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### Understanding How High Levels of Noise Affect the Equine Auditory System

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University of Northern Colorado  
Greeley, Colorado

UNDERSTANDING HOW HIGH LEVELS OF NOISE  
AFFECT THE EQUINE AUDITORY SYSTEM

A Thesis  
Submitted in Partial  
Fulfillment for Graduation with Honors Distinction and  
the Degree of Bachelor of Science

Shelby Brown

College of Natural Health and Sciences

MAY 2021

UNDERSTANDING HOW HIGH LEVELS OF NOISE  
AFFECT THE EQUINE AUDITORY SYSTEM

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## Abstract

Mounted shooting is becoming a very popular sport within the equestrian community, exposing many horses to extreme levels of noise that the animals would not be exposed to otherwise. I selected this project because it is important for me to know how this hobby that I personally enjoy is impacting the health and well-being of my equine partners. Veterinarians can provide an elementary answer by clapping and checking for a physical reaction. However, that does not tell the client much other than the animal responded to one auditory cue.

It is important to understand how firearm exposure could affect equine hearing to determine if these horses are being exposed to excessive loud and dangerous acoustic stimuli. Although a variety of studies have focused on how the sounds of firearms affect humans and other species, such as rats and dogs, there is currently no research available on how these loud sounds may be impacting a horse's auditory function.

Using the BAER (brainstem auditory evoked response) examination on a total of 12 equines split into two groups, horses unexposed to noise and horses exposed to firearm noise, the research team was able to compare data to answer the research question: How do high levels of noise affect the equine auditory system? The results were analyzed by comparing the absolute latency of wave V of the BAER. The BAER examination is an objective test that measures the changes in voltage in the EEG (electroencephalogram) response following the acoustic stimulation provided by the testing team.

The exposed group of seven equines met specific criteria to be selected. Each horse must have been frequently exposed, at least 3 days a month for at least one year, to be considered for this research. Ages ranged from 10 to 18.8 years in the exposed group, and 11.4 to 18.8 years in the

nonexposed group. The five horses in the nonexposed group must have had zero known noise exposure. There were no breed or color restrictions for any animal in this study.

The purpose of this research was to determine if there is a difference in BAER responses between adult horses that were frequently exposed to firearm noise versus those horses who had not been exposed to noise.

### **Statement of the Problem**

Exposure to brief or constant high levels of noise affects one's ability to hear, causing a sensorineural or more rarely conductive hearing loss. Sensorineural hearing loss may be caused by any issues within the inner ear or the eighth cranial nerve (vestibulocochlear nerve), and conductive hearing loss is related to problems in the middle or outer ear. This hearing loss associated with noise exposure is commonly referred to as noise induced hearing loss (NIHL) and is prevalent in those who work in loud settings such as factories, use heavy machinery, or use firearms (Martin & Clark 2019). Another term used to describe NIHL is acoustic trauma. The acoustics in the environment(s) that surround us may cause trauma to the anatomical structures in the inner ear, causing decrease in physiological function (Martin & Clark 2019).

Noise induced hearing loss has been studied significantly in humans and canines, but there is less research and understanding of how noise exposure affects the equine auditory system. Many equines are exposed to frequent loud noises. Mounted shooting as well as mounted patrol has become widely popular in our culture and could be affecting the horses more than we understand. There can be a wide variety of causes and knowing the type and configuration hearing loss allows a researcher to pinpoint a possible source of loss (Strain 2015). Understanding the effects of the sound environment on equine hearing will allow us to pinpoint if there is a correlation between high amounts of noise exposure and hearing loss.

## **Review of the Literature**

### **Equine Auditory System**

The normal equine ear has the ability to locate sounds all around, focus on one signal rather than others, and hear acoustic events farther away than humans can. Equines have a similar composition of the external, middle and inner ears compared to humans: the pinna, external auditory meatus, tympanic membrane, ossicles, cochlea, vestibular system and cranial nerve pathway are similar to those of other mammalian species. The equine auditory system can hear sounds ranging from 55 to 33,500 Hz with the best sensitivity at 1,000 Hz to 16,000 Hz (Heffner & Heffner 1983), while humans hear frequencies from 20 to 20,000 Hz. This suggests that equines can detect much higher sounds than humans but cannot detect some of the lower frequencies.

