2023

The Psychophysical Response to Music in Canines

Maxwell J. Gailey
The University of Vermont

The Psychophysical Response to Music in Canines:

An Analysis of Music's Capability of Improving the Life of Dogs

Maxwell J. Gailey

May 9, 2023

Dr. D. Thomas Toner – Thesis Advisor – Department of Music

Dr. Julia M. Smith – Committee Chair – Department of Animal and Veterinary Sciences

Dr. Yutaka Kono – Committee Member – Department of Music

The University of Vermont Honors College

Department of Music in the College of Arts and Sciences

ABSTRACT

The creation of music is well known to be considered “human nature”, but is it possible that music can influence other species? This study focuses on the psychophysical, or emotional and physical, responses of canines in response to musical stimuli. For support, literature including the basics of ear anatomy and sound processing in both canines and humans, the fundamentals of music creation and expression, the impact of music on human neuroscience and emotional conveyance, as well as past research of the impact of music on canine behavior and expression. To expand on this under-researched field, a voluntary survey was created using “Google Forms” that allowed canine owners to anonymously share their previous findings and experiences upon exposing their canine(s) to musical stimuli.

Upon analysis of the 96 received responses, it was found over 70% (70.84%) of canines had observable physical and/or emotional changes when presented with music from a variety of different genres including classical, pop, rock, and heavy metal. Overall, 83.56% of the canines impacted by the musical stimuli showed what can be considered “positive” physical and/or behavioral changes that can be used in settings where canines are presented and susceptible to increased levels of stress and anxiety including animal shelters and veterinary offices.

TABLE OF CONTENTS

DEDICATION & ACKNOWLEDGEMENTS

This work is dedicated to Fawn and Chloe – the best dogs to grow and mature alongside. Thank you for teaching me compassion and empathy, as well as sparking my desire to make the lifetime commitment of helping animals in need.

A special thank you to my parents, brother, and grandparents for always showing unwavering love and support, as well as pushing me to reach for the stars. I would also like to thank Dr. Toner from the University of Vermont Music Department for not only advising this project but expanding my knowledge of classical and world music. Lastly, I would like to thank Dr. Julie Smith from the University of Vermont Animal and Veterinary Sciences Department for helping with the development and clearance of this work, and Dr. Kono from the University of Vermont Music Department for serving on the defense committee for this thesis as well as allowing me to pursue music in an orchestral setting.

CHAPTER I – INTRODUCTION

Background and Hypotheses

Often described as a "human's best friend", the presence of canines in the lives of humans has evolved drastically from their first domestication tens of thousands of years ago. Once used for protection against foreign individuals and threats, canines are now considered members of the family, sharing homes with the individuals who care for them. Because of this symbiotic relationship, it should be no surprise that both the human and canine brain have evolved to form some similarities.

Humans have been creating music for over forty-two millennia, and it is extremely likely that music was being created before. Since music can impact the human brain in a variety of ways, from the expression of certain emotions to even physical reactions, it has been shown that the canine brain is also impacted by the same musical stimuli, producing similar emotional and physical responses. However, since the consideration of canines to be "members of the family" is relatively new in terms of societal advancements, there has not been much research completed to identify and solidify answers to whether music is beneficial to canines in everyday life, as well as stressful/fear provoking settings.

This thesis aims to expand the research on whether the exposure of music on canines can be beneficial. To help form additional conclusions, the comparison of cognitive science in both humans and canines needs to be understood. Simply stating the previous research done within the field of canine music exposure is not delving in far enough. To aid this, a full analysis is needed on the anatomy of both the human and canine ear, as well as how the brain can convert sound from sound waves into recognizable electric impulses. In the same frame, the structural

basics of what is “music” must be elaborated on to prevent the paradox of whether “all sound can be considered music”. Instead, all music is sound but not all sound can be considered music.

After the clarification of the basics of both sound processing and music, the neuroscientific question of how music can evoke emotions in humans is presented. Circling back to the co-evolution between the human and canine brain, explaining how music can impact the human brain allows for easier comparison and personification of the canine brain. Based on previous research, it has become common for locations that traditionally cause higher stress/anxiety levels in canines to play music in the background, such as veterinary offices or boarding kennels. Despite the use of this music within the above settings, its presence is commonly overlooked by humans, who often consider background music to be a standard place filler to prevent the heavy perforation of silence. Therefore, many individuals do not realize the potential power that music is capable of regarding their canine’s behavioral and physical expressions.

Presenting the idea that canines can be influenced by musical stimuli forces individuals to reflect on a question that does not cross the mind of the average person. By offering explanations to how music has the potential to offer therapeutic effects to dogs, it allows for people to absorb the information presented and to potentially use it in real life occurrences when those with canines experience so-called “negative” behaviors or periods of increased stress, fear, and anxiety.

The primary question being asked in this work is whether canines show behavioral and/or physical changes during the exposure to musical stimuli. In addition, the question of whether these behavioral and/or physical responses can be considered “positive” reactions since the

exposure of foreign sounds have the potential of creating positive or negative connections and expressions from the canine brain.

Purpose and Significance

I began my music career at the age of ten when I was in fifth grade through the music program in my school district. I continued this path throughout secondary school levels with a large impact, from being awarded principal chair in my school ensembles from the time I was in seventh grade, to participating as drum major in my high school marching band, lead jazz ensemble, musical productions, and participation in numerous all-state and district wide festivals. I did not know whether I was going to be able to continue with music when I accepted my offer to the University of Vermont, and a part of me wanted to distance myself from the image I had created throughout my upbringing. I believe this is common among students first arriving at the college or university of their choice – people attend college for educational prosperity, but to "find themselves" as well.

I added a minor in music two weeks into my first semester here at the University of Vermont. The transition to college was difficult for me, and I found myself to be able to stay focused on my music ensembles with Dr. Toner, Dr. Kono, and my lessons with Steve Klimowski, who pushed me to do my best through a rigorous practice schedule. At the conclusion of only my first semester, I had performed the Clarinet Concerto No. 3 in B Flat by Carl Stamitz for both a student performance recital as well as a jury for the University of Vermont music department, which I passed. I was scheduled to perform Mozart's Clarinet

Concerto in A Major at the end of my freshman spring semester, which was cancelled due to the pandemic. Throughout my years at this institution, I have remained a part of ensembles including the CBDNA National Intercollegiate Band, University of Vermont Concert Band, Symphony Orchestra, and Vermont Wind Ensemble. Lastly, I successfully finished my music minor after the spring of my junior year.

While my career in classical/instrumental music did not begin until primary school, I have always found to have a strong connection to various animals that have come into my life. Pets can evoke a plethora of emotions in a human, ranging from happiness, to peace, to grief. This impact amazes me, and the science behind the bond between humans and their pets is impressive.

I grew up with a 110-pound German Shepard/Husky mix that my parents adopted two years before my birth. We were raised together, and practically inseparable. I recall poring over old photo albums from my childhood, seeing countless images of my dog Chloe and I grow and mature simultaneously. She was my first friend and protector, from staying up in the late hours of the night watching “Teletubbies” with me and my poor sleep deprived parents, to me often falling asleep on her gingham L.L. Bean monogrammed bed (which ironically had the name “Max” on it) with her curled up around me. She was my best (and only) companion until I was three years old when my younger brother was born.

Chloe was by my side until I was eleven years old. Her hips and joints simply became too tired to hold her weight, as common with German Shepherds. I was present at her euthanasia

appointment, and she passed away in my arms while my eleven-year-old self proceeded to ugly cry, with a soft soundtrack of classical music playing in the background of the veterinary office. After that point, I swore off any possibility of going into the veterinary field in the future.

It was not until my sophomore year at the University of Vermont that my dream of becoming a veterinarian was reignited. I had originally accepted my offer to UVM as a student in the Biological Sciences department focusing on pursuing a career in research development. After only my first semester, I began to have doubts. The summer following my freshman year, I changed my major to Zoology and added a minor in Animal Science in hopes to focus primarily on the biological and behavioral topics within the science field, while still able to fulfil my minor in music.

This thesis is the amalgamation of the development of my education within the two primary fields where I am obtaining degrees. Throughout the research process, I encountered a critical point being the field of musical stimulation and enrichment in our dogs is a largely underdeveloped and under researched field (Lindig et al., 2020). An increased number of studies need to be conducted before concrete “species-specific” conclusions and recommendations are made. This thesis aligns within this framework to provide additional data to a field that has not received a large amount of attention thus far. The process of musical stimulation as a form of enrichment and stress relief in dogs has the possibility of becoming a widely used method to improve the quality of life for dogs who are living with increased anxiety or a shelter setting.

CHAPTER II – REVIEW OF LITERATURE

I- A Guide to Sound – The Basics

a- Human Ear Anatomy and Sound Processing

Before diving into the intricate neuroscience involved in how music stimulates the brain, it is important to explain the process of how sound is processed through the ear and interpreted as comprehensible signals. After sound waves enter the ear canal leading to the eardrum, the eardrum vibrates, sending signals to three bones (the malleus, incus, and stapes) in the middle ear which amplify said vibrations to the cochlea, a membranous fluid-filled cavity (NIDCD, 2022). The rippling of the cochlea's fluid causes a wave to form that is picked up by various hair cells depending on the pitch of the stimulus. As the hair cells are stimulated, the movement of the cells open channels that cause chemicals to create an electrical signal (the creation of nerve impulses) (NIDCD, 2022). Lastly, the auditory nerve is responsible for carrying the electrical signal to the brain, where it can be interpreted into audio feedback (NICDC, 2022).

