SIGNAL DETECTION AND SPEECH PERCEPTION WITH LEVEL-DEPENDENT HEARING PROTECTORS

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PROJECT SUMMARY

1. Introduction

Hearing protective devices (HPDs) are the mainstay of industrial hearing conservation programmes for the prevention of noise-induced hearing loss. Conventional muffs and plugs are level-independent devices, i.e., they reduce all sounds by the same amount regardless of decibel level. As a result, they may interfere with speech communication and acoustic cues to occupational hazard, particularly in individuals with pre-existing hearing loss. The present research was undertaken to determine whether level-dependent protectors might provide a more suitable alternative for this group. These newly-marketed HPDs either reduce sounds minimally or amplify them at low levels, depending on the design, and attenuate maximally at high levels judged hazardous to hearing. Signal detection and speech perception were assessed in quiet and in noisy surroundings with the ears unoccluded and protected with the two types of muffs. The effect on protected listening of ageing, as well as hearing loss, was assessed.

2. Experimental Design

Two level-dependent ear muffs (E-A-R 9000 and BILSOM 2390) and two level-independent ear muffs (E-A-R 3000 and BILSOM 2315) were evaluated. The E-A-R 9000 exemplifies a passive level-dependent design concept. The change in sound attenuation with level is accomplished without electronics. Sounds below 120 dBA are attenuated by 25 dB over the audible frequency range. Higher level sound impacts, however, create turbulent airflow within precision orifices in the cup that impedes sound, resulting in an additional 10 dB of attenuation. In contrast, the BILSOM 2390 houses a limiting electronic amplifier, and exemplifies an active level-dependent design concept. Sounds below 85 dBA are passed with a gain of 5-10 dB. Between 85 and 120 dBA, the level at the ear will remain constant at 85 dBA. The two conventional level-independent HPDs, E-A-R 3000 and BILSOM 2315, have the same style earcups and cushions as their level-dependent counterparts. They provide a constant attenuation of about 25 to 35 dB.

Three groups of twenty subjects participated, two with normal hearing, aged 25 to 35 years and 40 to 60 years, and one with mild bilateral sensorineural hearing loss, aged 40 to 70 years. In each subject, the detection thresholds for 1/3 octave noise bands, centred at 0.5, 1, 2 and 4 kHz, consonant discrimination and word recognition were measured. The speech materials were presented at an intensity of 80 dB SPL. The three types of measurements were made in quiet and in a background of continuous cable swager noise (75 dB SPL).

3. Summary of Results

a) In quiet surroundings, neither age nor hearing loss affected the sound attenuation achieved with the conventional level-independent HPDs (E-A-R 3000 and BILSOM 2315) or with the passive level-dependent muff (E-A-R 9000). The active level-dependent amplifying muff (BILSOM 2390) afforded the hearing-impaired listeners a small advantage (i.e., negative attenuation) at the mid-frequencies.

b) Signal detection in noise was unaffected by the wearing of muffs in the two normal-hearing groups. This was also true for the hearing-impaired group in their range of normal hearing (.5 to 2 kHz). However, at 4 kHz, the region of dysfunction, all four HPDs raised the threshold significantly, the three attenuating HPDs (E-A-R 3000, E-A-R 9000 and BILSOM 2315) more so than the amplifying HPD (BILSOM 2390). For the former set of devices, the thresholds in noise were similar to the thresholds in quiet, suggesting that the wearing of these protectors virtually eliminated the perceptual effect of the noise in the hearing-impaired subjects.

c) In normal-hearing subjects, none of the four HPDs affected consonant discrimination in quiet. Word recognition, however, was adversely affected by attenuation. In contrast, the wearing of the attenuating muffs was beneficial in noise, while the amplifying muff had no effect or a deleterious effect, depending on the task.

d) In the hearing-impaired subjects, speech perception was impeded by all four HPDs. The amount of additional impairment, relative to unoccluded listening, was positively related to the degree of attenuation, in the

quiet condition. There was no difference due to protector type in noise. The protected detection threshold at 2 kHz was a good predictor of intelligibility.

4. Conclusions

A level-dependent HPD which amplifies low sound levels will aid mid-frequency detection in quiet in hearing-impaired listeners and will improve their high-frequency detection in moderate noise, relative to devices which attenuate sound. Also, speech intelligibility in quiet for this group will be close to the result for unoccluded listening, although there is little or no advantage in noise. In normal-hearing listeners, attenuating protectors result in better speech perception in noise, compared with unoccluded listening, likely because these devices can improve the speech-to-noise ratio. The degree of this benefit will, in general, depend on the noise spectrum.

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6. References

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