Some differences noted by Blanke, Aupperle, Seeger, Kubick, and Schusser (2014) were additional ridges in the external auditory meatus that were not consistent in human anatomy. The ceruminous glands in the equine pinna are coiled tubular glands mimicking appearance of sweat glands. Equines also have a special musculature that allows the ear to rotate 180 degrees to help them locate and funnel sounds. The tensor tympani muscle is larger than in humans and is fan shaped in appearance. The average number of coils for a horse cochlea is 2.25 turns rather than the 2.5 turns present in most humans. The importance of understanding both the similarities and differences of the equine acoustic organ provides us with a better understanding of clinical aspects (Blanke et al., 2014). With this understanding, we are able to identify the main focus and physiological location of a possible hearing loss as well as alter our expectations in response time to the BAER test.

## **Noise Induced Hearing Loss (NIHL)**

Noise induced hearing loss occurs when an individual is exposed to high levels of noise. These sounds can be an extremely loud burst, or loud sounds that the individual has been exposed to over an extended period of time. (National Institute on Deafness and Other Communication Disorders, 2020). The sound damages the structures of the auditory system causing a temporary threshold shift or long-term loss of hearing.

When the hearing loss is considered conductive due to noise exposure, the sound is so damaging that it could rupture the ear drum or damage the ossicles, affecting the outer and middle ear function. However, it is most common for noise induced hearing loss to be sensorineural and damage the sensitivity of outer hair cells. Noise induced hearing loss can be short term and have a temporary threshold shift (Strain, 2015), or it can result in long-term damage even if the patient does not realize it; the hair cells will never “heal” once they have been affected. Many patients with NIHL commonly present with tinnitus (National Institute on Deafness and Other Communication Disorders, 2020).

### *Ear physiology in NIHL*

As mentioned before, NIHL is damage to the hair cells and other structures in the inner ear that vibrate in response to sound waves at specific frequencies (Schneider, 2019). When a sound is presented, the tympanic membrane vibrates, moving the three ossicles (malleus, incus, and stapes); the footplate of the stapes pushes on the oval window transducing the acoustical mechanical energy into electro-chemical energy in the cochlea. The cochlea has tonotopic (frequency) organization with the high frequencies coded at the basal end and low frequencies on the apical end. Movement of the endolymph within the scala media creates a traveling wave along the basilar membrane



until it reaches a maximum displacement, and then the wave quickly dies (National Institute on Deafness and Other Communication Disorders, 2020).

When it comes to noise induced hearing loss, there is little damage on the apical portion, but the outer hair cells, in the organ of Corti, may be severely damaged.

Focusing on the cochleas of rats after noise exposure, Chen and Fechter (2003) found that hair cells were not completely dead; however, their sensitivity was much lower compared to those who were not exposed (Chen & Fechter, 2003). There is also permanent damage to the cochlear neurons that adds to the increase in hearing thresholds in patients (Kurabi et al., 2017). In previous research focusing on humans, a swelling of the afferent nerve endings underneath the inner hair cells was found, which can suggest an overproduction of glutamate from overstimulated hair cells. It has also been reported that the excitotoxicity that the hair cells produced when exposed to loud sounds is irreversible, which can eventually lead to NIHL (Kurabi et al., 2017).

NIHL is correlated with the exposure to a sudden extremely loud sound, or constant exposure to a loud sound. Now that has been said many times but what does that mean? It means that for those who are working in environments where the sound is over 85 dB, they can have a total of 8 hours sound exposure for the entire day. The National Institute for Occupational Safety and Health (NIOSH), a program that is part of the CDC, determines safe levels of exposure for an individual; they claim a person can be exposed to 85 dB for 8 hours for total daily sound exposure. By using a 3-dB exchange rate, they can determine how much exposure is determined safe. NIOSH exposure parameters are as follows: 85 dB SPL for 8 hours, 88 dB SPL for 4 hours, 91 dB SPL for 2 hours, 94 dB SPL for 1 hour, etc. Exceeding these sound exposure recommendations

often is why NIHL is so common (Centers for Disease Control and Prevention, 2020). However, loud bursts such as firearms reach well over 100 dB and it is important to realize how even one sound can be damaging (Schneider et al., 2019)