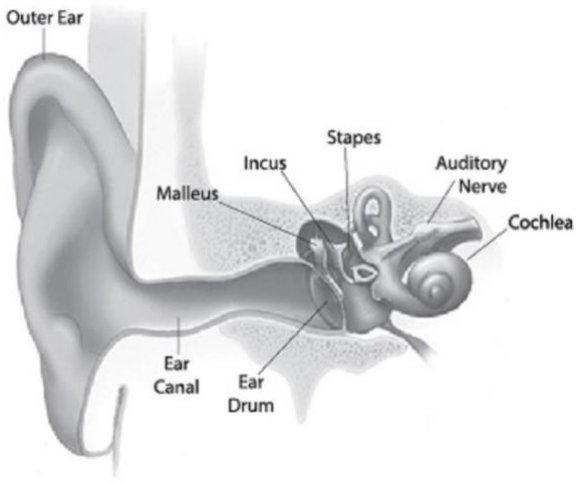

Image I – An anatomical diagram of the outer and inner ear of a human depicting the key structures involved in the processing of sound from exterior soundwaves to perceivable electrical impulses (Pomponio, 2017).

b- Canine Ear Anatomy and Sound Processing

Overall, the primary structures of the ear that provide the conversion of sound waves to perceivable "sounds" heard within the brain are largely like those found in humans. The largest difference is the presence of the "pinna" in the canine's ear, which is the area of the large outer ear found in most species of dogs (CPNI, 2021). The pinna acts as a "funnel" for soundwaves, directing them into the ear canal. Within the ear canal, the same three bones found in humans (the malleus, incus, and stapes) have a slightly modified design, allowing for sound to be amplified at greater volumes, creating larger electrical nerve impulses to the brain, which explains how canines can hear and process sounds that are undetectable by the human ear. (CPNI, 2021).

Because of this difference, the hearing range of a canine is between approximately 65 – 45,000 Hz, in comparison to the human hearing range of 20 – 20,000 Hz. This offers a practical answer as to why dogs commonly react greater to high frequency stimuli (CPNI, 2021).

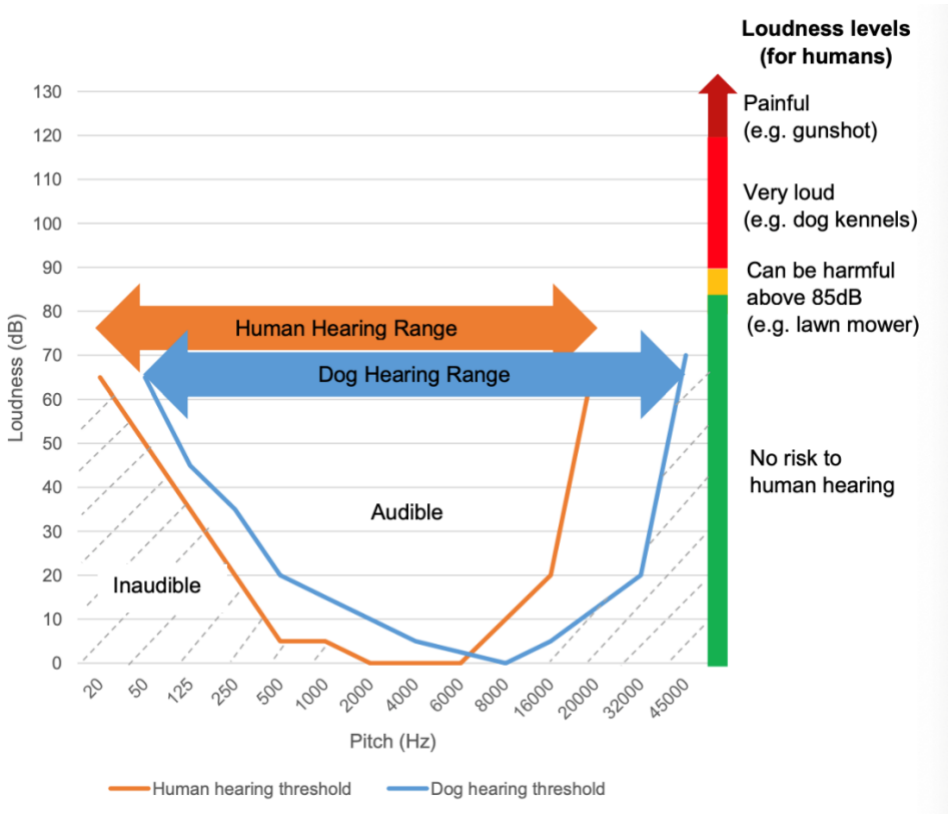

Image II – A visual comparison between the hearing ranges of humans and canines, where pitch in Hz (hertz) is on the horizontal axis and the volume in dB (decibels) is on the vertical axis. An additional scale of "loudness levels" in humans is shown on the right side of the vertical axis (CPNI, 2021).

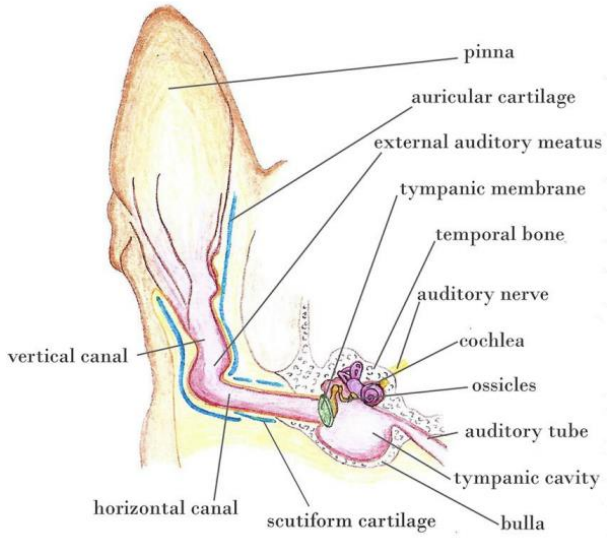

Image III – Anatomical diagram of a canine's ear with labeled structures (CPNI, 2021).

II – The Fundamentals of Music

The "true" functional definition of music is the process of "combining vocal or instrumental sounds for beauty or emotional expression" (Britannica, 2023). As described by the University of Vermont's own Dr. Toner in his course, "The Introduction of World Music Cultures," "music" can be described as "the organization of sound and silence." John Blacking supports this by offering the description that "music can be understood as humanely organized sound, or the purposeful organization of sound" (Blacking, 1973). When consuming music either by listening, reading, or performing, the premise is no more than the procession of different pitches of sound with gaps of silence. Individuals often forget the importance of silence within a musical piece, but it is almost equally as important as the sound being emitted, or the "music" itself. Without silence, there would not be a level of depth that is conveyed which relatively goes unobserved.

Music can also be considered as a form of communication, where some music relies heavily on a language component to convey a particular message or emotion, such as opera, musical theater, and popular music heard on the radio (GMU, 2005). Since it is natural, meaning music can be created by a variety of species without the need for human intervention, it is a process which has woven itself into the fabric of the Earth's societies and ecosystems (New World Encyclopedia, 2023). Stephen Malloch and Colwyn Trevarthen argue that "music is at the center of what it means to be human," and are the sounds produced by the "human body, voice, mind, and personalities" to create emotional connections, convey personal anecdotes, as well as a person's core beliefs (Malloch and Trevarthen, 2018). Some go as far as to consider music its

own language – one that is universal and can be understood by almost all populations and demographics without the need of additional translation or aid (Malloch and Trevarthen, 2018).

III - Music, Emotional Conveyance, and Expression

As previously described in the "Fundamentals of Music" subsection, music's ability to conjure and evoke a plethora of emotions is central to what it means to be considered "human". As technology has advanced in the past decade, society is seeing an emergence of Artificial Intelligence (AI) that is being used to aid human functions from simply offering conversation, to larger tasks including the drafting of papers and articles about literary topics. Universities and high schools are beginning to run into problems surrounding students plagiarizing work that was spit out using artificial intelligence software such as ChatGBT, which has been coded to interact in a humanized way as well as create lengthy explanations on brief topics or statements.

What separates humans from AI? The simple comparison is humans are conscious beings that use environmental and social stimuli to gain information, whereas AI relies on existing data and set parameters (Korteling et. al., 2021). However, if in the future AI begins to have the capability of going mobile – for example, in a humanoid suit, there would be no observable differences between humans and AI except for the presence of emotions. The ability to "feel" allows for humans to connect with each other on a deeper level, ranging from the earning of trust, love, and hatred. The intelligence of a human can be described as multidimensional – there is no single standard to measure intelligence due to there being multiple different forms that are central to what it means to be human. According to Gardner's Theory of Multiple Intelligences,

eight subject areas of intelligences are present in humans, including visual-spatial, linguistic-verbal, logical-mathematical, body-kinesthetic, musical, inter/intrapersonal, and naturalistic (Cherry, 2023). The presence of these different types of intelligence allows for humans to be multifaceted and dynamic.

As with the multidimensionality of intelligence, models of emotion can be described in the same manner, according to J.A. Russell, emotion can be described in two dimensions using the "circumplex model" (Russell, 1980; Hunter and Schellenberg, 2010). This model is composed of the "valence" dimension, a range between displeasure to pleasure, and "arousal", the level of activation of an emotional stimulus (Russell, 1980; Hunter and Schellenberg, 2010). Hunter and Schellenberg pose the question of whether the characteristics of a piece of music, including tempo, key, and volume have the ability of providing an accurate representation of emotional range (Hunter and Schellenberg, 2010).

The proposed answer to this open-ended question varies from person to person. It can be reasoned that those with a higher level of "musical intelligence" as described by Gardner's theory will have stronger emotions evoked by the presence of music. However, this is not a limiting property, and no conclusion can be drawn to a single "emotion" that is conveyed by a piece of music due to the sheer difference in human nature. Every person on Earth has a different variety of complex emotions that can be classified into the basic definitions (happy, sad, anger, jealousy), but those emotions are perceived differently depending on the person. Although there

is a variance in emotional expression when it comes to musical stimuli, researchers have been able to map the presence of stimuli in certain sections of the brain (Image IV) (Koelsch, 2018).

