is traveling, or its frequency, is measured in hertz (Hz). One Hz is defined as one wave cycle per second. Humans hear frequencies of 20 – 20, 000 Hz. Although values for animals vary, we know that many species can hear higher frequencies than humans. The high range for dogs is at least 50,000 Hz.

Loudness is measured in decibels (dB). Common sounds and their corresponding dB are listed below:

Whisper	30 dB
Traffic	70 dB
Conversation	50 dB
Lawnmower	90 dB
Alarm Clock	70 dB
Rock concert	130 dB

Hearing damage occurs at 100dB, but can also be caused by prolonged exposure to levels above 85dB.

Psychoacoustics is the discipline that studies the perception of sound in humans. This includes how we listen, our psychological responses, and the physiological impact of music and sound on the human nervous system. Bioacoustics is the study of sound in animals. It looks at how animals communicate, as well as the positive and negative effects of sound in their environments.

Much of the discipline of psychoacoustics is based on the principles of resonance and entrainment. Resonance describes the effect of one vibration (or frequency) on another, i.e., the vibration of sound causing a change in the frequency of a vibration of a cell, muscle, organ, etc. 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.

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

the focus of the brain turns to this sensory input. This is termed *active listening*. Once the pattern has been processed, the brain returns to a *passive hearing* state. This is an instinctive process which also occurs in animals, called the orienting response.

The orienting response is a survival mechanism, and is especially important in prey animals. We have all witnessed the sudden arousal of an animal when an unusual or loud sound is heard. While the orienting response can have a positive effect on survival, negative consequences should also be considered. As animals have been domesticated, and housed in unnatural environments, they have been exposed to sounds that may continually activate their orienting responses. Even though the environmental sounds may not elicit overt fear, the ongoing instinctive reaction to sudden noise can interrupt the animal's relaxed state. When sounds do elicit fear, the consequences can be even more serious.

Noise pollution is a growing problem in human society, and has been linked to a decrease in immune system function. While no specific research in this area has been done in dogs or cats, studies in rodents and humans suggest that immune compromise may be a possibility. When we consider that the average American household watches seven hours of television daily, and with the increasing use of electronic gadgets and gaming devices, noise pollution could be a real influence on our animal companions' health and well-being. Behavior issues are discussed with family veterinarians in a reported 45% - 90% of visits. It is important to consider what effect noise pollution has on these statistics.

Music is one way to counteract noise pollution, and enrich the environments of animals and humans. Psychoacoustic principles of music have been well established in people. Multiple studies on the effect of music on animals have been published, with a recent study done by Debra Wells and her colleagues showing that classical music is the preferred calming sound source in dog shelters. Anecdotal evidence from concert pianist Lisa Spector revealed that certain pieces of classical music produced a difference in the behavior of dogs. For example, when she played certain pieces, a highly energized puppy would calm down within one minute, and stay that way for the duration of her playing. When caring for an ailing, elderly dog, the sound of wind produced anxiety. Lisa noticed that when she introduced piano music into the environment, the dog relaxed.

What is not known, however, is whether the same human oriented psychoacoustic principles of resonance, entrainment, and pattern identification apply to domesticated animals. While animals possess more highly tuned hearing than their human guardian's, we do not know if their cerebral function allows them to recognize sonic relationships (i.e., intervals, harmonies and fast or slow external rhythms).

The purpose of our study was to investigate multiple types of psychoacoustically arranged classical music on the behavior of dogs. The music was chosen and arranged according to the principles of entrainment and harmonic complexity. Dogs have the same brain waves patterns as humans, but their heart rates vary according to size; the larger the dog,

the slower the heart rate. The tempos used in this project were based on an average sized dog.

The project was divided into two phases:

Phase I

The purpose of Phase I was to test four types of psychoacoustically arranged classical music in home and group environments.

R1 – solo piano with simplified arrangements at 50-70 beats per minute (bpm)
R2 – piano trio with simplified arrangements at 50-70 bpm
T3 – solo piano with more complex arrangements at 60-80 bpm
T4 – piano trio with more complex arrangements at 60-80 bpm

Group environments tested included 3 humane societies, 2 boarding facilities, 2 guide dog training facilities and 1 veterinary hospital. Over 150 dogs were tested in the group setting. Seven dogs were evaluated in their home environments.

Testers were instructed to start the music, then fill out a questionnaire after 30 minutes. They did not have to stay in the presence of the animals while the music was being played. They were requested to continue playing the music for the remainder of the hour. This was repeated 10 days in a row for each CD. The sequence of the CDs was randomly varied, to avoid being played in the same order at each facility or home.

In the home setting, testers were asked to rate whether their dog(s) stayed the same, became more anxious, became calmer or went to sleep. In the kennel setting, they reported the percentage of dogs exhibiting

those behaviors each time the music was played. For example, if 20 dogs were evaluated on Day 1, and 10 of those dogs' behaviors stayed the same, the tester would report 50% for that category.

