P369- Fit testing results and training outcomes: Effects of training on personal attenuation rating for uniform fit earplugs

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INTRODUCTION

Previous literature has shown achieved attenuation of hearing protection devices (HPDs) in a laboratory setting is often lower than the labeled Noise Reduction Rating (NRR) (Berger, 2003). Other literature has shown large variability in the achieved attenuation of musician's HPDs (MHPDs), as well as lower attenuation compared to the labeled NRR (Zaccardi et al 2022). These data indicate a need for verifying the amount of attenuation achieved before assuming the achieved attenuation of the wearer. Additionally, there is a need to educate individuals before fitting the an HPD during the fitting process. Training has been shown to be effective in improving the achieved attenuation of the wearer (Schulz, 2011; Tufts et al, 2013; Nodoushan et al 2014; Murphy et al, 2022). However, more research is needed to better understanding how training on one HPD may transfer to another HPD. The NOISE lab at the University of Texas at Dallas sought to understand how training on one HPD may carry over to training on another HPD. This was done as part of a larger study evaluating factors that influence subjective music quality during the use of MHPDs (see partner poster). We examined training benefits during HPD fit training sessions by contrasting the achieved attenuation during the initial fit for those who had training on another HPD previously, and those who had no training.

METHODS

<u>Subjects</u>: 27 participants (11M, 16F) provided written informed consent. Three did not meet inclusion criteria and seven withdrew after completing 0 (n=1), 1 (n=3), 2 (n=2), or 3 (n=1) test sessions. Data shown here are from 15 participants that completed all four HPD conditions and 6 participants that contributed data in one to three HPD conditions. Hearing thresholds $\leq$25 dB HL from 0.25-8 kHz were required. Attitudes towards noise and previous HPD use were surveyed prior to in-person testing.

<u>Ear plugs</u>: Four high-fidelity ear plugs were included. HPD order was preassigned to assure counterbalanced HPD order across participants. HPDs 1, 2, and 4 had multiple size options. Lab personnel selected the size to be used based on visually inspecting ear canal size.

<u>Pure-tone audiometry</u>: Pure-tone air-conduction thresholds were obtained at 0.25, 0.5, 1, 2 3, 4, 6, 8 kHz using soundfield speakers and a GSI AudioStar Pro/GSI-61 Audiometer. Thresholds were obtained in the unoccluded condition three times at the initial visit and once at each follow up visit.

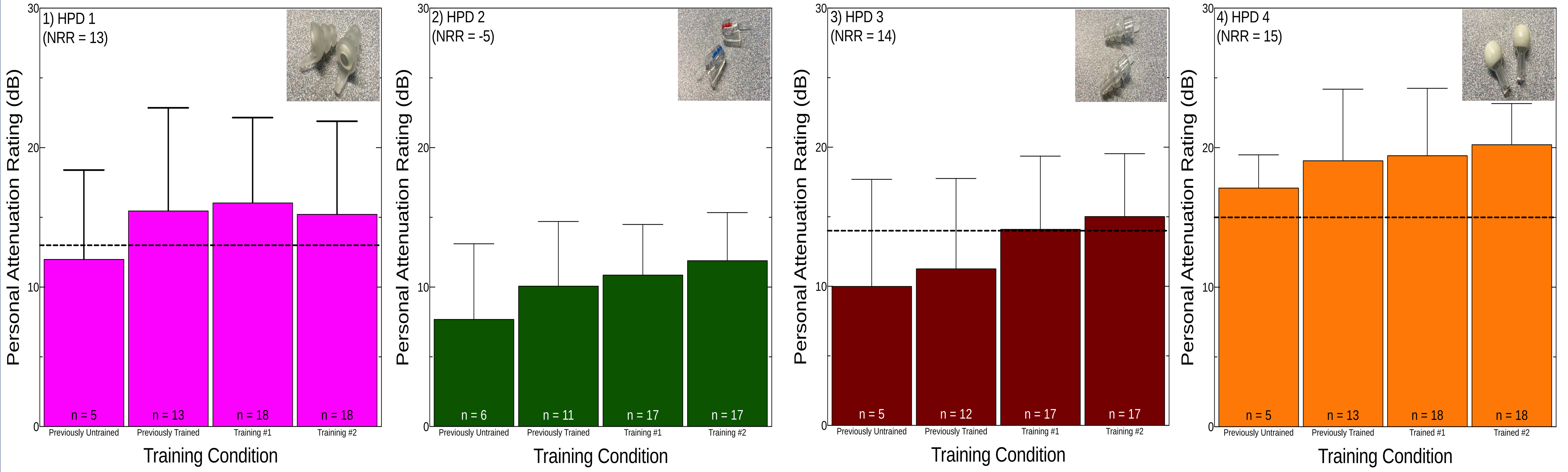
<u>HPD Testing (Untrained)</u>: Participants were educated on the importance of hearing protection and given HiFi HPDs. Participants inserted the HPDs with no additional instruction. Then, pure-tone audiometry was repeated in the occluded condition.