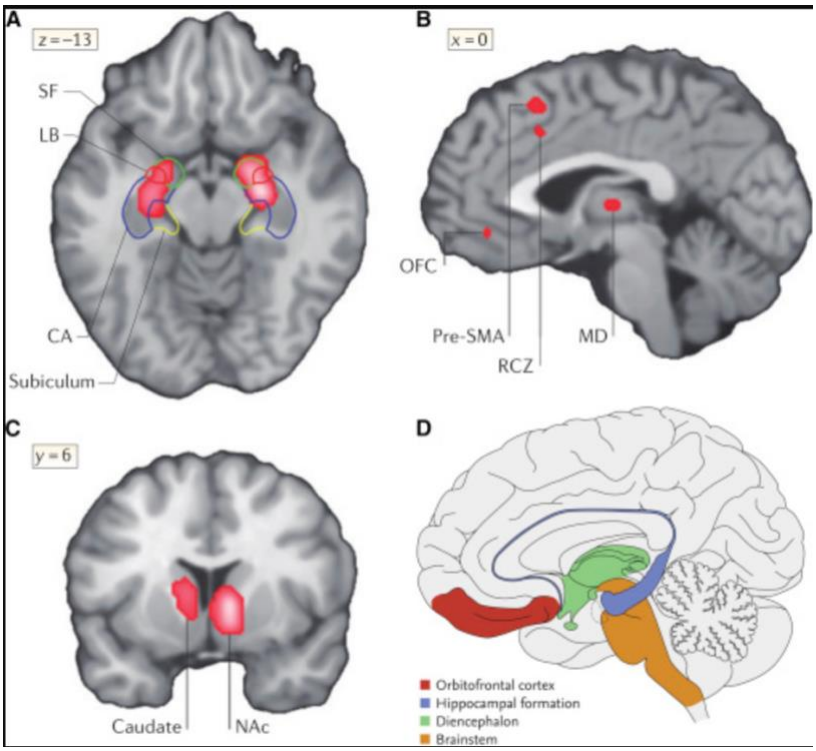

Image IV – Three views of human brain scans with labeled locations of brain activity when exposed to a musical stimulus. Diagram "D" highlights and labels significant areas of the brain where responses to musical stimuli were found (Koelsch, 2018).

An important cue to when a particular emotion is evoked to a certain piece of music is the presence of "goosebumps", or "horripilation". This is an evolutionary response that occurs when the sympathetic nervous system activates and causes minuscule muscles at the base of hair follicles, called the "arrector pili", to contract in response to a stimulus, one of which is emotional (Cleveland Clinic, 2023).

The presence of goosebumps proves a “strong feeling or emotion” is felt in humans when exposed to musical stimuli. Although this phenomenon does not occur to everyone, it is common to hear “that part gave me goosebumps” when music is playing, and the brain is able to focus on it. However, the question is how is music able create such a significant neurological response?

The process of “emotional induction” is when a certain emotion is triggered from a stimulus (Scherer and Coutinho, 2013). Scherer and Zetner (2001) have addressed this process as multifactored and do not contain one specific reason for the prominence of neurologic feedback. Instead, they describe “routes” in the process to put emphasis on the limited number of cognitive pathways that stimuli can be traced (Scherer and Coutinho, 2013; Scherer and Zetner, 2001). The five routes include “types of appraisals, music-related memory associations, contagion and empathy, entertainment and proprioceptive feedback, and the facilitation of pre-existing emotions” (Scherer and Zetner, 2001). Although the definitions and classifications of emotional responses above can be quantized, Scherer emphasizes the presence of variation and ubiquity (Scherer and Coutinho, 2013). This two-millennia year old question has no concrete answer now, but with the presence of rapidly advancing technology that is become interwoven into the fabric of society, it is likely that some answers will be unearthed soon.

IV – The Basics of Canine Behavior

How a canine (dog) expresses its behavior is directly related to a combination of development, epigenesis, and the individual’s genetic response to its surrounding environment (Lindsay, 2013). An age-old debate when referring to the development of a child is the concept

of “nature versus nurture”, where epigenesis suggests that an organism’s genetic expression can be altered by the environment which it matures in – the same hypothesis can be applied to canines (Image V) (Harvard NSC, 2010). Similarly, to humans, the basis of canine genetics is encoded with the variability that is needed for survival (Lindsay, 2013). In canines, this requires a dog to “learn and adjust future behavior based on past experiences” (Lindsay, 2013).

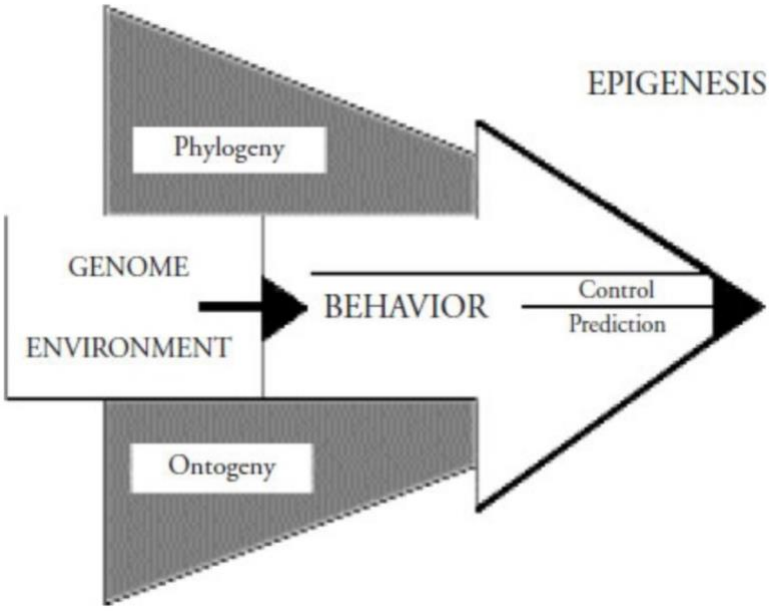

Image V – A diagram showing the variables included in epigenesis and how both genetics and the surrounding environment of a canine can impact its behavior (Lindsey, 2013).

It can be said that the relationship between a human and a dog is symbiotic and mutualistic, since both parties can benefit the other. Elsevier Science states the canine species is “the only carnivorous species that has the potential to significantly harm or kill a human that we allow to live and exist in close proximity” (Kaminski, 2014 – p. 10). In American culture, it is common for dogs to be treated as family – a more equal standard than some European, Asian,

and African cultures where canines are considered subordinate to humans. Although there is no "right or wrong" culture, it is important to remember that many canines have grown to become dependent on humans for survival due to their long history of domestication. Domestication has resulted in a change in genetic/phenotypic expressions in canines including the shortening of the face and the reduction in tooth size that has arisen from this centuries-old practice (Olsen, 1985; Dayan, 1994; Clutton-Brock, 1995).

This long-time cospecies relationship is one of the many justifications for the behavior we see in dogs today. To understand some of the behavioral patterns commonly exhibited by dogs, explanations are crucial. The "head tilt" is a common action in dogs that is frequently interpreted by humans as "questioning" or "confusion". While a dog may tilt its head when exposed to foreign stimuli such as sounds, it can also mean the dog is simply shifting positions to heighten its hearing or sight (Stregowski and Fox, 2022).

Vocalization is one of the primary methods that dogs use to both communicate with conspecifics and humans. Although some vocalizations such as loud barking or howling can become irritating, it is a crucial and normal behavior that allow dogs to "express themselves" (Stregowski and Fox, 2022). Barking itself can be the cause of a wide range of emotions or signals that the dog is attempting to convey. "Danger" can be a trigger for barking as well as howling since it is simply an instinctive behavior, where excessive barking can be the result of boredom or distress (Stregowski and Fox, 2022). When attempting to analyze a possible cause for a dog barking, it is important to note the canine's body language, which can be an easier, more streamlined method to identifying a threat or possible problem. (Image VI)

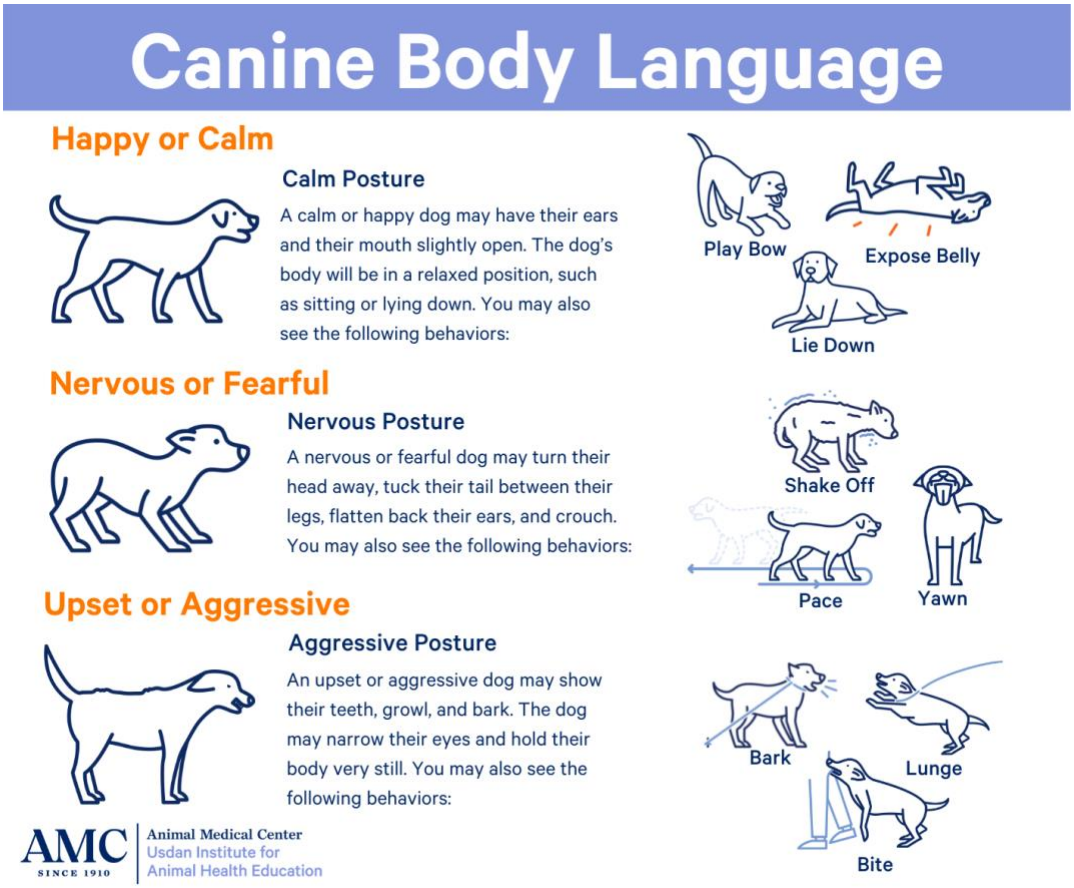

Image VI – A diagram and descriptions of common behaviors and canines and their commonly associated meanings highlighting calm, fearful, and aggressive behaviors (AMC, 2022).

