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Attenuation Produced by Foam Earplugs Worn by Chinchilla

By

James H. Patterson, Jr.
Ilia M. Lomba Gautier
Melvin Carrier, Jr.
Dennis L. Curd

Sensory Research Division

and

C. E. Hargett, Jr.

State University of New York
at Plattsburgh

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United States Army Aeromedical Research Laboratory
Fort Rucker, Alabama 36362-5292

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Animal use

In conducting the research described in this report, the investigators adhered to the Guide for care and use of laboratory animals, as promulgated by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Resources Commission on Life Sciences, National Academy of Sciences-National Research Council.

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Introduction

Animal studies of the effects of noise on the auditory system have exposed the animals to noise without hearing protection. By contrast, many occupational exposures to high level noise require the use of hearing protection. Military exposure to high level impulse noise from weapons firing is one of these occupational exposures requiring the use of hearing protectors. At the present time there is no generally accepted method to predict whether the hearing protection will be adequate for a given impulse noise. The study reported here is a preliminary to a series of experiments designed to address this problem in an animal model.

Before any noise exposures with protected animals can begin, we need to know two things. First, can the animal wear the protector? Earmuffs designed for human heads have obvious problems if one attempted to adapt them to most animals commonly used in noise research. The earplugs, especially the hand formed type, offer greater adaptability. Second, we must be able to characterize the attenuation provided by the protector when worn by the animal model. This requires determining an attenuation characteristic by a method similar to the real attenuation characteristic for humans (ANSI S12.6). This method involves the determination of audiometric thresholds with and without the protector in place. The difference between these two audiograms is used as a measure of the attenuation of the hearing protector. In the study reported here, we adapted this method to measure the attenuation characteristic of modified foam earplugs when inserted into the chinchilla.

This study was conducted in 1983, before the current version of the ANSI standard was issued. At the time, real ear attenuation measurement procedures were in a state of transition. The long standing procedures specified in ANSI Z24.22 (1957) used pure stimuli for the audiometry. This standard has been replaced with ANSI S3.19 (1974) which used 1/3 octave bands of noise as stimuli for audiometry. ANSI S3.19 was revised to become the current ANSI S12.6 (1984). Since a large amount of attenuation data for humans existed using pure tone audiometry under ANSI Z24.22 and the chinchilla audiometric test system used pure tones, the study reported here was patterned after the older Z24.22 methods.

Methods and instrumentation

The subjects for this experiment were 10 male chinchilla villadera. They were trained for behavioral audiometry using a shock avoidance procedure described previously (Burdick et al., 1978, and Patterson et al., 1986).

The method for determining the attenuation was adapted from ANSI Z24.22(1957). This standard used pure tone stimuli in a sound field to determine the audiogram. The ANSI method requires 10 subjects be tested three times each without the protector (unoccluded) and three times each with the protector (occluded). In this study, we used 10 subjects. We obtained five unoccluded and five occluded audiograms on each subject. The five unoccluded audiograms were averaged and subtracted from the average of the five occluded audiograms to produce an attenuation estimate for each subject. This was done to provide a better estimate of the attenuation for individual subjects.

The earplugs were foam earplugs (NSN 6515-00-137-6345) modified for the chinchilla. Since the chinchilla external ear canal is smaller than a human one, the diameter of the plugs had to be reduced. This was done by compressing the plug along the axis of the cylindrical shape to form a thin, circular disk. A 7.2 mm cork cutter was used to cut out the center of this disk. After reexpansion, this produced a cylindrical plug with a 7.2 mm diameter. The final size was chosen after trying several diameters for fit and ease of insertion. These modified plugs could be inserted easily into the chinchilla by rolling them into an even smaller cylinder. The rolled down plug was inserted into the external canal of the subject and allowed to reexpand in a manner analogous to the procedure used to insert a foam ear plug into a human subject.

After training was complete, five unoccluded audiograms were obtained on successive test days. Then five occluded audiograms were obtained at 1-hour intervals on one test day. The plugs were inserted at least 5 minutes before audiometry began. The plugs remained in the ear canal for all five audiograms. After the audiometry was complete, the plugs were left in the ear canal until the next day when they were removed.

Results and discussion

The attenuation characteristics for each of the subjects and the overall average and standard deviation are shown in Table 1. Subjects K-134 and K-117 show lower attenuation values than the others. Thus, considerable individual differences in attenuation can be found. The overall attenuation characteristic is shown in Figure 1. Also shown in Figure 1 is the real attenuation for foam earplugs in human subjects using the ANSI Z24.22 procedures.

Table 1.

Average attenuation of 7.2 mm
foam earplug in chinchilla.