<u>HPD Testing (Trained)</u>: Participants were instructed on proper insertion of HPDs and inserted the HPDs, then lab personnel visually inspected the HPD placement. If they were not inserted properly, the participant was asked to reinsert the devices. Pure-tone audiometry was repeated with HPDs in place (Training #1). Participants removed then re-inserted the HPDs and pure-tone audiometry was repeated after verification of HPD placement (Training #2).

<u>REAT calculations</u>: Real-ear attenuation at threshold (REAT) was calculated as the within-subject difference between unoccluded (baseline) threshold and occluded threshold at each frequency, for each set of HPDs. Frequency-specific REAT was used to calculate a personal attenuation rating (PAR) using a formula that generally followed the calculation for labeled Noise Reduction Rating (NRR). NRR is derived from group data, with participants wearing expert fit HPDs. Higher REAT and PAR values greater attenuation of sound; i.e., more effective hearing protection.

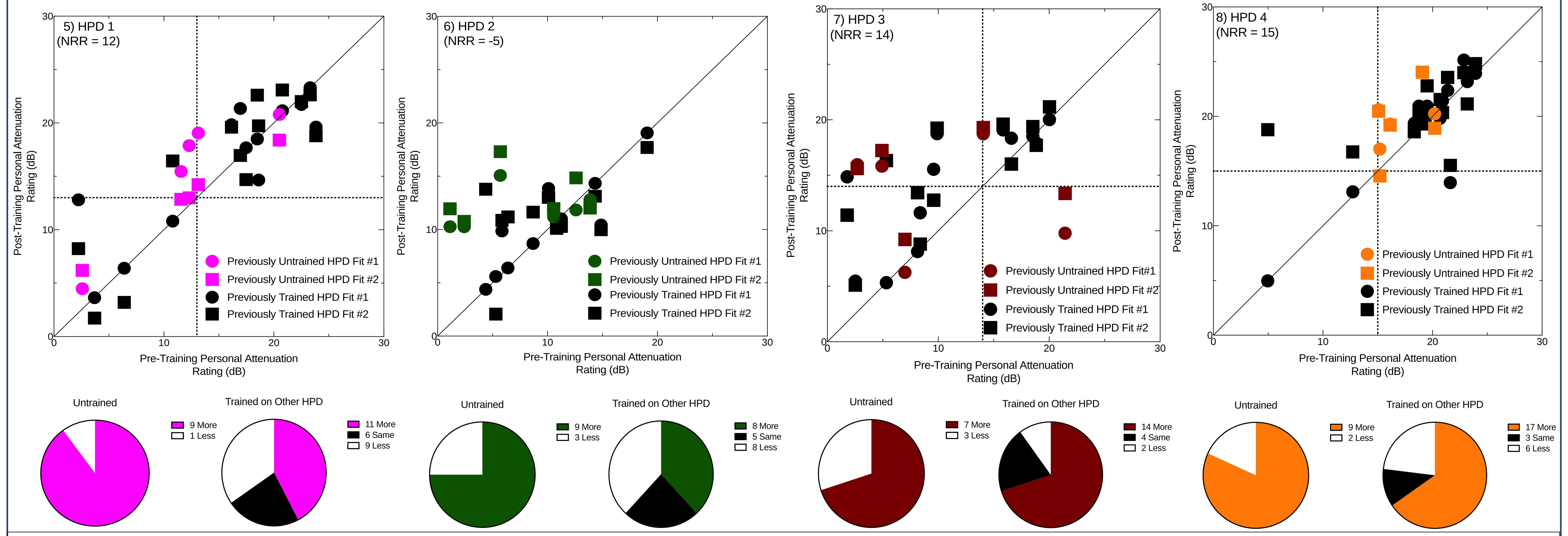
<u>Statistical Analyses</u> Due to violations of data normality, Kruskal Wallis Tests and pair wise Dunn tests were completed to assess statistically significant differences between groups of *Previously Untrained* and *Previously Trained* participants, and if either group were statistically significantly different from *Training #1,* and *Training #2.*