The three primary locations to look to decipher a canine's emotions and intentions include the position of the tail, ears, and posture (Gibeault, 2020). It is commonly thought that when a dog is wagging its tail, it is a sign the dog is happy. However, while this may be one of the reasons for a wagging tail, it often occurs during periods when the dog is emotionally aroused or heightened (Gibeault, 2020). The faster the tail is wagging, the higher the emotional arousal of the dog and vice-versa. The tail can also inform the level of possible aggression/assertiveness of the canine. The higher the tail is in the air, the more assertive and

dominant the dog is feeling. When a dog has their tail tucked between their legs, it is a telltale indicator of increased levels of stress and fear (Gibeault, 2020). Starting along the neckline running to the base of the tail along the spine contain the canine's "hackles", which can be raised due to a process called "piloerection", which is the same phenomena as "goosebumps" in humans where the muscles at the bottom of each hair follicle contract to make the hair stand on end. (Gibeault, 2020) This can indicate increased levels of cortisol in the dog, as well as intense excitement or interest (Gibeault, 2020).

When attempting to judge a dog's emotional state based on the position of their ears, it is important to note there are varying reasons as to why a dog's ears are in that position. When the ears are perked up and angled forward, it commonly is a result of the dog being alert in case of attack, or alert in hopes for a reward (excitement) (De La Harpe, 2022). When a dog is "relaxed", the ears will usually be in a "neutral" position, not up or down (De La Harpe, 2022). When a dog is feeling anxious, stressed, scared, or aggressive, the ears will commonly be pulled back. This behavior is also usually accompanied by other body language such as a cowering position. When a canine assumes this position, it is important to avoid eye contact, as canines see extended eye contact as a threat (De La Harpe, 2022).

V – The Impact of Music on Canine Behavior

As canines have evolved alongside humans, it is not entirely unanticipated to see that stimuli that impact the human brain also can impact the canine brain. This comparison has been made increasingly often due to the development between the residentiary atmosphere between

humans and canines. As of only fifty to 100 years ago, canines that were considered pets were commonly separated from the family, sleeping outside, and living off food scraps discarded by humans (O'Malley, 2020). Since this time, in American culture, it has become increasingly common for dogs to be considered as "part of the family", where they are permitted to reside in the house among humans as well as fed a controlled diet.

Recent studies have supported that there is a positive correlation between music exposure and canine behavior, and it is beginning to emerge in the field of animal science by being used in locations that typically cause increased stress to canines including veterinary hospitals, shelters, and boarding kennels. Bowman (2015) was able to analyze the heart rate (HR) and respiratory rate (RR) of canines in a shelter setting and successfully concluded that the exposure to classical music can decrease cortisol levels in the canine brain, therefore reducing the level of stress due to environmental impacts. In addition, Brayley (2016) tested this hypothesis using audiobooks to provide a source of auditory stimuli, resulting in changes in physical behavior concerning the presence of an external audio source.

In recent years, the use of music therapy in both humans and animals has increased to combat sources of potential stressors (Lindig et al., 2020). This industry has developed a type of "dog music" – a collection of audios that is purposely designed to ease and relax canines (Lindig et al., 2020). Overall, this has been proven to be successful, where canines appear less anxious when exposed to auditory/musical stimuli (Lindig et al., 2020). A key element in a canine's response to stressors has to do with the autonomic nervous system (ANS) and the increased production of corticosteroids and increased heart rate (Amaya et al. 2020). Upon attaching a

heart rate variability (HRV) monitor to the canines involved in the study, the results suggest that musical stimuli activate both branches of the ANS, which can be seen as a helpful method to reduce stress in kennel/shelter environments (Amaya et al. 2020).

While the above anchors reasoning in the overall presence of music in a shelter setting, the type/genre of music plays a large role in the behavioral feedback from dogs. As in humans, similar responses to varying genres of music played result in different responses. Kogan et al. (2012) and Kinnaird et al. (2022) suggest that classical music, specifically pieces with a lower, steady tempo and less volume outliers (extremely loud sections), leads to kenneled dogs spending a greater amount of time sleeping and laying down, where heavy metal, for example, has been shown to increase anxiety and stress-related feedback responses, including shaking and barking. Wells et al. (2002) confirm this, with results mirroring those of Kogan et al. (2012) in both genres of classical and heavy metal response.

Variations in musical pitch and tempo are also largely dependent on the genre of music being played. Amaya et al. (2020) confirmed this difference, where canines exposed to low-frequency pitches increased the level of alertness. This could largely be a result of the dogs' association of low pitch noises with combative or conflictive environments as described in the "canine ear anatomy" section.

CHAPTER III – METHODOLOGY, SUBJECTS, AND ANALYSIS

The original sampling method outlined in the thesis proposal indicated the research for the study would be commenced in-person at shelters local to the Burlington, Vermont and

Portland, Maine regions. However, due to time constraints due to university approval as well as studying at University College London for the fall semester, the sampling method was required to be revised to achieve a high enough sample size to prove validity of the hypotheses. Originally, the sample size planned when completing in-person research with canines was between 25 – 50. Using a power calculation where the standard probability that a canine will have some form of behavioral and/or physical change when exposed to music, it was found the minimum sample size was required to be 19 subjects.

I – Sampling Method and Population

The selected sampling method was a voluntary response sample in the design of an online survey for accessibility. (Appendix I) This format of data collection allowed for ease of access for participants, no funding was necessary, and a larger sample size was able to be obtained at a faster rate when compared to in-person analysis of canine behaviors, which could be considered "under coverage", where not enough data was able to be collected to provide a significant result. The primary downfall of the voluntary sampling method is the presence of "response bias", where individuals who have stronger opinions on topics would be more likely to participate in studies/sampling population than those who are ambivalent. To potentially reduce this bias, the online survey created was opened for a week, and was anonymous so the individuals responding in the survey could not be identified and skew results.

The survey in the form of a "Google Form" was created and administered to the public using a variety of social media platforms including Instagram, Snapchat, and Facebook. This

allowed for the survey to be accessed by all individuals with these platforms, encompassing a wide variety of individuals ranging from university students to adults. However, the survey was explicitly rendered and designed for dog owners. The primary limiting factor within this experimental design was whether the individuals exposed to the survey owned a dog. In total, the survey gained 96 responses.

In addition, this method was chosen to eliminate the behavioral bias that could emerge when working in-person with canines. Since there would be an unfamiliar individual conducting research in-person, it could result in a variety of behavioral changes in the canines ranging from over-excitement to increased levels of fear and stress from an unknown human. Using the voluntary survey method allowed for dog owners to comment on their own pets, most of the time allowing for the dogs "natural behavior" to be monitored as a baseline due to familiarity with the canine's surroundings and individuals.

The created form explored simple questions to provide anonymity as well as ease of access to all ages and demographics, where no questions asked for information about the individual taking the survey. The form contained six required questions, four of them multiple choice. It was led with "how old is your dog?" and provided three options – puppy (0-2 years old), adult (2-8 years old), and senior (>8 years old). This was used to quantify the ages of the dogs mentioned in the study to compare with the results found. The proceeding question, titled "has your dog ever been exposed to music?" left individuals only having to decide between "yes" and "no". After addressing music exposure, the question "have you noticed any changes in your dog when music is playing" was asked accompanied by three multiple choice answers,

"yes", "no", and "maybe". The follow-up question associated asked individuals to describe the changes (or lack of) of their canines during music exposure.

To continue, the next question presented to subjects asked them to classify the changes observed in their canine(s) during music exposure, with options of either "behavioral changes", "physical changes", "no change", or "other". The structure of this question allowed for subjects to choose more than one answer if their pet could fit under multiple categories of classification. An additional question was used to expand on those who selected "other", asking them to explain their reasoning. This question was not required. The final required question verified the subjects involved with the sample were acceptable with their anonymous responses used to further the thesis. To submit the form, a "yes" response was required to guarantee permission.

II – Methods of Data Analysis

The first step used to analyze the data gathered in the voluntary survey was to export the responses into an Excel workbook. This allowed for each response to be organized and visual for ease of comparison, as well as the added functions of graph development and mathematical calculations. The counts/distribution of each data category was taken and converted into graph form, both pie charts and bar graphs. The created graphs include "Age of Canine", "Number of Canines Exposed to Music", "Changes Noticed During Music Exposure", "Classification of Observed Changes During Music Exposure", and "Positive or Negative Changes in Canines When Presented with Music". The graphs show counts of the data collected. In addition, percentages of each category were calculated.

To determine the mean, standard deviation, and medians of both the age and observed changes during music exposure, univariate analyses were used. However, since it is not possible to gain the mean, median, and standard deviation of simple counts of categorical data, each data set was converted into a series of numbers (0, 1, and 2). In the canine age category, puppies (age 0-2 years old) were designated with a “0”, adults (2-8 years old) were designated with a “1”, and seniors (>8 years old) were designated with a “2”. This same method was used in quantifying whether a change in canine behavior/physical state was observed, with “0” representing “no change”, “1” as “possible/slight change”, and “2” as “changes observed”. This allowed for the statistical analysis of the categorical data on a scale from 0 to 2. In addition, those who observed physical/behavioral effects during music exposure were compiled to analyze whether the changes observed were positive or negative. A “positive” or “negative” change can be described as a “difference” from the baseline behavior observed in the canines. In this case, a “positive” change refers to the expression of canine behaviors such as calm, even breathing, neutral body posture including the ears and tail, and laying down, sleeping, or the stopping of vocalization. A “negative” change upon exposure to music includes signs of anxiety such as panting, crying, pacing, or leaving the room of the stimulus completely. To quantify, a percentage was taken of those who observed changes, as well as split up to differentiate the percentage of canines who exhibited positive or negative changes.

CHAPTER IV – RESULTS

To begin, the totaled sample population was 96 entries, therefore converting to 96 canines included. Included in the population were 14 puppies (0-2 years old), 45 adults (2-8 years old), and 37 seniors (>8 years old). The table below (Table I) shows the distribution of canine ages as well as the percentage of each age group in the sampled population. 14.58% of the sampled population were puppies, 46.89% adults, and 38.53% seniors.