Subject	0.125	0.25	0.5	1.0	1.4	2.0	2.8	4.0	5.7	8.0
	Frequency in kHz									
K-134	18	33	41	33	39	34	41	27	29	38
K-121	46	40	34	46	48	44	38	32	36	44
K-126	40	41	50	40	50	44	46	40	44	44
K-113	39	55	45	47	51	37	47	43	49	37
K-123	40	52	46	50	56	50	46	48	44	46
K-110	42	54	56	48	56	44	46	46	56	44
K-113	46	48	52	50	52	46	48	50	46	44
K-119	38	46	56	40	40	38	40	44	40	46
K-104	38	50	58	56	60	50	51	48	38	52
K-117	17	33	43	33	39	37	41	25	35	37
Group	36	45	48	44	49	42	44	40	42	43
s.d.	10.4	8.1	7.6	7.6	7.5	5.5	4.2	9.0	7.9	4.6

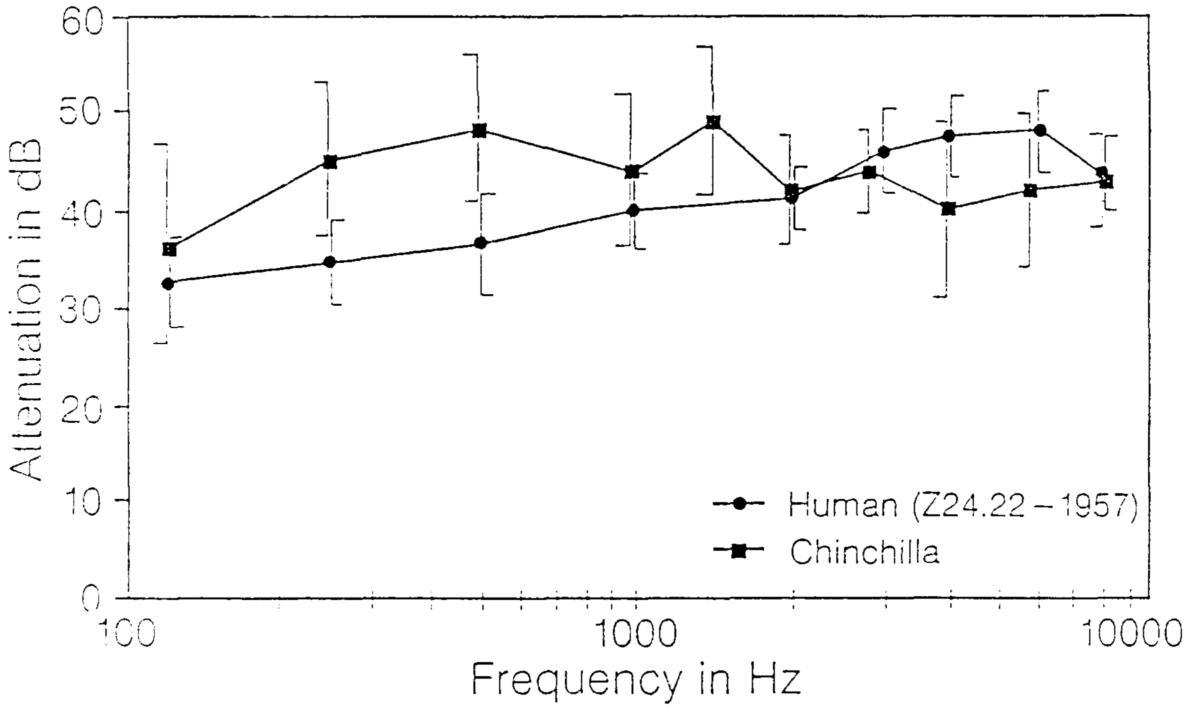

Figure 1. Attenuation of earplugs worn by humans and chinchilla. The vertical lines indicate +/- 1 standard deviation.

The human data were taken from the box in which the plugs were received. The attenuation measured at the lower frequencies is greater than for human; while the reverse is true at higher frequencies. Since the individual data for the human subjects was not available, the difference at each frequency was tested using a t-test corrected for unequal variance (Brownlee, 1960) These tests indicate that the attenuation at 250 Hz and 500 Hz was higher for the chinchilla ($P<.002$) and that it was lower for the chinchilla at 4 kHz and 6 kHz ($P<.05$). All other frequencies had a $P>.1$. Following the method of Hays (1963) for multiple comparisons, for an overall significance level of .05 we test each of the nine mean differences at the .0055 level. The attenuation at 250 and 500 Hz is still significantly higher than for humans. It is not clear why this occurs. It may be related to the smaller diameter ear canal of the chinchilla.

All subjects tolerated the foam earplugs for extended periods of at least 24 hours. This result indicates that either the chinchilla cannot or does not attempt to remove these plugs. Informal observation indicated they made little effort to remove them.

Conclusions

We can conclude that the modified foam earplugs can be used in noise exposure studies involving chinchillas as subjects. The noise exposures could last for hours without concern that the plugs would be removed by the subject.

The attenuation characteristic reported here can be used as a reference for typical attenuation for the modified foam plugs. However, the attenuation attained by each subject should be verified in any study of noise exposure with hearing protection since large individual differences can occur.

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This report documents the attenuation of modified foam earplugs (NSN-6515-00-137-6345) when worn by chinchilla. Since the ear canal of the chinchilla is smaller than human, the earplugs were trimmed to a diameter of 7.2 mm. This provided a good fit to the chinchilla ear canal. Methods for determining the attenuation were adapted from ANSI standard methods for determining attenuation for humans. The average attenuation of the earplugs for the chinchilla was generally higher than for humans; however, this difference was not statistically significant.

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