Field Study News

Hearing Protection for People with Hearing Loss

Serenity DP protects hearing and at the same time enhances speech understanding

Abstract

Hearing loss among workers in noise is common and can be an indicator of low compliance and/or a higher individual sensitivity for noise induced hearing loss. The usage of passive hearing protection by those with hearing loss however increases the hearing loss by adding a conductive component, which even further limits the capability of such people to hear and understand speech and environmental sound signals.
To test the hypothesis that dynamic (level dependent) hearing protection may improve communication in noise for people with hearing loss, the speech recognition scores of seven listeners with hearing loss were measured. Measurements took place at various noise levels and with different distances between talker and listener. During testing the listeners used either passive, level-independent hearing protection, or dynamic, level-dependent hearing protection.
The results indicate that with dynamic hearing protection speech recognition scores improved significantly (up to 50 - 60% improvement for noise levels up to 60 dB(A)) when compared to passive hearing protection. The improvements were found to be higher for those people with more severe hearing losses. It is concluded therefore that people with hearing loss whose ears need to be protected against loud noise, are better served with dynamic hearing protection than with passive hearing protection; communication is enhanced, which may also lead to better compliance.

Introduction

Hearing care professionals and health and safety officers are often confronted with the challenge of protecting the hearing of workers with hearing loss against the hazards of loud work place noise, while at the same time also needing to improve their communication.
Should hearing instruments be fitted to improve communication, one still cannot ignore the fact that hearing instruments are not certified hearing protection devices, even if they feature closed ear molds. Alternatively, if passive (level-independent) hearing protection devices are fitted, this effectively adds an extra conductive hearing loss to the existing hearing loss, which reduces communication possibilities even further. As such, each time a worker with hearing loss needs to hear something important (a conversation, a warning sound etc.) with passive protection he is tempted to remove his ear plugs or ear muffs, which is annoying if this happens frequently during the working day. This will also reduce hearing protection compliance and reduced wearing time significantly limits the effective damping significantly (see Table 1).

Maximum protection provided by non-continuous use of hearing protection	
% of time used	**Maximum protection**
50%	3 dB
60%	4 dB
70%	5 dB
80%	7 dB
90%	10 dB
95%	13 dB
99%	20 dB
99.90%	30 dB

Table 1. The maximum protection provided by hearing protection is reduced significantly when wearing time is reduced.

The vicious circle can be described as follows: when the need to communicate leads to lower compliance with hearing protection, it also leads to greater exposure to noise. This may worsen the hearing loss, which in itself will increase the need to remove hearing protecting devices.
A hypothesis was formulated that level-dependent hearing protection may offer better communication in noise for workers with hearing loss, while at the same time ensuring the ears stay protected. This was assuming that noise exposure levels vary during the day and that communication most commonly takes place during quieter moments (during a break, or when stepping back from a noise source such as a running machine).
To test this hypothesis, listener speech understanding was measured using both passive and dynamic hearing protection in noise, but not noise above 80

dB(A), in order to reflect these more quiet moments.
Occupational hearing loss is a serious concern for many workers. Although precise numbers are difficult to come by, estimates indicate that in the USA alone between 4 and 30 million people are at risk from work place exposure to hazardous noise. The prevalence of noise-induced hearing loss can be high (up to 36%), depending on the industry sector (see for instance Steege 2003, Tak and Calvert (2008), Tak et al (2009)). A solution that increases hearing protection compliance while at the same time improving communication could therefore be beneficial to millions of workers worldwide.

Test subjects, speech understanding testing and devices

Seven adults with hearing loss, all males aged between 37 and 72, participated in the study. The hearing loss in the best ear ranged from Fletcher Index 36 dB to 60 dB, and in the worst from 39 to 80 dB. All subjects were hearing instrument users, however their hearing instruments were not used during the testing.
Speech understanding was measured in free field with the OLSA test (Oldenburger Satz Test), a German sentence test. Sentences were presented at a fixed, normal conversation level of 70 dB(A) at a distance of 1 meter. A diffuse noise field (type: speech noise) was generated with the help of an Aurical Plus at various levels: no noise, 45, 50, 55, 60, 65, 70, 75 and 80 dB(A).

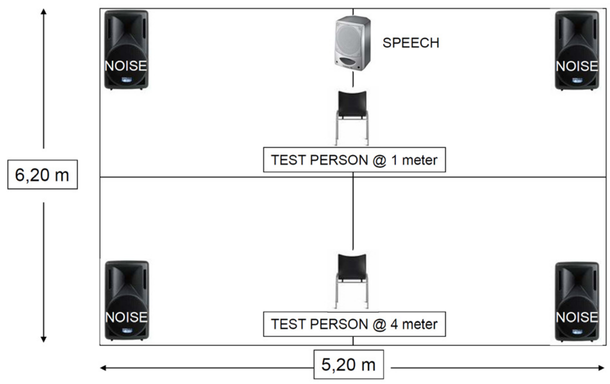

Figure 1. Schematic lay-out of the test set-up. The height of the room was 2.60 meters.