Age of Canine	Count in Population	Age %
Puppy - 0 - 2 years old	14	14.58%
Adult - 2 - 8 years old	45	46.89%
Senior - > 8 years old	37	38.53%

Table I – The distribution of canine ages in the sampled population as well as the percentage of each age group.

Using descriptive statistics, with “0” being puppies, “1” being adults, and “2” being senior canines, the mean equated to 1.2396, meaning the average age of the sampled canines was a middle-aged dog, somewhere between late adulthood and early senior years. The standard deviation of the sample was 0.6884, showing the relative spread of the data, and the median value of 1, where an adult canine was the center of the data set. To show the distribution of ages, a pie chart was constructed to give a visual approach with included counts of each group. A pie chart was chosen as the method to convey this data to diagram the proportion of each age group.

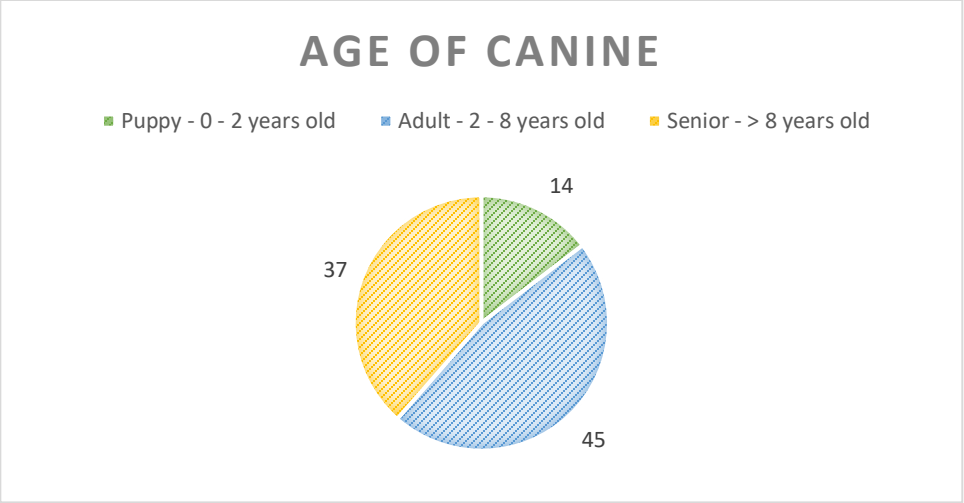

Figure I – Pie chart showing the distribution of canine ages within the sample population along with counts. Puppies (14) are shown in green, adults (45) are shown in blue, and seniors (37) are shown in yellow.

To complement the age distribution, a pie chart was constructed to show whether canines had been exposed to music. (Figure II) Within the sampled population, 96 dogs had been exposed to some form of musical stimuli (100%), where 0 dogs had never been exposed (0%).

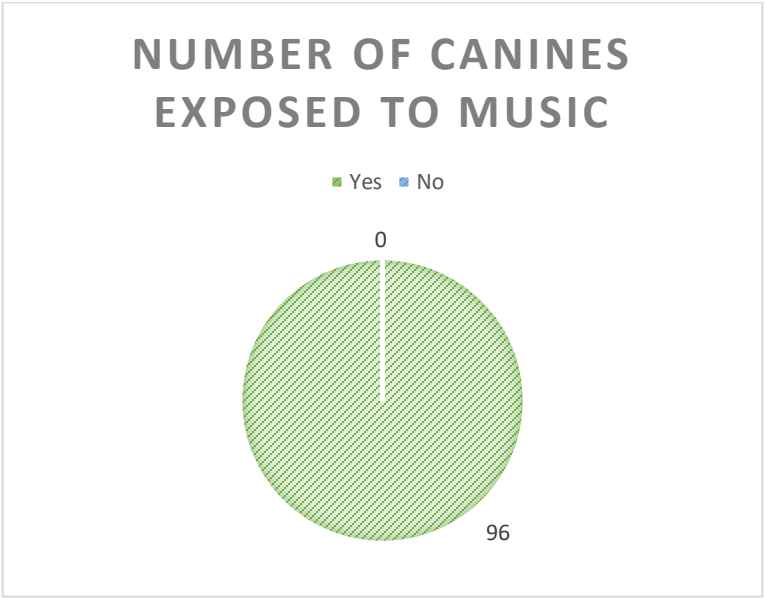

Figure II – A pie chart showing the number of canines exposed to musical stimuli within the sample population. In total, 100% (96) of canines within the sample had been exposed to some kind of musical stimuli within their lifetimes, which is shown in green.

Using the 100% exposure rate graphed above, it can be reasoned that almost all canines within households are exposed to some form of musical stimuli within their lifetimes. However, although there is frequent exposure, it does not attribute any further findings such as any possible changes in the canine, both physically and behaviorally. The bar graph below shows the distribution of canines that had observable behavioral/physical changes among exposure to musical stimuli. (Figure III)

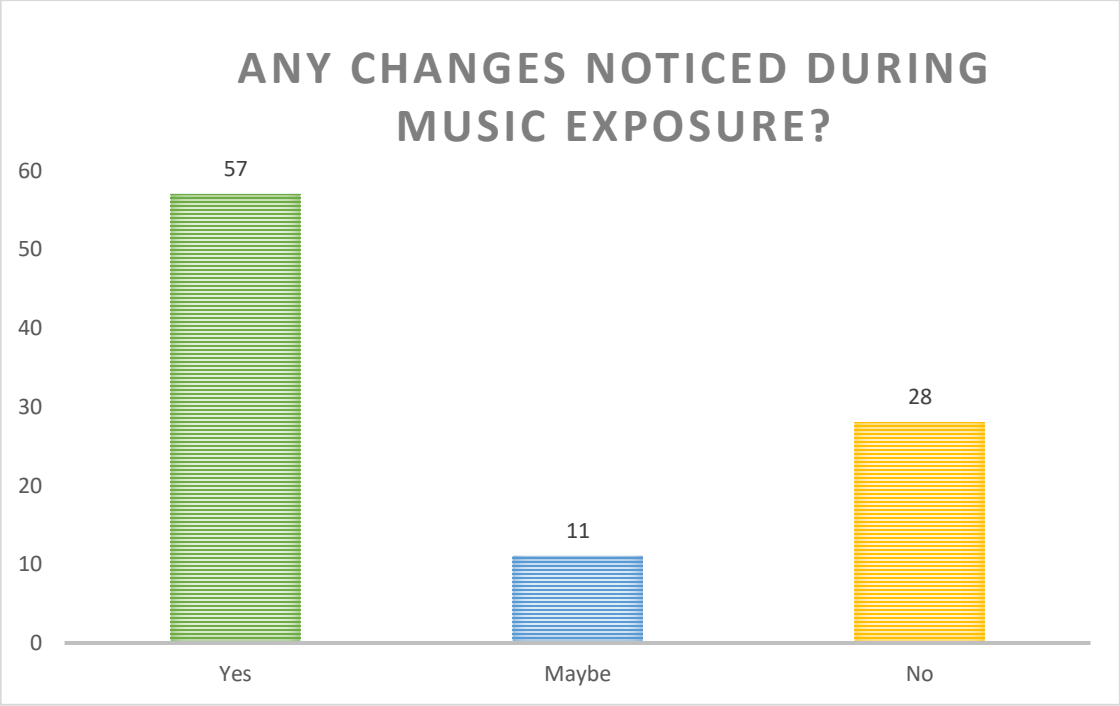

Figure III – The distribution of whether physical or behavioral changes were observed in canines by their owners during the exposure to musical stimuli. Noticeable changes (57) are shown in green, minimal changes shown in blue (11), and no apparent changes are shown in yellow. (28)

It can be theorized that most canines show some connection to the exposure of musical stimuli, either physically, mentally, or both. Using a 1-variable statistics test with "0" representing no change, "1" representing minimal change, and "2" representing visible change, the mean value of 1.3021 showed observable changes were more likely. The standard deviation

of the data was 0.8912 with a median value of 2, meaning a large amount of the data set included canines that showed a level of observable change when exposed to music. To quantify, 59.38% of canines showed significant or noticeable changes, 11.46% showed minimal changes, or the changes reported were uncertain, and 29.16% observed no apparent change in their canines. By combining the data, the total percentage of canines showing a visible impact to musical stimuli was 70.84%. To further expand on the observable changes in canines upon exposure to music, Figure IV shows the classification of observed changes during musical exposure.

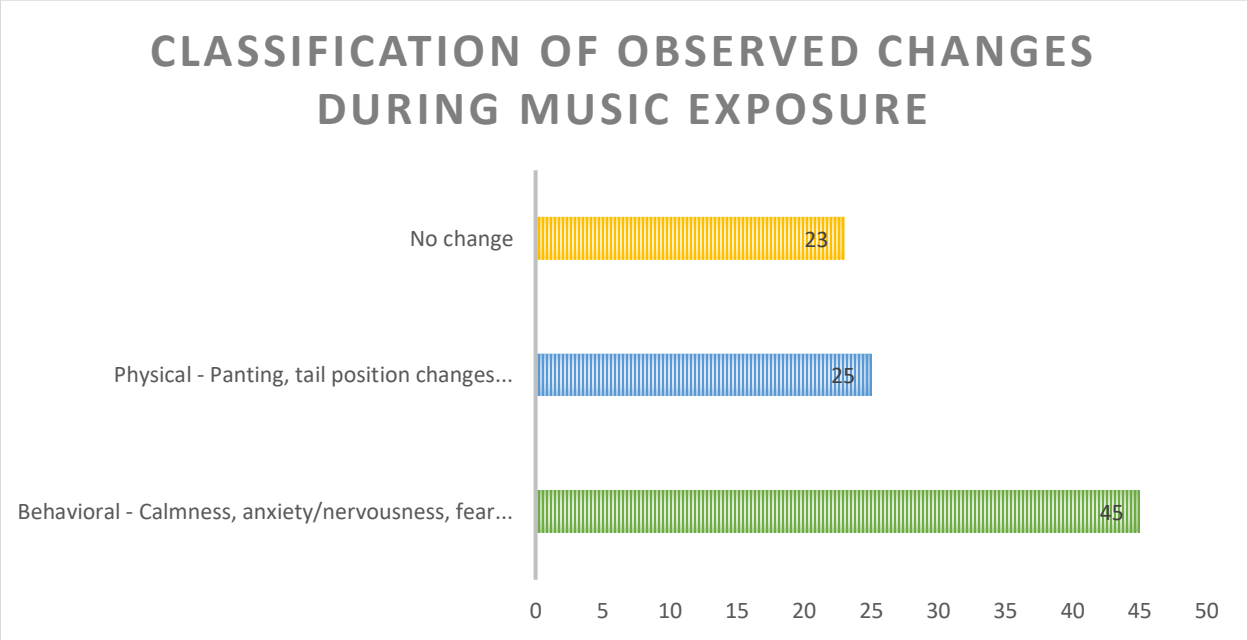

Figure IV – The classification of observed changes in canines during music exposure. Changes can be described as behavioral (45) highlighted in green, physical (25) in blue, or no changes noticed (23) in yellow.