### **Auditory Brainstem Response**

The brainstem auditory evoked response (BAER) is the test that measures the evoked potential after a stimulus has been applied. The stimulus can be delivered by air conduction as pulses or tone bursts or by bone conduction through the mastoid. It is important to be aware that when using the BAER test there must be at least 3 electrodes used for recording, grounding, and reference. When testing animals, these electrodes are small-gauge subcutaneous needle electrodes placed on the top of the head, by the tragus, and either contralateral to the ear or over the dorsal spinous process (King & Sininger, 1992). By placing headphones and providing an acoustic stimulus with intensity anywhere from 90 to 120 dB SPL, the electrodes will record neurologic activity (Oken & Phillips, 2009). A waveform is produced that contains seven peaks labeled waves I through VII, but in the clinical setting, we label and focus on waves I, III, and V. When it comes to testing an animal with normal hearing, we see a symmetrical BAER response between both ears (Webb, 2009; Møller & Jannetta, 1982; Møller & Jannetta, 1985). We typically see a series of five peaks that are identified during the first 10 milliseconds after the stimulus is presented (Webb, 2009).

#### *Waves of the Brainstem Auditory Evoked Response Test for Humans*

When testing an individual with a normal audiogram, we will be able to see and label the five main peaks. We are then able to identify the general anatomical location of each wave. Some waves can be generated by one region, or one wave can be generated

by more than one anatomical location (Møller & Jannetta, 1982; Møller & Jannetta, 1985; Møller et al., 1995).

The first wave (wave I) can be seen as early as 1 to 2 milliseconds after the onset of the auditory stimulation and has been identified as generated at the distal portion of the eighth nerve. The afferent nerve fibers traveling away from the cochlea and entering the internal auditory meatus are the main generators of wave I. The peak of wave I drops off into a trough after the signal has passed through the internal auditory meatus (Oken & Phillips, 2009; Møller & Jannetta, 1982).

Wave II is also generated by the eighth nerve but from the proximal portion of the nerve, close to the brainstem near the junction of the pons and the medulla. Sometimes this signal is not always picked up in BAER testing due to a shorter length of the nerve (Oken & Phillips, 2009; Møller & Jannetta, 1982; Møller & Jannetta, 1985; Møller et al., 1995).

Wave III is commonly associated with the pons near the superior olivary complex. There may be noticeable changes in the wave if there is an abnormality or lesion within the superior olivary complex (Britt & Rossi, 1980; Oken & Phillips, 2009).

The generator site that creates the peaks seen for wave V is the lateral lemniscus or inferior colliculus. This wave is the most prominent of them all and is the best at indicating an abnormality if delayed or not present at  $4.71 \pm 0.24$  ms for a horse (Rolf et al., 1987)

Waves VI and VII, although part of the BAER response, are harder to pinpoint generators for. These are less “important” when looking at the evoked potentials for clinical use (Møller & Jannetta, 1982).

### *BAER Testing with Horses*

Best practice for BAER testing on horses is still being determined. Some research shows a correlation of hearing loss with genetic markers and/or age. Looking into the difference in latencies, there has been little found that says that gender or breed, besides the American Paint Horse, influences test results (Magdesian et al., 2009).

Older horses begin to show a decline in threshold and partial deafness compared to younger horses. Aleman et al. (2014) found that of 76 horses, 57 showed decline compared to normal hearing levels and those horses were 17 to 22 years of age. They were able to determine that the most common bilateral auditory loss was sensorineural, but the causes could have been congenital, thyrohyoid osteoarthropathy, multifocal brain disease, and/or otitis media or interna (Aleman et al., 2014). However, Melvin (2018) found that there were no differences in thresholds, latencies, or amplitudes in BAER results of older and younger horses. There were some “insignificant” differences between the groups that could be defined as presbycusis in terms of some hearing loss that may also be attributed to noise exposure, environments, and/or ototoxicity.