HPD and Group Differences in Training Effect



HPD order was counterbalanced for HPDs 1-4 **(see Fig. 5-8)** and thus 5-6 participants had no previous training ("Previously Untrained") in each of the four HPD conditions. The other participants had completed at least one previous training session ("Previously Trained"). Because there was no statistically significant difference between *Training #1* and *Training #2*, we only show *Training #1* here. There were no statistically significant differences between those with who were *Previously Trained* and those who were Previously *Untrained.* Additionally, there was no statistically significant difference found between any of the training conditions for any HPD. Of note, the difference between *Previously Untrained,* and *Training #1* and *Training #2* was larger for all HPDs than the difference between *Previously Trained*, and *Training #1 and Training #2.*

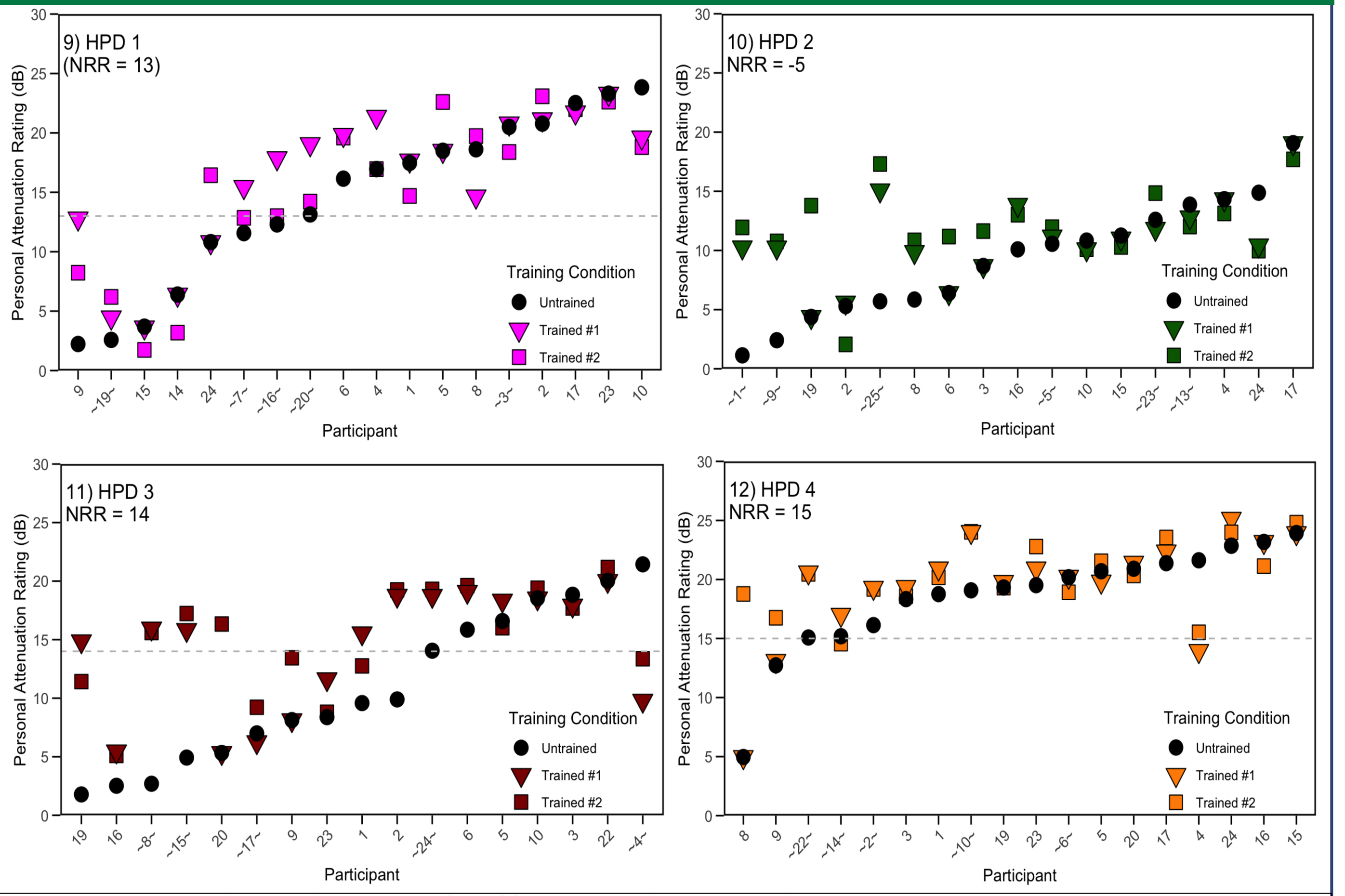
Individual Training Effects and Proportion of Training Benefit



