ACTIVE NOISE CANCELLATION VS PASSIVE SOUND ATTENUATION: HELP OR HINDRANCE?

Sharon M. Abel and Deborah L. Spencer

Mount Sinai Hospital
600 University Ave., Room 843
Toronto, Ontario M5G 1X5

1.0 INTRODUCTION

Normal-hearing subjects show improved speech understanding when they wear conventional passive hearing protectors in noisy surroundings. In contrast, hearing-impaired subjects are at a disadvantage. Sound attenuation exacerbates the handicap from hearing loss (Abel et al., 1982). Level-dependent (active) hearing protectors which provide limited amplification of sounds below 85 dBA have the opposite effect. Normal-hearing listeners are at a disadvantage. In contrast, hearing-impaired listeners show some improvement in consonant discrimination and word recognition (Abel et al., 1993).

Unlike limited amplification, active noise reduction (ANR) appears to improve speech intelligibility in noise in normal-hearing listeners. However, it is unclear whether the benefits oberved with ANR are greater than those from passive attenuation (Gower and Casali, 1994; Nixon et al., 1992). The present study was designed to answer this question. The effect of muffs with active low-frequency noise cancellation was compared with the effects of conventional muffs and plugs with good low-frequency attenuation and plugs with minimal attenuation, in young and middle-aged normal-hearing subjects. Aging, apart from hearing loss, has been shown to affect speech discrimination ability (Bergman, 1980).

2.0 METHODS AND MATERIALS

2.1 Subjects

Two groups of 16 subjects with normal hearing, aged 21-36 yrs and 40-59 yrs participated in the study. Across individuals, free-field binaural hearing thresholds were equal to or less than 20 dB SPL in the range of 500 Hz to 4000 Hz. All were native English speakers. Some had participated previously in studies of hearing protectors.

2.2 Hearing Protective Devices

Each subject was tested with the ears unoccluded and fitted binaurally with E-A-R foam plugs, E-A-R HI-FI plugs, Bilsom Viking muffs and Peltor 7004 muffs without and with ANR operational. Based on the manufacturers' specifications, all but the E-A-R HI-FI plugs were Class A, as defined by CSA Standard Z94.2-94.

2.3 Psychoacoustic Measures

Two types of measurements were made within each of the six ear conditions: free-field binaural hearing thresholds for 1/3-octave noise bands centred at 250, 500, 1000, 2000, 3150, 4000, 6300 and 8000 Hz and word recognition for speech presented at 80 dB SPL. These measurement were made in quiet and in a background of continuous 75 dB SPL-cable swager noise. The noise was similar in sound to riveting. It had a repetition rate of 20 impulses/sec and a low-frequency bias.

2.4 Procedure

Each subject was tested individually in a sound proof semi-reverberant chanber that met the requirements of ANSI Standard S12.6-1984. Acoustic stimuli and noise were presented over a set of three Celestion DL10 three-way loudspeakers. The unoccluded condition was presented first, followed by the protected conditions, the order counterbalanced across subjects.

Hearing thresholds were obtained using a variation of Bekesy tracking (Giguère and Abel, 1990). One threshold determination was made for each of the eight frequencies within each ear by background condition. Word recognition was assessed using the SPIN test (Bilger et al., 1984). The test comprises eight alternative pre-recorded lists of 50 sentences. In half the sentences in each list, the final word is highly predicatable from the context, and in the remainder, poorly predicted. In the present study, one list was randomly selected for presentation in each ear by background condition within subject. The subject wrote down the final word in each sentence.

3.0 RESULTS AND DISCUSSION

The attenuation provided by each hearing protector was derived by subtracting the unoccluded from the protected hearing threshold for each of the eight frequencies. An analysis of variance performed on the data indicated that age of subjects was not a significant factor. The means for the two plugs were within 5 dB, and those for the muffs within 10 dB, of the manufacturers' specifications. The Bilsom Viking muff and the Peltor muff without ANR were virtually identical. With ANR, the Peltor muff provided an additional 10 dB of attenuation at 250 Hz.

The mean percentage of final words correctly recognized in sentences with good (high) and poor (low) contextual cues is shown in Fig. 1. Age was not significant and the two groups were collapsed. Overall, the presence of noise resulted in a significant decrement in score. In the quiet condition, a significantly lower mean score was observed for the E-A-R foam plug compared with the other ear conditions, given low contextual cues only. In noise, protected listening improved outcome relative to unoccluded listening for both types of speech materials. With high context, the mean score for the E-A-R foam plug was significantly lower than the scores for both the E-A-R HI-FI plug and Peltor muff with ANR operational. There was no difference due to device with low context.

4.0 CONCLUSIONS

The results support previous findings of a beneficial effect of conventional hearing protectors for speech intelligibility in noise, in normal listeners. Under the conditions of the present experiment, there was no clear improvement or decrement with active low-frequency noise cancellation.

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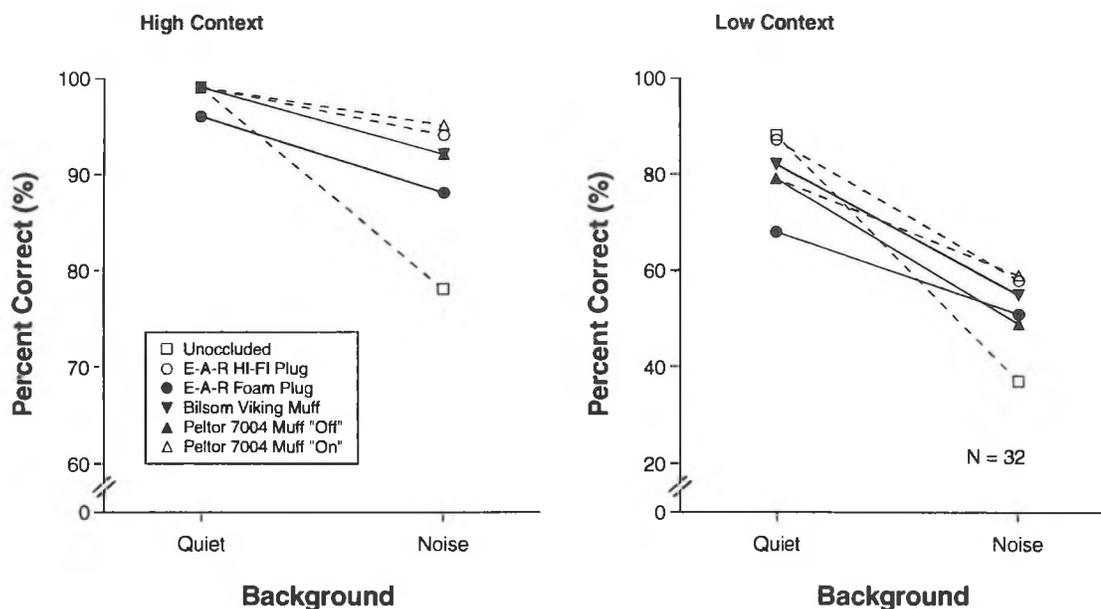
Fig. 1 Word recognition by normal-hearing listeners: Effects of background, hearing protector and context.