Another cause for abnormal BAER results stems from congenital factors. It has been linked to animals with white pigmentation. The overall lack of pigmentation has been correlated to underdeveloped organs. These organs can be intestinal, vital, or auditory organs (Strain, 2015). The American Paint Horse, if not marked with lethal white syndrome, is more prone to underdeveloped auditory systems, which can lead to unilateral or bilateral hearing loss (Harland et al., 2006)

When looking over the methods for evaluating the auditory systems of animals, one that seems to be the most effective is the BAER test. In early studies, the active electrode was placed on the forehead, the reference electrode was placed at the bottom of

the ear canal, and the ground electrode was placed on the outside of the pinna of the contralateral ear. One ear at a time was tested with a bandpass filter of 300 to 8000 Hz. The auditory stimulus was presented at 55 clicks per second in 10 dB increments ranging from 10 dB HL to 90 dB HL until they had the ability to identify the thresholds (Marshall, 1985).

In 1990, Mayhew and Washbourne used a different method of testing. They used moderately sedated horses and placed the electrodes on the vertex and zygomatic processes on both sides of the head. By using the sedation, they were able to ensure that the results obtained were from the acoustic stimulation. They used intensities ranging from 30 dB HL to 100 dB HL. Using a higher sampling rate of clicks, they were also able to obtain more results. They found that it helps to mask the non-test ear with at least 10 dB of white noise to ensure they are getting information from only one ear (Mayhew & Washbourne, 1990).

### **Firearm Noise Levels**

Firearms can release large booms of sound, damaging our auditory system. NIOSH considers safe levels of daily total exposure: 85 dB SPL for 8 hours, 88 dB SPL for 4 hours, 91 dB SPL for 2 hours, 94 dB SPL for 1 hour, etc. (CDC, 2020). A firearm's peak sound pressure level can range from 140 dB SPL to 175 dB SPL. The opposite ear (away from the barrel) is often exposed to levels as high as 155 dB SPL. That is enough sound to damage the auditory system (Murphy et al., 2012).

#### *How loud sounds affect working animals*

Dogs who have been exposed to high levels of sound such as firearm noise may demonstrate bilateral sensorineural hearing loss. In one study of three dogs, one dog never had the ability to regain his hearing, and the other was able to regain hearing after

doses of Vitamin B, E, and N-acetyl-cystine. The three dogs tested worked in loud occupation settings (Schneider et al., 2019).

The dog in Case 1 worked as a sniffer for the Metropolitan Police in the United Kingdom. When training began, the dog had no hearing abnormalities and was considered normal, but later had to be woken by physical stimulus as anything verbal or acoustic was not working. The BAER results determined that the bilateral threshold was at 80 dB HL (Schneider et al., 2019)

Case 2 was a working hunting dog (otherwise called a gundog) with exposure to at least 40 shots a year. In this case, the owner claimed that the dog was less and less responsive when it came to hearing a whistle. Although there were no obtained BAER results due to a hardware crash, with no evidence of abnormalities either physical or neurogenic, they were able to conclude that the dog had some form of hearing loss (Schneider et al., 2019).

The Case 3 dog was a working police dog that would often be exposed to exercises where the firearm was fired five times near the right ear with an estimated noise level at 140 dB SPL. One day the dog had a hard time hearing sounds when lying on his side as well as hearing verbal cues in the field. There was an absence of waveforms in the right ear during the BAER examination, and it was concluded that there was a “unilateral NIHL” (Schneider et al., 2019).

This study, although not large was able to identify that NIHL is likely to be underdocumented in working canines. The issue is much larger than what the veterinary community believes and can impact the behavior of a canine in the field. As dogs are not

able to tell us that they cannot hear, it is the job of the owner to look for the signs for hearing loss if their canine is working in loud settings (Schneider et al., 2019).

### **Conclusion**

While there is an understanding of the effects of noise on the human and canine auditory systems, there is little we know about effects that it has on equine hearing. We have research to determine the anatomical and physiological similarities and differences of their hearing systems as well as how high levels of noise affect other species. There is still little we understand about the effects that high levels of noise exposure such as firearms have on horses. With shooting sports and working horses, it would be important to understand how noise can affect horses in the short and long term. By specifically looking at horses and their hearing, we may be able to add knowledge about noise induced hearing loss in horses and determine if intervention is needed.

