

Evaluation of Hearing Protection Device Effectiveness for Musicians

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Background

Hearing protection devices (HPD) may help reduce harmful sound exposures for musicians who perform and teach in a variety of settings where engineering and administrative controls may be impractical or ineffective.¹

HPD designed to have a **uniform attenuation across frequencies** may offer protection for musicians without distorting sounds they need to hear clearly.²

Even though uniform attenuation earplugs (UAE) are available, many studies find that musicians, especially instructors, do not wear them.^{3,4}

Studies indicate many users do not achieve good fit and adequate sound reduction with many types of HPD⁵ which has led to recommendations for fit-testing.⁶

By gathering information on the effectiveness of different HPD in combination with musicians' opinions about wearing them, we can make better recommendations for which types may provide the most effective control.

Objectives

- 1) To compare personal HPD attenuation to manufacturer ratings for three devices commonly suggested for musician use
- 2) To compare uniformity of response across frequencies for each HPD type
- 3) To determine whether personal attenuation differences exist by participant age

Methods

Hearing Protection Devices (HPDs)

- Foam earplugs: 3M Yellow Neons™ - \$0.20/pair
- Non-custom UAE: Etymotic ER20XS High-Fidelity (standard and large sizes) - \$20/pair
- Custom UAE: Westone Style 49 mold with Etymotic ER-15 filter - \$200/pair



Figure 1. Illustration of HPD tested in this study

Participants

- 24 music instructors and musicians from the Iowa City/Cedar Rapids area
- 12 over and 12 under the age of 30
- Trained on the proper insertion, use, and maintenance of each HPD type

Audiometric testing was performed

- To obtain baseline hearing thresholds and thresholds while wearing HPD
- With Otometrics Madsen Astera audiometer (Natus, Schaumburg, IL)
- In a sound booth using circumaural headphones
- Across frequencies (125, 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz)

Data Analysis

- For each HPD and at each frequency, computed:
 1. Personal Attenuation, dB = (Thresholds with HPD in) – (Audiometric Baseline)
 2. Attenuation Difference, dB = (Personal – Manufacturer)
- To identify significant differences in attenuation between age groups: Wilcoxon-Rank-Sum tests ($\alpha = 0.05$; SAS 9.4, Cary, NC)
- To assess uniformity of attenuation across frequency: Personal Attenuation coefficient of variation (CV%)

Results

23 participants completed audiometric testing; performance of 45 ears assessed.

There was substantial variability in attenuation by HPD.

Participants achieved more attenuation at *higher* frequencies than at *lower* frequencies.

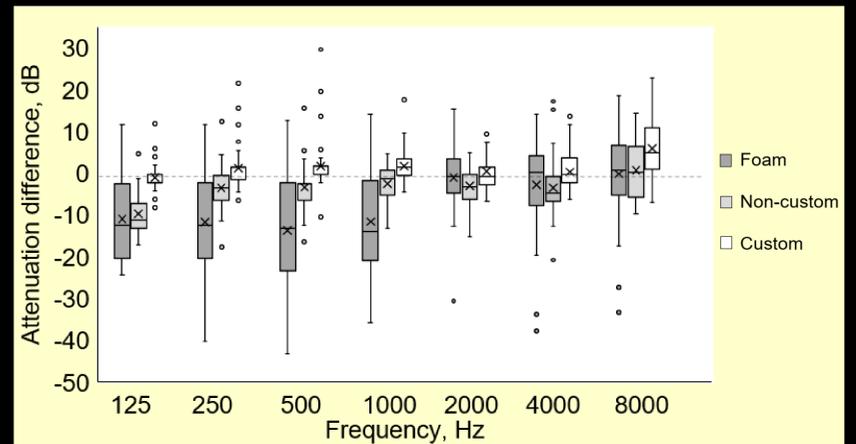


Figure 2. Attenuation difference (user achievement minus manufacturer rating) at each frequency for the three HPD.

The non-custom UAEs showed the greatest variation in attenuation across frequencies.

- **Foam:** CV Range = 9% - 87%, median = 29%
- **Non-custom:** CV Range = 11% - 82%, median = 32%
- **Custom:** CV Range = 8% - 53%, median = 28%

For Foam HPD, participants < 30 years old had higher personal attenuation.

Table 1. Frequency-specific median attenuation achieved, by HPD type and age group (younger or older than 30 years)

Hz	Foam		Non-Custom		Custom	
	Age < 30	Age ≥ 30	Age < 30	Age ≥ 30	Age < 30	Age ≥ 30
125	25	26	9	8	15	14
250	32	20	14	14	16	18
500	34	22	18	16	18	16
1000	33	24	20	18	16	16
2000	40	36	24	22	14	12
3000	44	38	20	18	17	16
4000	49	40	19	16	15	14
6000	52	45	18	18	18	18
8000	51	46	25	24	22	28

*Numbers in bold indicate significant difference between age groups ($p < 0.05$)

Conclusions

The **custom UAEs** provided the most *consistent* attenuation across frequencies, and participants were most likely to achieve manufacturer attenuation ratings with these HPD.

The **non-custom UAEs** came in two sizes: 7 of 23 participants needed large. Without fit-testing, it is unlikely musicians will select the appropriate size to protect hearing.

The **foam earplugs** were the most difficult for participants to fit themselves, even with individual coaching, especially for participants over the age of 30.

Without training and fit-testing, musicians may not be able to size and seat HPD properly, which would result in **minimal attenuation** and/or **sound distortion**, which may discourage musicians from wearing these earplugs.

Future Work

In addition to audiometric testing, participants are completing four surveys over a six-month period to identify the frequency of use and the benefits and barriers to using each HPD.

Measuring the effectiveness (*i.e.*, attenuation) of different HPD, while incorporating musicians' feedback regarding the benefits and barriers of wearing each type, will help to recommend the HPD most likely to be adopted for specific tasks.

Acknowledgements & References

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