The test set-up is depicted in Figure 1. In a normally reverberant room four loudspeakers created a diffuse noise field and one loudspeaker, positioned at the middle of one wall, presented the OLSA sentences. The comparative testing of speech understanding in free field was performed with passive (static) and dynamic (level dependent) hearing protection. In total there were four test conditions : listening at distances of one and four meters, with static protection and with dynamic hearing protection. The order of conditions (distance and type of hearing protection) was randomized according to a Latin square design.
The passive hearing protection devices used were Serenity SP (with white filter which offers a single noise rating of 28 dB) by Phonak. Serenity's custom-molded ear shells, made of biocompatible clinical nylon, provide passive, level-independent damping. This damping was verified with the Phonak SafetyMeter test, an in-situ objective frequency-dependent test for measuring individual damping per ear.

Figure 2. Serenity SP by Phonak was the passive, level-independent hearing protection device (HPD) used in the test.

Figure 3. The dynamic, level-dependent HPD used in the test was Serenity DP by Phonak.

The dynamic or level-dependent hearing protection devices were Serenity DP. These make use of the same custom-made shells as Serenity SP, however SP's white passive filter is replaced by an electronic, dynamic filter, which is contained in an external box, connected by wires to the shells. In the shells an outward facing microphone picks up all ambient sounds and an inward facing loudspeaker replays the ambient sound. The DP filter dampens all sounds above 85 dB(A), but is acoustically transparent below 85 dB(A).

Results

In figures 4 and 5 the average word recognition scores are depicted at distances of one and four meters respectively; with passive hearing protection and with dynamic hearing protection. In figure 6 the same data are used to show the improvement in word recognition scores between passive and dynamic hearing protection.
Figures 7 and 8 show the average improvement in word recognition score for each individual listener as a function of the Fletcher Index (FI) for the better ear. In these two figures the word recognition scores at 50, 55 and 65 dB(A) are averaged, as these may represent typical conversation levels during short breaks.

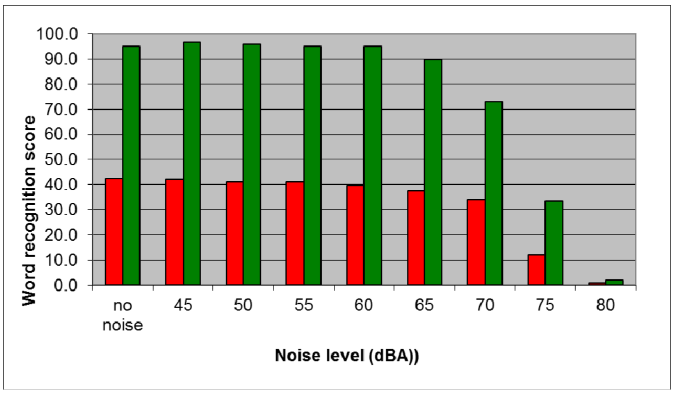

Figure 4. Average word recognition scores at one meter distance with passive (red bars) and dynamic (green bars) hearing protection for different ambient noise levels.

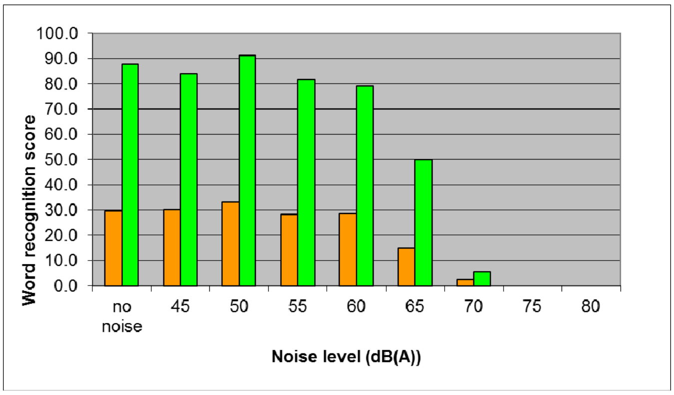

Figure 5. Average word recognition scores at a distance of four meters with passive (orange bars) and dynamic (light green bars) hearing protection for different ambient noise levels.