## Methodology

### Participants

This project was approved by the Institutional Animal Care and Use Committee (IACUC) before recruitment and testing were completed to obtain BAER examination results from a total of 12 equines. Five of the horses were grouped into a non-exposed group (C1-C5); all had zero exposure to firearms with ages ranging from 10 years to 18.8 years. The remaining seven horses were grouped into the exposed group (E1-E5), ages ranging from 11.4 years to 18.8 years (see Table 1).

**Table 1.**

*Subject characteristics.*

Subject	Physical Factors	Age (years)	Exposure Time (years)
E1	Roan, grade, gelding	17.8	6
E2	Mustang, black, 4 white stockings, gelding	18.8	10
E3	Palomino, gelding, no white markings	11.6	4
E4	Bay, grade, gelding	13.8	2
E5	Black and white paint with blue eye, mare, APHA	11.4	5
E6	Bald face sorrel, grade, gelding	14.8	3
E7	Grey, AQHA, mare	12.5	4
C1	Sorrel, AQHA, gelding	11.8	None
C2	Fleabitten grey, arabian, gelding	18.8	None
C3	Sorrel, AQHA, mare, moon blindness in left eye	17.6	None
C4	Buckskin, AQHA, gelding	18.6	None
C5	Black and white paint, grade, mare	11.4	None

To be considered exposed, horses must have been repeatedly exposed to firearms over a period of at least two years. The horses were of varying breeds and backgrounds, as breed was not a specific factor when considering the qualifications for this research. Some of the noteworthy abnormalities within the participant pool include: one horse in the control group was diagnosed with moon blindness four years ago (2017), and one



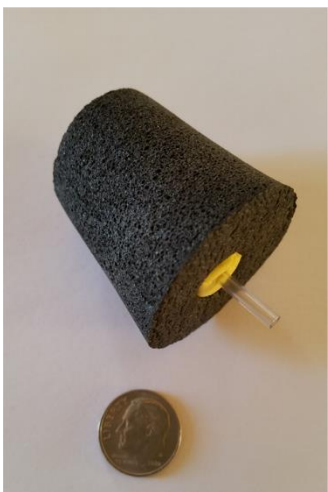
horse within the exposed group was a black and white paint mare with one brown eye and one blue eye. Each horse owner signed a consent form that described the procedure and the purpose of the study. All testing was done on the owner's premises or that of their contracted boarding facility. The horses were held by the owners in a rope halter and lead rope, either outside or in an indoor arena. All horse owners were given a pair of Cashel foam earplugs to practice inserting and removing the earplug, both ensuring comfort and desensitizing the horse to having an object in the ear.

#### *Preparation of Equines*

On the day of testing, all horses had a thin film of lidocaine topical cream (lidocaine 2.5%/prilocaine 2.5%) applied to the site of electrode placement (side of neck, middle of forehead, and above C2). Rhythmlink disposable bent subdermal needle electrodes with a 13 mm length and 0.4 mm diameter were placed in the middle of the forehead, on the side of the neck, and above C2 under the mane. The lidocaine was rubbed in and absorbed before placing electrodes, which were then inserted while standing at the right shoulder of the horse. By pinching the skin and pushing, the electrodes were inserted with the opposite hand. A check for correct placement was conducted by running the index finger over the placed electrode to make sure the needle was able to be felt under the skin. Vet wrap was placed around the horse's neck in between placement of the ground and reference electrodes to ensure they remained in place if the horse were to move (Figure 1).

**Figure 1***Horse prepared for BAER testing*

After placement of the electrodes, standing at a diagonal between the horse's nose and shoulder, the research team placed the Cashel earplug, with the ER2 insert earphone in the middle, into the ear. As soon as the earplug was correctly placed, the clinician put vet wrap around the pinna to ensure no movement of the earplug.