The data shown above is not mutually exclusive, meaning respondents were able to select more than one option if the canine observed expressed both physical and behavioral changes upon stimulus. In total, 68 canines showed some form of change when exposed to stimuli. 45 canines showed a form of behavioral change (46.88%), 25 showed physical changes (26.04%),

and 23 canines showed no apparent physical or behavioral changes upon exposure (23.96%). Subjects were asked to describe any physical or behavioral changes they noticed during exposure, and Table II describes each of the entries in the exact language provided by the subject on the survey. (Appendix II)

CHANGES OBSERVED
She relaxes
He gets calm when I listen to piano music
Ever since she was a puppy, she will immediately relax when she listens to Lex Zeppelin. She will stop panting and crying and fall asleep.
She tends to go with the tune if it's chill, she's chill. If it's hype, she's intrigued.
Anxiety and walks out of room with loud music or heavy bass. Soft or medium toned music calms my dog.
My dog gets anxious and puts her ears down depending on how heavy the bass is on the song. She's yet to like any music really.
If the music is loud if super upbeat, he runs around crazy.
Higher pitches make him whine
Matches the changes in humans around it
She gets very calm when peaceful/slow music, is relaxed and sleepy.
Either more relaxed or energized.
No changes
Barks less at things outside
She totally chills out and relaxes -- like she's having a massage!

None
They both relax with 70’s (SiriusXM Bridge) classic rock and more excited with 2020’s metalcore (SiriusXM Octane).
If the music is too loud, he gets scared
She just seems happier!
My dog appears to be more alert and sensitive to noise.
When playing marimba, she would sit nearby but I always got the impression she didn't love it (ears weren't up, lying down, etc.)
My typically anxious dog usually mellows out and gets less hyperactive. She goes from pacing and crying to a less extreme form of anxiety (panting or laying down)
Head tilt, confusion
We listen to all types but mostly old rock and roll plus country. Dog is never afraid of music playing, usually laying on his bed relaxed
We generally play spa music if we go out and our golden retriever falls sound asleep!
Sometimes he gets wiggly if we are all dancing, he’s reactive to us reacting to the music.
If anything, he barks in the car if I sing too loud
Doesn't bark at outside noises
She likes Mannheim Steamroller’ Classical Gas
Some tones frighten him.
Cocks head at certain sounds. Shakes head as if trying to get rid of sound esp. loud rock music
Calmer when music is playing
He is much happier.
Reacts more to watching TV

My dog is very affected by the way music affects us. When we listen to exciting music and dance, he gets very excited and a little bit confused. He starts to jump and look around at us while we dance.
More chill. Depending on the music he knows we are leaving and will go to his pen.
No changes
none
Mellow music helps him relax in the car. If we listen to fast music, he gets mayfly with us.
N/A
No changes
In general, she likes music (we have always played music from the time she was a puppy, so she's used to it), but if it gets too loud, she will hide.
No changes
fawn still sleeps
Depends on the music. Calm/ sleepy when lullabies are being played for baby, or more hyper when rock or hip hop is played.
we played music while we were gone when we first got him before we were managing his anxiety with medication and pheromones. he started to associate music with us leaving and his separation anxiety and for a while it made him not anxious. now that he is medicated, he doesn’t get anxious with music anymore, but we still don’t play it while we are gone anymore.
More attentive
My dog is very scared of thunderstorms and when we turn on music on the TV, usually some kind of indie folk music, he stops pacing around and seems more content.
She knows something is different and she watches us to see how we react.

Noticeably more excited
n/a
None noticed
Usually goes and lays down and doesn't seek as much attention. But sometimes she dances with us too!
She focuses on people more and feels closer to us - we think!
I play the flute, and I can tell my dog doesn't like when I play higher octave pieces because he will leave my room, but occasionally he will stay and hang out if I'm playing low octave and less intense pieces
None
he gets a little scared by loud noises
There appears to be a few songs that she recognizes or maybe because I sing them louder
Acts the same with or without music.
he's very calm and curious.
More calm, likely to fall asleep depending on the music
Doesn't bark when I leave the house.
N/a
None noted
Calmer
calm
There was nothing
I blast music on my echo, and he just lies there's nothing happens
None

ears perk up
The music selections tend to be acoustic type melodies. I find that that our dog reaches a more relaxing state just as a human would.
Falls asleep
Turning on music has calming effect
Howling
Not much change.
He dances with us!
Lays down and relaxes.
He does not like rap
No changes
Haven't noticed!
Excited tail wagging, panting
He wags his tail and calms
He gets very interested when my sister is playing the flute. He wants to be as close to her as possible and sings along with her playing. He especially likes scales.
When I play calming music while working or meditating, he becomes very relaxed complete with deep audible breathing and twitching in his sleep.
My dog is a rescue and almost any noise is a disturbance to him. Any music above a certain volume and he will shake and hide, but he seems to enjoy and choose to lie under the speakers if it's an acceptable volume to him.
I haven't noticed any

She was having a seizure one time and when she was done, she was still panting and very shaken up, so we played classical music to help soothe her and she laid down and drank water and let us pet her and feed her treats which she wasn't allowing us to do before
We leave the radio on whenever we must leave him alone as it seems to calm him down!
She is very chill and doesn't seem to care at all. However, my dog I had before who passed away didn't seem to like music and would leave the room. I think it made her a little stressed
N/A
Sleeps
Meditation music relax him
She moves around especially when the children are up, singing and dancing. Also, she wants to be a part of it.
Excitement with "peppy" music and calmness with my meditation or soothing music
None that I noticed
When I turn music on in the house, it is a signal to my dog that I am not going to, in fact, take her outside to play frisbee... so she drops "frisbee" near her bed and curls up and glares at me.
He perks up and listens to some music- not common, though

Table II – Survey responses highlighting the observable changes in canines as described by owners. In the total 96 sample population, 73 responses highlight some form of change during music exposure.

After reviewing the above comments, it was found that while 68 canines presented some sort of change upon exposure to music, 61 canines showed some level of positive behavioral and/or physical change, and 12 canines showed negative behavioral and/or physical changes. Figure V compiles these observed changes into a pie chart for a visual view of the distribution.

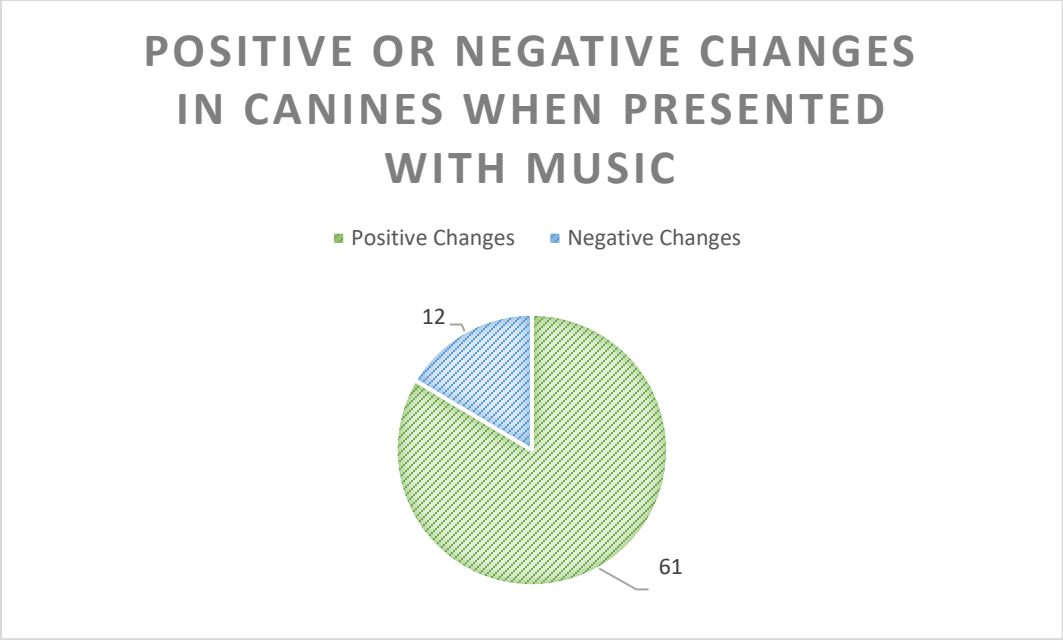

Figure V – Pie chart showing the distribution between canines showing a positive change when exposed to music (61), and canines showing a negative change when exposed to music (12). Responses could contain both positive and negative change depending on the type of music exposed to.

To conclude, 16.44% of canines that showed a level of change when presented with music had a negative reaction, where 83.53% of canines had a positive reaction upon the exposure of stimuli. This shows that although not all canines have a visible reaction/change during the exposure of music, those reported to show changes have an over 80% chance of showing positive or favorable behavior or physical changes.

CHAPTER V – DISCUSSION, LIMITATIONS, AND CONCLUSIONS

Discussion of Results and Implications

Upon the analysis of the results gained from the study, there is not only an impact on canines when exposed to music, but an overall positive impact on the behavior and physical

stature. Despite the differences in age of the sampled canines, 100% of the subject had been exposed to music at some point. However, it was found that canine owners noticed more behavioral/physical changes in puppies over both adults and seniors. 79% of responders who selected they own(ed) a puppy observed a physical/behavioral change, where only 69% and 70% of adult and senior canines respectively were observed to have the same changes. Over 70% of the sampled canines showed some form of change when exposed to music, supporting the conclusions drawn in studies conducted by Lindig et al., (2020), Kogan et al., (2012), and Wells et al., (2002). There are several factors that could possibly contribute to different levels of change/impact depending on the age of the canine. Puppies, typically hyperactive, have the possibility of either having a decreased likelihood of behavioral/physical change due to said hyperactivity, or increased behavioral/physical change due to their need for more sleep. To contrast, senior canines present a similar paradox, where although they usually have lower levels of energy due to increased age, external factors such as the gradual loss of hearing could result in no difference in reaction.