To show individual benefit of training, each instance of HPD fitting was plotted on a scatter plot showing pre- vs. post-training achieved PAR (**Fig. 5-8**). Each point on the scatter plots represent the achieved PAR of each participant. The colored points show participants who had not received training on a previous HPD ("Previously Untrained") and the black points represent participants who had received previous training on another HPD ("Previously Trained"). Each instance was then separated by if the achieved was during their initial fitting after training ("HPD Fit #1") or second fitting after training ("HPD Fit #2"). We then counted how often participants achieved more, less, or the same amount of attenuation following training. Most *Previously Untrained* participants achieved more attenuation following training. Every *Previously Untrained* participant was able to achieved more attenuation following training at least once following training for HPD #1 and #4. *Previously Trained* participants achieved more attenuation following training on HPD #1, #3, and #4 more often. Of note, there were more instances of participants who were *Previously Trained* who achieved the same or more attenuation on every HPD.

Dashed gray line indicates NRR. NRR is -5 for HPD 2 (not marked).

Variability in Individual Training Effects



To illustrate variability in individual benefits of fit testing and training, individual data are show in **Figures 9-12** with a target attenuation of 15 dB marked using a gray dashed line (conceptually, a reduction from 105 dBA to 90 dBA). Even with training most participants did not achieve 15 dB attenuation with HPD 2. HPDs 1, 3, and 4 had relatively similar NRRs (12-15 dB) but the rate at which the 15-dB target was achieved differed across HPDs. Almost all participants obtained 15 dB attenuation with HPD 4 even with no training. Most, but not all, participants achieved 15-dB attenuation before or after training with HPDs 1 and 3.

SUMMARY/CONCLUSIONS

- As shown in previous studies evaluating real-world attenuation in sound field settings, there was significant individual variability in the attenuation achieved at the first HPD insertion (see black circles in Figures 9-12).
- After training to insert HPDs, increases in achieved attenuation were observed for most but not all participants. Some participants had no increase in attenuation or less attenuation when reinserting HPDs after training, and some had lower levels of attenuation after training.
- Every participant was able to obtain greater than 10 dB attenuation on at least two HPDs, and all but one participant were able to obtain at least 10 dB attenuation on three of the four HPDs.
- Every participant was able to obtain greater than 15 dB attenuation on at least one HPD, and all but two participants were able to obtain at least 15 dB attenuation on two of the four HPDs.
- These data highlight three important points:
  1. **Verification through fit testing is crucial to ensuring proper attenuation of the device**
  2. **Proper training of HPD insertion can help individuals achieve greater attenuation of their HPDs**
  3. **Alternative products should be considered if an individual does not achieve the expected attenuation of an HPD**

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