**Figure 2***Cashel earplug*

### *Obtaining Data*

The Intelligent Hearing Systems USB box with Smart EP software version 5.42 was connected to an HP laptop computer with a Windows 10 operating system. Electrode impedance was checked and monitored with a 2-channel Opti-Amp power transmitter prior to each test and impedance was kept between 1 and 3 kiloOhms at the electrode sites. If the electrode impedance was not within acceptable parameters, we would adjust the electrode until we obtained the desired impedance. By using a 100-microsecond broadband click with a 12,000 HX bandwidth power spectrum, we elicited a response. A click stimulus produced by the computer was directed into the Cashel earplug to the ear (Figure 2). The click stimulus was presented at a rate of 21.1 clicks per second using a rarefaction polarity. The stimulus intensity for all horses was 118 dB peSPL in the right ear. One horse from each group was tested for hearing threshold as well, starting at 118 dB peSPL decreasing in 10 dB increments until wave V was no longer visible. At least two recordings at each intensity were collected in a 12 ms window to ensure reliable results.

### **Results**

Absolute latencies of waves I, III, and V, and interpeak intervals of I-III, III-V and I-V were measured at 108 dB SPL. Wave V peaks were identified and agreed upon between the researcher and one professional experienced in BAER waves. The two to three latency measurements for each participant were averaged (Table 2) and then compared between groups using the Mann-Whitney U two-tailed nonparametric statistical test. There was no statistical difference between the exposed and the nonexposed group for the absolute latency of wave V ( $N = 12$ ,  $p = .255$ ). The latencies obtained for all horses are in agreement with those reported by Aleman et al. (2014).

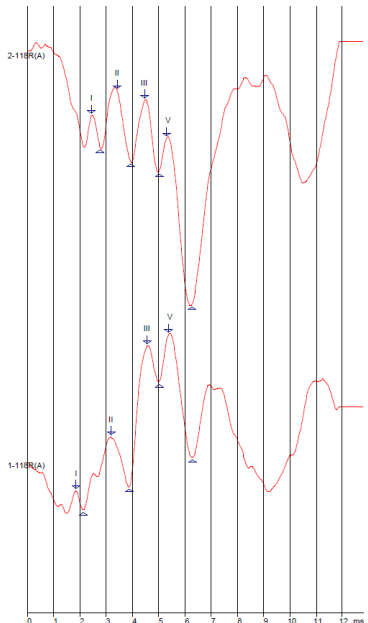
**Table 2**

*Mean BAER latencies for each subject. Subjects C1-C5 were in the nonexposed group; subjects E1-E7 were horses exposed to firearm noise.*

Participant	Wave I	Wave II	Wave III	Wave IV	Wave V
C1	1.815	2.3	3.2	4.315	5.235
C2	1.49	2.38	3.56	4.09	5.33
C3			3.59	4.35	5.385
C4	0.95		3.285	4.265	5.315
C5	1.925	2.435	3.305	4.59	5.4
E1				4.5	5.215
E2				4.345	5.175
E3	1.11		3.34	4.165	5.275
E4				4.055	5.044
E5	1.775		3.71		5.4
E6		2.41	3.49	4.36	5.425
E7		2.41	3.39	4.055	5.205

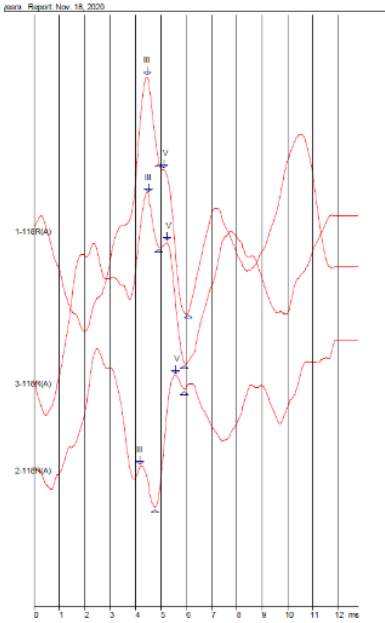
After determining that there were no wave V differences, the team analyzed the overall morphology of the waveforms. The control group horses were considered to have good wave morphology and the exposed horses ranged from fair-to-good morphology to poor morphology. The morphology was categorized by comparing visibility of waves and overall repeatability between wave forms. Figure 3 represents a good waveform and Figure 4 suggests a poor waveform in which some, but not all of the waves, are present with poor repeatability. Figure 5 shows extremely poor wave morphology, taken from a medicine cap, blue eyed, paint horse in 2020. Previous data from humans shows that wave morphology can indicate a possible cochlear loss (Watson 1999) and hearing can be considered abnormal if the morphology is poor.