Kennel Observation: Results for the kennel environment are shown in Table 1. The value reported is the average percentage of dogs exhibiting that behavior, with the range in parentheses. To achieve this number, the percentage of dogs in each category reported for each testing day was added together. The average was obtained by taking this number and dividing it by the number of days the music was played. Because the number of dogs on each day would vary, the average number of dogs in each group was listed. In order to ascertain early or late effects, the overall percentages, those from days 1 – 3 and those from days 4 – 10 were teased out.

The large ranges seen in the group situation speak to the variability seen with different dogs and different observers. Even with that, the numbers show some interesting trends. Despite the stress of a kennel environment, upwards of 70% of the dogs became calmer with the R1 and R2 discs. (There was one outlier in the group day 4-10 data. If that is removed, the overall calm percentage approaches the 78% mark.) Most of the groups show only a 50% range with the T3 disc.

Home observation: Results for the home environment are shown in Table 2. As in the group study, the value reported is an average percentage of dogs exhibiting that behavior, with the range in parentheses. (The percentage reported was an average of all the days.)

In order to ascertain early or late effects, the overall percentages, those from days 1 – 3 and those from days 4 – 10 were teased out.

The same pattern seen in the kennel environment is far more visible in the home group, although the numbers are much smaller. The R1 disc in this environment showed an overall average of 85% becoming calm, and over half went to sleep. Perhaps the lower stress in the home vs. the kennel environment was a factor. R2 percentages, however, were not as high. Once again, T3 produced values in the 50% range.

Phase I summary: The purpose of Phase I was to determine the efficacy of external rhythm and pattern identification on canines in the kennel and home environment. Four types of classical music were tested. The results suggest that all classical music does not have the same effect on behavior in dogs. Varying the instrumentation and tempo can produce marked differences in results, with slower tempos and simpler sounds have a greater calming effect.

Table 1

GROUP SUMMARY

Value is % dogs exhibiting behavior with range in parentheses

Overall

	Sleep	Calmer	No change	Anxious	# dogs in group
R1	13 (0-40)	70 (23-100)	27 (0-72)	3 (0-20)	61 dogs
R2	11 (0-27)	71 (17-100)	20 (0-50)	4 (0-15)	57 dogs
T3	7 (0-30)	59 (0-100)	33 (0-55)	11 (0-42)	26 dogs

Day 1 - 3

	Sleep	Calmer	No change	Anxious	# dogs in group
R1	14 (0-40)	78 (59-100)	22 (0-37)	3 (0-20)	80 dogs
R2	11 (0-29)	68 (43-100)	22 (0-50)	6 (0-15)	79 dogs
T3	10 (0-30)	50 (3-100)	38 (17-42)	18 (0-42)	36 dogs

Day 4 - 10

	Sleep	Calmer	No change	Anxious	# dogs in group
R1	12 (0-32)	56 (23-100)	34 (0-72)	3 (0-6)	61 dogs
R2	13 (0-20)	77 (54-93)	15 (3-30)	2 (0-3)	57 dogs
T3	2 (0-4)	74 (48-100)	26 (0-52)	0	26 dogs

Table 2

HOME SUMMARY

Value is % dogs exhibiting behavior with range in parentheses

Overall

	Sleep	Calmer	No change	Anxious	# dogs in group
R1	57 (29-86)	85 (67-100)	10 (0-29)	5 (0-17)	7 dogs
R2	68 (57-86)	68 (57-86)	23 (14-29)	7 (0-14)	7 dogs
T3	36 (0-60)	55 (40-60)	10 (0-60)	25 (20-40)	5 dogs

Day 1 - 3

	Sleep	Calmer	No change	Anxious	# dogs in group
R1	57 (29-86)	81 (71-100)	14 (0-29)	5 (0-14)	7 dogs
R2	29 (0-43)	76 (57-86)	19 (14-29)	5 (0-14)	7 dogs
T3	27 (0-40)	53 (40-60)	27 (20-40)	20 (20-20)	5 dogs

Day 4-10

	Sleep	Calmer	No change	Anxious	# dogs in group
R1	57 (33-71)	87 (67-100)	8 (0-17)	4 (0-17)	7 dogs
R2	39 (29-57)	65 (57-71)	25 (14-43)	8 (0-14)	7 dogs
T3	40 (0-60)	56 (40-60)	18 (0-25)	24 (20-40)	5 dogs

Phase II

The purpose of Phase II was to determine if music arranged according to psychoacoustic principles would have an effect on specific anxiety issues in dogs, such as fear of thunderstorms, separation from the guardian and fireworks. Upon review of the data from Phase I, it was decided that R1 CD showed the most consistent results for calming dogs in both the kennel and home environment. Because many guardians turn the radio on for their pets when they leave home or when a thunderstorm is approaching, another CD of standard classical music (C1) was chosen for comparison. C1 CD was a compilation of frequently played music that had not been psychoacoustically arranged. The music was taken from the play list of a San Francisco classical radio station.