Of the 68 canines that were reported showing some form of reaction/response when exposed to stimuli, it was found that 25 canines exhibited some form of physical change. There is a wide variety of changes that can take place upon the exposure of foreign sounds or stimuli, including panting, the raising or lowering of the tail, and changes in ear position. The presence of these physical clues helps indicate to humans/pet owners how their dogs are feeling in that moment, where said changes in a canine when exposed to music confirms the basis that dogs hold a certain awareness to what humans have designated as “music”.

A question that can be further pondered is whether canines are able to “recognize” what is considered music by the definition of humans. Do canines recognize patterns such as chord

progressions, tempo changes, and relative keys? Canine behavioralist Nick Jones offers insight, stating although a definite answer to whether dogs can hear and process music in the same way humans do, they "may not be as perceptive to notes on a scale" (Jones, 2022). This can largely be explained by the increased range of hearing that canines possess in comparison to humans.

The survey results indicated that in addition of physical changes, behavioral changes were noticed and described by the subjects in 45 of the observed canines. Referring to the previous results that show changes in physical expression, it is important to note that physical and behavioral changes are not mutually exclusive and can occur simultaneously, since it is a method to how canines express their emotions. These behavioral changes included decreased stress/anxiety levels where the canine became calmer, hyperactivity, and visible excitement. Responses suggest the behavior of the canine changing/being impacted by the genre of music that was playing, where quite a few respondents wrote that when they were listening to classical music in particular, their canine showed calming behavioral effects such as sleeping, laying down, and general calm behavior. Seemingly contradictory, others report their canines appear calmer with "upbeat" music, including rock, techno, and metal. In these instances, a canine could be using its knowledge on familiarity and memories to facilitate this calming nature, since canines have the ability of feeding off the emotions of humans. The same response can be elicited in humans – often, humans present emotions of higher intensity when exposed to music that is considered "nostalgic" to them, such as bands and types of music they were exposed to during childhood and adolescence.

Simply stopping the collection of data at the changes observed does not indicate the possible benefits that music can have on canines, since it would not be known if these physical expressions and behaviors should be taken in a positive or negative way. To reiterate, 83.53% of

canines had a “positive” reaction upon the exposure of stimuli, where the other 16.44% of canines showed what can be considered as “negative” reactions or behaviors. When compiling the responses, many subjects reported “negative” behaviors such as dropping the ears, walking out of the room upon the presence of the stimulus, barking, or shaking of the head. Typically, it was reported that these instances of “negative” behaviors or expressions can’t be attributed to the presence of stimuli itself, but the characteristics of the music instead. For instance, these “negative” behaviors were commonly perceived where music with loud volumes, high pitch, or heavy bass levels were present. Although the reason for these behaviors is unknown and largely dependent on the individual canine and their personality, it could be the result of certain music sounding “threatening”, or better described as possessing similar sound characteristics to what the canine brain considers “dangerous”. In this case, the instinct of “fight or flight” takes over, where the canine feels forced to defend or remove itself from the stimulus.

A possible development that could arise from this expanding research field is the use of music therapy on canines. One subject reported that when their canine had just concluded having a seizure, the dog was very frightened and disoriented. The subject states that when they played classical music, the dog was able to calm down, shown by it drinking water, as well as accepting treats and physical affection. However, since the preceding observation does not contain a “control”, or baseline behavior, it should be taken with a grain of salt. Much like the human brain, the canine brain can create and respond to trauma stimuli. The process of music therapy aims to decrease these trauma stimuli, and it has been proven to work in humans. This response gives hope that the field of music therapy can be expanded to the veterinary field and has the possibility of benefiting millions of not only canines, but other pets and animals as well.

Limitations

As said previously, the field of how canines respond to music is still a developing field that will require many more hours of research and insight to reach an accepted theory. For this thesis, the primary limitation was the lack of time to produce research. In addition, since the survey administered was done via voluntary sampling, all responses, although anonymous, should be taken with the smallest grain of salt. Since many canine owners love and care for their canines deeply, the "placebo effect" can arise when presented with a survey, where the brain subconsciously produces inflated responses and reactions to real life situations, leading to increased levels of unintentional bias. In addition, since I am only an undergraduate student, I do not possess all the knowledge required to fully analyze the behavioral and physical expressions of canines and translate their "true meaning".

The lack of previous research within this field created a disadvantage when attempting to find necessary data and conclusions to support the information contained in this work. There is almost no research fully delving into this field, such as the impact on canines when exposed to varying genres, pitches, and environments where the stimulus is played. In addition, although there are recorded breed-based "typical" behaviors in canines, there is no significant research present that takes the breed and its associated traits into account upon stimulus exposure. The result of this is a highly complex field where research has only scratched the surface of the potential results that are able to be gained.

Ideally, further studies to contribute to this field should be performed by accredited individuals in the veterinary or animal cognitive science field. The model study would take many hundreds of hours to complete, analyzing the impacts of music on not only household dogs, but locations such as veterinary offices and animal shelters that have the potential of causing

increased cortisol levels in canines. The framework could be broken down into categories of music such as tempo, pitch, chord progressions, key changes, or genres, where canines could be classified by their “normal” cortisol/stress levels, breed, or setting. The result of this is a multidimensional problem that cannot be addressed looking at only one side.

Conclusion

To answer the primary question targeted in this work, the collected data supports that canine owners have reported their canines do express both physical and behavioral changes in response to musical stimuli. In addition, several of the responses received indicate that music exposure has largely positive impacts on canines when presented in stressful situations and settings. The desired outcome of this research is not only to add additional data to the developing field, but to raise awareness to pet owners as well as professionals working with canines by providing methods that can be used at a relatively low cost to provide much needed relief to the animals in their care.

There are a multitude of varying research methods that can expand on the work within this project. Anything from breed-based responses to varying methods in terms of pitch, genre, and sequential passages can provide additional information that has the possibility of improving the lives of canines depending on their breed or behavioral preferences.

A primary study that could be completed has to do with whether canines prefer to be exposed to music in the first place. To test this, two identical rooms could be arranged, each with the same incentive to enter, such as a bowl of food, treats, or toys. One room could be set up playing music, while the other remains silent. Upon entering, the canine has the choice of entering the room with the music, or without. This can be expanded on further to highlight

differences in pitch, genre, and volume of the stimulus to further indicate the canine's preference. A secondary test that could be performed includes exposing canines to various repeated pitches at different volumes, allowing for the deciding factor of whether a canine does not prefer a certain tonal pitch, or the volume of the of the stimulus has more impact on the behavior/physical state of the canine.

As humans, when we choose to adopt or care for a dog, we sign a mental "moral contract" that states there is an obligation to care and nurture for an animal that while has the capability of surviving on its own, thrives in an environment where it can bond and be nurtured. By using the insights conveyed within this work, the inseparable bond between a human and their companion can only flourish.

REFERENCES

Amaya, V., Paterson, M. B. A., Descovich, K., & Phillips, C. J. C. (2020). Effects of Olfactory and Auditory Enrichment on Heart Rate Variability in Shelter Dogs. *Animals*, *10*(8), 1385. https://doi.org/10.3390/ani10081385

Barber, A. L. A., Wilkinson, A. V., Montealegre-Z, F., Ratcliffe, V. F., Guo, K., & Mills, D. S. (2020). A comparison of hearing and auditory functioning between dogs and humans. *Comparative Cognition & Behavior Reviews*, *15*, 45–94. https://doi.org/10.3819/ccbr.2020.150007

Bowman, A., Spca, S., Dowell, F. J., & Evans, N. (2015). 'Four Seasons' in an animal rescue centre; classical music reduces environmental stress in kennelled dogs. *Physiology & Behavior*, *143*, 70–82. https://doi.org/10.1016/j.physbeh.2015.02.035

Brayley, C. R., & Montrose, V. T. (2016). The effects of audiobooks on the behaviour of dogs at a rehoming kennels. *Applied Animal Behaviour Science*, *174*, 111–115. https://doi.org/10.1016/j.applanim.2015.11.008

Cherry, K. (2023). Gardner's Theory of Multiple Intelligences. *Verywell Mind*. https://www.verywellmind.com/gardners-theory-of-multiple-intelligences-2795161

Cpdt, S. G. M. (2020). How To Read Dog Body Language. *American Kennel Club*. https://www.akc.org/expert-advice/advice/how-to-read-dog-body-language/

De La Harpe, T. (2022, October 17). The Meaning Behind Your Dog's Ear Positions: What Your Dog's Ears Can Tell You - PawSafe. *PawSafe*. https://pawsafe.com/blogs/ear-care/the-meaning-behind-your-dogs-ear-positions-what-your-dogs-ears-can-tell-you#Dog_Ear_Position_Chart

Do dogs like music? (2022, August 24). Petplan. https://www.petplan.co.uk/pet-information/dog/advice/do-dogs-like-music/#:~:text=own%20particular%20taste%3F-,Can%20dogs%20hear%20music%3F,to%20notes%20on%20a%20scale.

Epperson, G. (2023, March 30). *Music | Art Form, Styles, Rhythm, & History*. Encyclopedia Britannica. https://www.britannica.com/art/music

H.M. Government, Eatherington, C., Barber, A., Mills, D., Wilkinson, A., & Soulsbury, C. (2021). An Introduction to How Dogs Hear. *CPNI*, *1*.

How Do We Hear? (2022, March 16). NIDCD. https://www.nidcd.nih.gov/health/how-do-we-hear

Hunter, P. S., & Schellenberg, E. G. (2010). Music and Emotion. In *Springer handbook of auditory research* (pp. 129–164). Springer Nature. https://doi.org/10.1007/978-1-4419-6114-3_5

John Blacking, *How Musical is Man?* (Seattle: University of Washington Press, 1973), p. 3; Kay Shelemay, *Soundscapes: Exploring Music in a Changing World* (New York, London: W.W. Norton and Company, 2001).