**Figure 3**



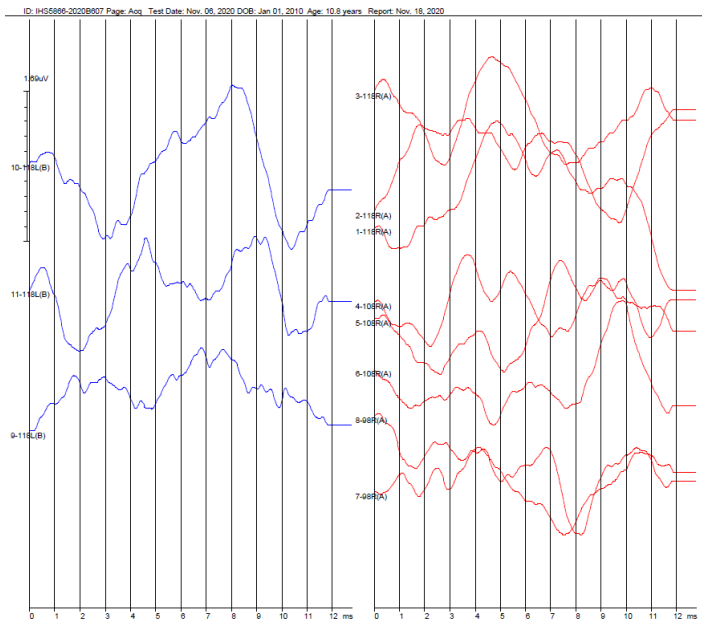
*Good waveform*

**Figure 4**



*Poor/inconsistent wave form*

**Figure 5**



*Extremely poor wave morphology*

**Table 3**

*Overall ratings for each set of BAER waveforms.*

Subject ID	Outcome	Testing Group
C1	Good Morphology	No exposure
C2	Good Morphology	No exposure
C3	Good Morphology	No exposure
C4	Good Morphology	No exposure
C5	Good Morphology	No exposure
E1	Poor Morphology	6 years
E2	Poor Morphology	10 years
E3	Fair to Good Morphology	4 years
E4	Fair Morphology	2 years
E5	Fair Morphology	5 years
E6	Fair Morphology	3 years
E7	Poor Morphology	4 years

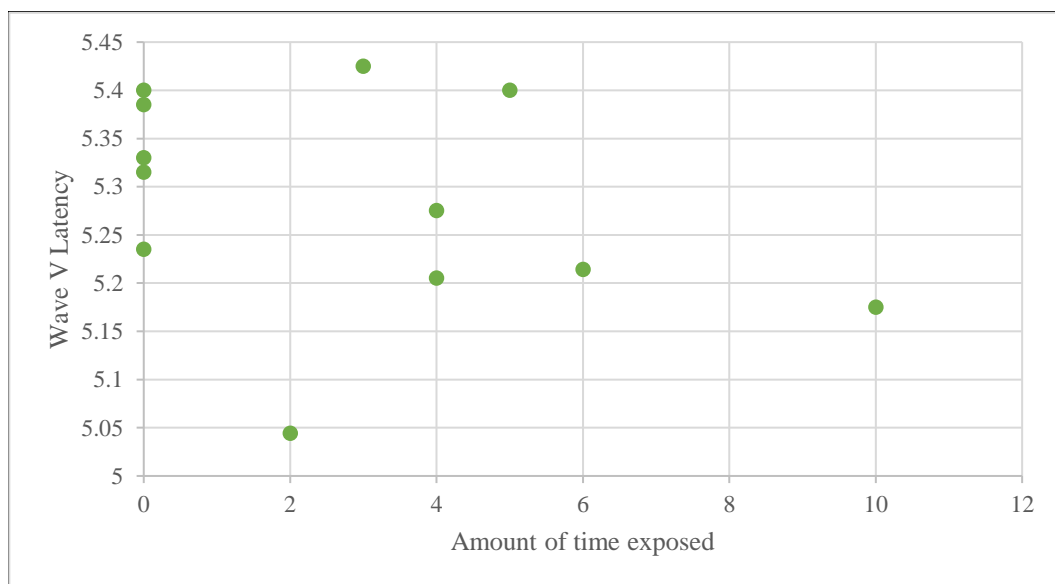
Table 4 shows the averages that were determined using the test results by calculating the means of the absolute latencies for waves that were present. Figure 4 is a scatterplot of the wave V latencies for both groups.