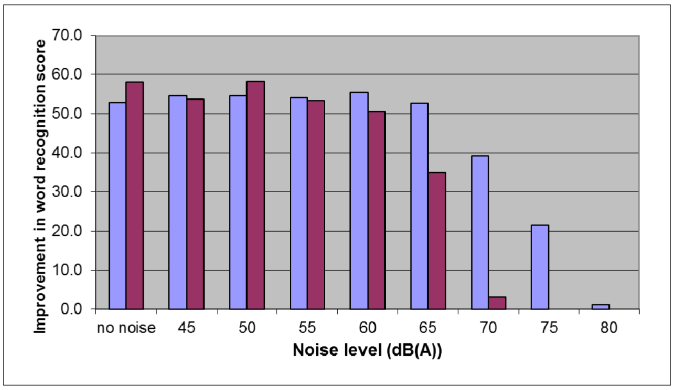

Figure 6. Average improvement in word recognition score at distances of one meter (blue bars) and four meters (violet bars).

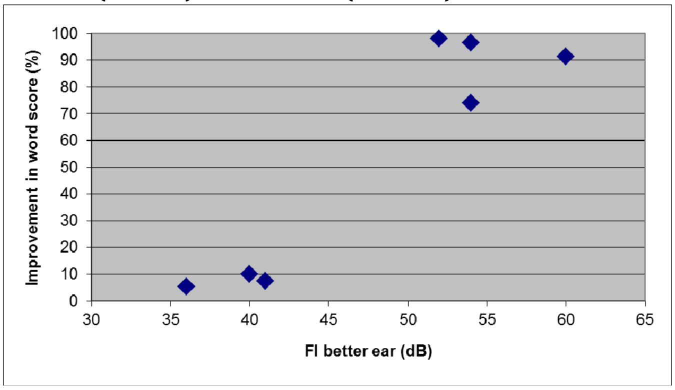

Figure 7. Average improvement in word recognition score at a distance of one meter for each individual listener when changing from passive to dynamic hearing protection at 50, 55 and 65 dB(A) ambient noise levels.

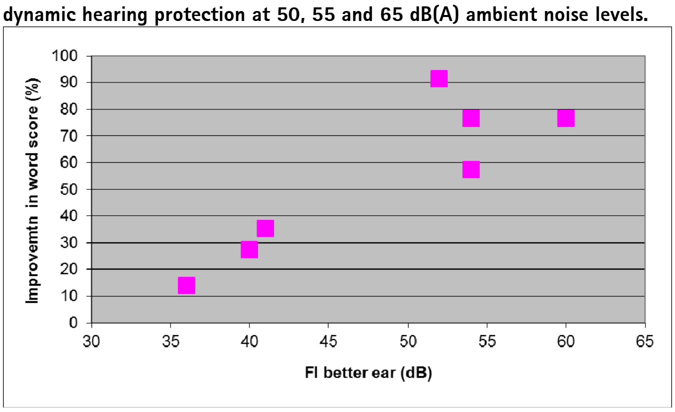

Figure 8. Average improvement in word recognition score at FOUR meters for each individual listener, when changing from passive to dynamic hearing protection at 50, 55 and 65 dB(A) ambient noise levels.

Discussion and conclusion

For all noise levels up to 75 dB(A) at one meter distance and up to 65 dB(A) at four meters distance an improvement was seen in speech recognition scores when changing from passive to dynamic hearing protection.

As both the speech signal and the noise followed the same acoustic and electronic path through the hearing protection to the eardrum, the effect can only be explained by improved audibility and not by an improved signal-to-noise ratio.

Despite the fact that the number of subjects (7) was not high, the results are a clear indicator of the potential benefits of dynamic hearing protection for people with hearing loss who need to communicate in noisy environments. Static hearing protection significantly reduces speech understanding in noise levels below 80 dB(A). Dynamic hearing protection allows for better speech understanding at non-dangerous ambient noise levels than static hearing protection. This benefit tends to increase strongly with an increasing Fletcher Index for the better ear. Therefore people with hearing loss who need hearing protection and who need to communicate or hear ambient signals at times when the noise is not dangerously loud should not use static hearing protection, but are better served with dynamic hearing protection. More investigations are required to come to more precise recommendations or to establish the benefits of technologies that improve the signal-to-noise ratio, such as wireless FM or radio systems, without jeopardizing proper hearing protection.

References

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Tak, S., Calvert, G.M. (2008). Hearing Difficulty Attributable to Employment by Industry and Occupation: An Analysis of the National Health Interview Survey-United States, 1997 to 2003. Journal of Occupational & Environmental Medicine. 50(1): 46-56.

Tak, S., Davis, R.R., Calvert, G.M. (2009). Exposure to hazardous workplace noise and use of hearing protection devices among US workers—NHANES, 1999–2004. American Journal of Industrial Medicine, Vol. 52, Issue 5, 358–371.

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