Kaminski, J., & Marshall-Pescini, S. (2014). *The Social Dog: Behavior and Cognition*. Elsevier.

Kinnaird, R. F., & Wells, D. L. (2022). The effect of auditory stimulation on pet dogs' reactions to owner separation. *Applied Animal Behaviour Science*, *254*, 105688. https://doi.org/10.1016/j.applanim.2022.105688

Koelsch, S. (2018). Investigating the Neural Encoding of Emotion with Music. *Neuron*, *98*(6), 1075–1079. https://doi.org/10.1016/j.neuron.2018.04.029

Kogan, L. R., Schoenfeld-Tacher, R., & Simon, A. (2012). Behavioral effects of auditory stimulation on kenneled dogs. *Journal of Veterinary Behavior*, *7*(5), 268–275. https://doi.org/10.1016/j.jveb.2011.11.002

Korteling, J., Van De Boer-Visschedijk, G. C., Blankendaal, R. A., Boonekamp, R., & Eikelboom, A. (2021). Human- versus Artificial Intelligence. *Frontiers in Artificial Intelligence*, *4*. https://doi.org/10.3389/frai.2021.622364

Lindig, A. M., McGreevy, P. D., & Crean, A. J. (2020). Musical Dogs: A Review of the Influence of Auditory Enrichment on Canine Health and Behavior. *Animals*, *10*(1), 127. https://doi.org/10.3390/ani10010127

Lindsay, S. R. (2013). *Handbook of Applied Dog Behavior and Training, Adaptation and Learning*. John Wiley & Sons.

Malloch, S., & Trevarthen, C. (2018). The Human Nature of Music. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.01680

Milnea. (2023, March 28). Goosebumps: The What, When and Why. *Cleveland Clinic*. https://health.clevelandclinic.org/why-do-you-get-goosebumps/

Music - New World Encyclopedia. (2022). https://www.newworldencyclopedia.org/p/index.php?title=Music&oldid=1104174

Music. (2005). https://chnm.gmu.edu/worldhistorysources/unpacking/musicwhatmakes.html

O'Malley, C. I. (2020). Dogs & Music: Do Dogs Like Music? *Petozy*. https://petozy.com/blogs/about-dogs/do-dogs-like-music

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, *39*(6), 1161–1178. https://doi.org/10.1037/h0077714

Scherer, K. R. (2001). Appraisal considered as a process of multilevel sequential checking. In K. R. Scherer, A. Schorr, & T. Johnstone (Eds.), *Appraisal processes in emotion: Theory, methods, research* (pp. 92–120). Oxford University Press.

Scherer, K. R., & Coutinho, E. (2013). How music creates emotion. In *Oxford University Press eBooks* (pp. 121–145). https://doi.org/10.1093/acprof:oso/9780199654888.003.0010

Stregowski, J. (2022). Common Canine Behaviors Explained. *The Spruce Pets*. https://www.thesprucepets.com/common-canine-behavior-explained-1118306

Wells, D. L., Graham, L., & Hepper, P. (2002). The Influence of Auditory Stimulation on the Behaviour of Dogs Housed in a Rescue Shelter. *Animal Welfare*, *11*(4), 385–393. https://doi.org/10.1017/s0962728600025112

What is Epigenetics? The Answer to the Nature vs. Nurture Debate. (2020, October 30). Center on the Developing Child at Harvard University. https://developingchild.harvard.edu/resources/what-is-epigenetics-and-how-does-it-relate-to-child-development/#:~:text=%E2%80%9CEpigenetics%E2%80%9D%20is%20an%20emerging%20area,is%20no%20longer%20a%20debate

IMAGES

Body Language of Dogs - The Animal Medical Center. (2022, January 20). The Animal Medical Center. https://www.amcny.org/pet_health_library/body-language-of-dogs/

Faaa, M. E. P. a. C. (2017, November 29). *Bone Anchored Hearing Systems*. Temple Health. https://www.templehealth.org/about/blog/bone-anchored-hearing-systems

Appendix I

Music and Your Dog!

A Quick Survey to aid my Honors Thesis!

* Indicates required question

1. How old is your dog? *

Mark only one oval.

- ◯ Puppy - 0 - 2 years old
- ◯ Adult - 2 - 8 years old
- ◯ Senior - > 8 years old

2. Has your dog ever been exposed to music? *

Mark only one oval.

- ◯ Yes
- ◯ No

3. Have you noticed any changes in your dog when music is playing? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe
- ◯ Other: _____

4. Describe the changes: *

5. What would you classify the changes in your dog? *

Check all that apply.

- [ ] Behavioral - Calmness, anxiety/nervousness, fear...
- [ ] Physical - Panting, tail position changes...
- [ ] No change
- [ ] Other: _____

6. If "Other", please describe

7. By selecting "yes" below, you acknowledge your anonymous answers may be used in the development of my Honors Thesis Paper through the University of Vermont Honors College. *

Mark only one oval.

- ◯ Yes

Appendix II

CHANGES OBSERVED
She relaxes
He gets calm when I listen to piano music
Ever since she was a puppy, she will immediately relax when she listens to Lex Zeppelin. She will stop panting and crying and fall asleep.
She tends to go with the tune if it's chill, she's chill. If it's hype, she's intrigued.
Anxiety and walks out of room with loud music or heavy bass. Soft or medium toned music calms my dog.
My dog gets anxious and puts her ears down depending on how heavy the bass is on the song. She's yet to like any music really.
If the music is loud if super upbeat, he runs around crazy.
Higher pitches make him whine
Matches the changes in humans around it
She gets very calm when peaceful/slow music, is relaxed and sleepy.
Either more relaxed or energized.
No changes
Barks less at things outside
She totally chills out and relaxes -- like she's having a massage!
None
They both relax with 70's (SiriusXM Bridge) classic rock and more excited with 2020's metalcore (SiriusXM Octane).

If the music is too loud, he gets scared
She just seems happier!
My dog appears to be more alert and sensitive to noise.
When playing marimba, she would sit nearby but I always got the impression she didn't love it (ears weren't up, lying down, etc.)
My typically anxious dog usually mellows out and gets less hyperactive. She goes from pacing and crying to a less extreme form of anxiety (panting or laying down)
Head tilt, confusion
We listen to all types but mostly old rock and roll plus country. Dog is never afraid of music playing, usually laying on his bed relaxed
We generally play spa music if we go out and our golden retriever falls sound asleep!
Sometimes he gets wiggly if we are all dancing, he's reactive to us reacting to the music.
If anything, he barks in the car if I sing too loud
Doesn't bark at outside noises
She likes Mannheim Steamroller' Classical Gas
Some tones frighten him.
Cocks head at certain sounds. Shakes head as if trying to get rid of sound esp. loud rock music
Calmer when music is playing
He is much happier.
Reacts more to watching TV
My dog is very affected by the way music affects us. When we listen to exciting music and dance, he gets very excited and a little bit confused. He starts to jump and look around at us while we dance.

More chill. Depending on the music he knows we are leaving and will go to his pen.
No changes
none
Mellow music helps him relax in the car. If we listen to fast music, he gets mayfly with us.
N/A
No changes
In general, she likes music (we have always played music from the time she was a puppy, so she's used to it), but if it gets too loud, she will hide.
No changes
fawn still sleeps
Depends on the music. Calm/ sleepy when lullabies are being played for baby, or more hyper when rock or hip hop is played.
we played music while we were gone when we first got him before we were managing his anxiety with medication and pheromones. he started to associate music with us leaving and his separation anxiety and for a while it made him not anxious. now that he is medicated, he doesn’t get anxious with music anymore, but we still don’t play it while we are gone anymore.
More attentive
My dog is very scared of thunderstorms and when we turn on music on the TV, usually some kind of indie folk music, he stops pacing around and seems more content.
She knows something is different and she watches us to see how we react.
Noticeably more excited
n/a
None noticed

Usually goes and lays down and doesn't seek as much attention. But sometimes she dances with us too!
She focuses on people more and feels closer to us - we think!
I play the flute, and I can tell my dog doesn't like when I play higher octave pieces because he will leave my room, but occasionally he will stay and hang out if I'm playing low octave and less intense pieces
None
he gets a little scared by loud noises
There appears to be a few songs that she recognizes or maybe because I sing them louder
Acts the same with or without music.
he's very calm and curious.
More calm, likely to fall asleep depending on the music
Doesn't bark when I leave the house.
N/a
None noted
Calmer
calm
There was nothing
I blast music on my echo, and he just lies there's nothing happens
None
ears perk up
The music selections tend to be acoustic type melodies. I find that that our dog reaches a more relaxing state just as a human would.

Falls asleep
Turning on music has calming effect
Howling
Not much change.
He dances with us!
Lays down and relaxes.
He does not like rap
No changes
Haven’t noticed!
Excited tail wagging, panting
He wags his tail and calms
He gets very interested when my sister is playing the flute. He wants to be as close to her as possible and sings along with her playing. He especially likes scales.
When I play calming music while working or meditating, he becomes very relaxed complete with deep audible breathing and twitching in his sleep.
My dog is a rescue and almost any noise is a disturbance to him. Any music above a certain volume and he will shake and hide, but he seems to enjoy and choose to lie under the speakers if it’s an acceptable volume to him.
I haven’t noticed any
She was having a seizure one time and when she was done, she was still panting and very shaken up, so we played classical music to help soothe her and she laid down and drank water and let us pet her and feed her treats which she wasn’t allowing us to do before
We leave the radio on whenever we must leave him alone as it seems to calm him down!

She is very chill and doesn’t seem to care at all. However, my dog I had before who passed away didn’t seem to like music and would leave the room. I think it made her a little stressed
N/A
Sleeps
Meditation music relax him
She moves around especially when the children are up, singing and dancing. Also, she wants to be a part of it.
Excitement with “peppy” music and calmness with my meditation or soothing music
None that I noticed
When I turn music on in the house, it is a signal to my dog that I am not going to, in fact, take her outside to play frisbee... so she drops "frisbee" near her bed and curls up and glares at me.
He perks up and listens to some music- not common, though