**Table 4**

*Mean BAER latencies for each subject group*

Group Averages	Wave I	Wave II	Wave III	Wave IV	Wave V
Control Group	1.545	2.372	3.388	4.322	5.33
Exposed Group	1.436	2.41	3.483	4.257	5.248

**Figure 4**



*Exposure Time vs. Wave V Latency*

After seeing no differences in the averages, we looked into determining if we were able to see any differences in the presence of wave V by calculating the standard deviation (Table 5) and range (Table 6). Once again, there were no statistical differences between the standard deviation and range of wave V between the control and exposed category.

**Table 5**

*Wave V Standard Deviation*

Standard Deviation	Wave V
Control Group	0.065
Exposed Group	0.132

**Table 6**

*Wave V Range*

Range	Wave V
Control Group	0.165
Exposed Group	0.381

## Conclusions

The goal of this thesis was to evaluate if there is a need for continued research of the equine auditory function when exposed to firearms. Based on previous studies on humans and our results suggesting differences in the presence of wave I and the change in morphology between the two test groups, there is a need to re-evaluate this concept and seriously consider that firearms harm horses' auditory systems. Although there were no statistical differences in wave latencies between groups, it was determined that wave I was less likely to be present in the group of horses exposed to firearm noise. In addition, the morphology of the waveforms from the two groups displayed noticeable differences. Specifically, the morphology of the waveforms from the horses exposed to noise showed reduced repeatability and missing peaks, especially wave I. Visual analysis of the waveforms indicated that all five of the nonexposed horses had good waveform morphology, while all seven of the exposed horses had fair to poor morphology. Good morphology was defined as the presence of five peaks on repeatable waveforms. Poor morphology was defined as absence of one or more peaks with poor repeatability.

The present study did not control for breed, medical history, or age. Future studies might evaluate horses using the BAER with the following considerations:

1. Adding breed restrictions to eliminate breeds such as the American Paint Horse who may have hearing loss due to genetic abnormalities.
2. Expanding the test group size.
3. Completing BAER evaluations on horses before exposure and tracking any changes over time following noise exposure.





Audiology Speech-Language Sciences  
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**Project Title:** Understanding How High Levels of Noise Affect the Equine Auditory System

**Principle Investigators:** Shelby Brown & Kathryn Bright, PhD

Contact Number: 720-416-3844

Contact E-mail: brow3746@bears.unco.edu

**Faculty Advisors:** Kathryn Bright, PhD

You have been asked to allow your horse(s) to receive a hearing test as part of a study being conducted through the Honors Program at the University of Northern Colorado (UNC) to evaluate the hearing status of your horse. Your horse will be tested using the Brainstem Auditory Evoked Response (BAER) test.

We will be using very small subdermal needles placed in three (3) different locations on the horse(s). We will apply Lidocaine/Prilocaine (2.5%/2.5%) to the sites before placing the electrodes to numb the area. Foam-covered insert earphones will be placed into the ear canal of the ear being tested to present a low-level click stimulus.

The test requires that the horse stay relatively still for no more than 30 to 40 minutes. If the horse exhibits too much movement during the test or shows excessive stress/anxiety we will discontinue the test.

You will receive a report on the status of your horse's auditory health and any recommended follow-up activities. All hearing assessments will be analyzed and confirmed by an audiologist. By signing below, you indicate that you understand that your horse's participation is voluntary and that you may withdraw your horse from the test at any time. You also understand that you are responsible for your horse's health and behavior and that UNC will not be responsible for injuries to your horse, to others, or any property damage that the horse may cause.

**HORSE OWNER**

Signed: \_\_\_\_\_

Name: \_\_\_\_\_

Phone or Email: \_\_\_\_\_

**PRINCIPLE INVESTIGATOR**

Signed: \_\_\_\_\_

Name: \_\_\_\_\_

Date: \_\_\_\_\_

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