Ten dogs with anxiety were entered into Phase II. Their specific anxieties were as follows:

Other dogs and children (2 dogs)
Other dogs
Visitors in the home environment
Thunderstorms
Riding in the car
Excessive need for attention – pawing at guardian
Separation anxiety (2 dogs)
Fireworks

The guardians were asked to play the music for 20 minutes, then rate if the music caused a reduction in 15 behaviors associated with anxiety. All behaviors are listed in Tables 3 and 4. An example is listed below.

My dog showed a reduction in the following behaviors while listening to the CD:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Panting -- Intensity NA	1	2	3	4	5
Panting -- Duration NA	1	2	3	4	5

As you can see, these ratings were based on a scale of 1 to 5, with 1 being strongly disagree, 2 disagree, 3 neutral, 4 agree and 5 strongly agree. They were instructed to circle not applicable (NA) if their dog did not exhibit a particular behavior.

Results: When adding up all the behaviors elicited by the 10 dogs, a total of 60 behaviors were recorded for R1 CD and 59 for C1 CD. Tables 3 and 4 summarize this data. The numbers listed are the number of dogs exhibiting the particular behavior in each specific rating category.

Table 3

C1 CD SUMMARY

	Number of Dogs Receiving the Following Ratings				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Panting – Intensity	1	2	1	2	0
Panting - Duration	1	2	2	1	0
Pacing - Intensity	1	1	2	1	0
Pacing - Duration	0	1	2	1	0
Trembling - Intensity	0	1	1	0	1
Trembling - Duration	0	1	1	0	1
Barking - Intensity	0	1	2	1	0
Barking - Duration	0	1	0	3	0
Whining - Intensity	0	1	0	3	0
Whining - Duration	0	1	1	2	0
Drooling - Intensity	0	0	1	0	1
Drooling - Duration	0	0	1	0	1
Hiding - Intensity	0	0	0	1	0
Hiding - Duration	0	0	0	1	0
General anxiety	2	3	4	1	0
Totals – Absolute	**5**	**15**	**18**	**17**	**4**
Totals – Percentage	**9**	**25**	**31**	**29**	**7**

C1 CD results show a fairly even split, with 34% of the behaviors recorded as strongly disagree or disagree, 31% as neutral and 36% as agree or strongly agree. The detailed breakout was 9% strongly disagree, 25% disagree, 31% neutral, 29% agree and only 7% with strongly agree.

Table 4

R1 CD SUMMARY

	Number of Dogs Receiving the Following Ratings				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Panting – Intensity	0	0	3	3	1
Panting - Duration	0	0	3	4	0
Pacing - Intensity	0	0	1	1	1
Pacing - Duration	0	0	1	1	1
Trembling - Intensity	0	0	1	1	1
Trembling - Duration	0	0	1	1	1
Barking - Intensity	0	1	0	2	1
Barking - Duration	0	1	0	0	3
Whining - Intensity	0	1	1	3	0
Whining - Duration	0	1	1	3	0
Drooling - Intensity	0	0	0	1	1
Drooling - Duration	0	1	0	1	1
Hiding - Intensity	0	0	0	1	0
Hiding - Duration	0	0	0	1	0
General anxiety	0	2	0	7	1
Totals – Absolute	**0**	**6**	**12**	**30**	**12**
Totals – Percentage	**0**	**10**	**20**	**50**	**20**

R1 CD results revealed that 10% were recorded as strongly disagree or disagree, 20% were neutral and 70% were agree or strongly agree. Detailed breakout showed that 0% listed strongly disagree, 10% disagree, 20% neutral, 50% agree and 20% strongly agreed.

The guardians were also asked if their pet would lie down or go to sleep, and if they themselves felt calmer while listening to the music. Interestingly, 60% of the guardians felt calmer when R1 was played, but only 20% of them reported a calming effect with C1. As for lying down or sleeping, there were no differences between the two CDs. Most of the dogs would lay down (8 for R1 and 9 for C1), but only 1 in each group went to sleep. These results suggest that any classical music will help a dog calm enough to lie down, but R1 CD addresses specific anxiety behaviors more effectively.

Phase II Summary: 70% of anxiety behaviors were reduced with R1 CD and 36% of anxiety behaviors were reduced with C1 CD. Both CDs calmed the dogs enough to make them lie down, however, it appears that the R1 music, with slower tempos and simple arrangements and sounds, is more effective in reducing anxiety.

Future Projects: Further studies would be helpful in ascertaining the mechanisms of entrainment with dogs. Continuous monitoring of heart and respiration rates and brain waves would allow us to understand the physiologic effects of music arranged according to psychoacoustic principles. Also, understanding whether there are differences in breed and species size would be clinically relevant. Pets such as cats, pocket pets (hamster, guinea pigs, etc) and horses may not respond in the same manner as dogs. This work may be useful in reducing stress in farm and research animals, which has repercussions that extend beyond behavior to public health and animal welfare.