Indices of Communication Handicap in Mildly Hearing-Impaired Listeners

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1.0 Introduction

The aim of the present experiment was to measure auditory performance decrements among normal-hearing and mildly hearing-impaired Canadian Forces personnel with communications experience. In previous research with inexperienced subjects, we demonstrated that aging, without concomitant hearing loss, resulted in decreased acuity for changes in both stimulus frequency and duration. Compared with aged-matched controls, older individuals with bilateral high-frequency hearing loss showed decrements in frequency discrimination at 4000 Hz, and in consonant discrimination and word recognition in noise. The degree of high-tone hearing loss was correlated with the decrement in speech perception [1].

The measurements chosen for the present study were detection and masked detection thresholds for 2000 Hz and 4000 Hz pure tones, frequency selectivity in the region of 2000 Hz, consonant discrimination of CVCs in quiet and speech spectrum noise (S/N = -4 and +8 dB) and the recognition of the final word in sentences presented in multi-talker babble noise (S/N = 0, +5 dB). Subjects also completed two questionnaires to document their occupational noise exposure history and perceived difficulty with speech perception. The results of the questionnaire surveys are presented elsewhere [2].

2.0 Methods and Materials

2.1 Subjects

Two groups of subjects, aged 24-52 years, were tested. The first group comprised 15 subjects with screened normal hearing, i.e., audiometric thresholds less than 10 dB HL on average from 500 Hz to 4000 Hz. The second group comprised nine subjects with average thresholds less than 10 dB HL from 500 to 2000 Hz, and about 30 dB HL at 2000 Hz and 4000 Hz.

2.2 Apparatus

Subjects were tested individually in a sound proof booth. For details see [2]. For all tests, the stimuli were presented binaurally over a Telephonics TDH-39 matched headset. Levels were calibrated by means of a Bruel & Kjaer artificial ear (Type 4153). Subjects responded using a computer terminal keyboard.

2.3 Procedure

For each of detection, detection in noise and frequency selectivity, a four-interval forced-choice signal detection paradigm was used [3]. On each trial, the subject was presented a ½s warning light, followed by a sequence of four listening intervals of 300 ms, cued by flashing lights on the subject's terminal. In the detection tasks, the 300 ms-pure tone to be detected occurred during one of the intervals randomly determined from trial to trial, while the remaining intervals were silent. For detection in noise, pre-recorded 90 dB SPL-helicopter noise was present continuously throughout the trial. The subject chose the "correct" interval. The intensity of the stimulus was varied across blocks, so as to generate a psychometric function from which the detection threshold, the value of intensity yielding P(C) of 0.625, was interpolated.

In frequency selectivity, a narrowband masker was gated on in each of the four intervals and the 2000 Hz pure tone probe was presented simultaneously with the masker in one of intervals, randomly determined from trial to trial. The duration of the probe and masker were 300 ms. The level of the probe was fixed at 10 dB SL. Across blocks of 24 trials, the level of the masker was varied, so as to generate a psychometric function from which the critical masker level, that value of the masker intensity yielding P(C) of 0.625, was interpolated. The critical masker value was determined for maskers centred at 1250, 1600, 2500 and 3150 Hz.

Consonant discrimination in quiet and in speech spectrum noise and speech perception in noise were assessed by means of the California Consonant Test [4], the Four Alternative Auditory Feature Test [5], and the Speech Perception in Noise Test [6], respectively.

3.0 Results

3.1 Detection and Frequency Selectivity

The mean detection thresholds for the groups were not different at 2000 Hz, but were significantly greater for the hearing-impaired at 4000 Hz. Except for the hearing-impaired at 4000 Hz, the masked threshold was significantly greater than the threshold in quiet. For frequency selectivity, although the probe was on average 6 dB higher in the hearing-impaired, the difference was not significant. The critical masker levels were virtually the same for the two groups.

3.2 Speech Intelligibility

Consonant discrimination, using CVCs in quiet, was over 90% in both groups, regardless of the method of scoring (overall percent correct or the percent correct for items contrasting the initial or the final consonant). For CVCs in noise, a decrease in the S/N resulted in a significant decrement in performance of 11% to 20% depending on the group and method of scoring the data. Mild hearing loss resulted in significantly lower scores of about 8%. With regard to the word recognition, performance improved in both groups as the S/N increased. For sentences with high and low contextual cues, the differences due to S/N were 9% and 25%, respectively, for the normal-hearing group, and 20% and 36% for the hearing-impaired group. With S/N = 0, the results were significantly worse in the impaired group by 12% and 19% for the sentences with high and low contextual cues, respectively.

To assess the relationship between hearing and speech perception, correlation coefficients were computed within group between the detection thresholds for 2000 Hz and 4000 Hz pure tones and the audiometric thresholds for 250, 500, 1000, 2000, 4000 and 8000 Hz and each of the speech perception measures. In the normal group, the audiometric threshold at 2000 Hz was significantly correlated with consonant discrimination in quiet. For the hearing-impaired group, the detection threshold at 2000 Hz in quiet and the audiometric threshold at 2000 Hz were significantly correlated with consonant discrimination in quiet and speech perception for sentences with low contextual cues and S/N of 0 dB. The audiometric threshold at 8000 Hz was significantly correlated with consonant discrimination in quiet and in noise with low S/N and speech perception with low contextual cues in noise and low S/N.

4.0 Discussion

In line with previous outcomes, in the hearing-impaired, low frequency masking noise had no effect on detection at the frequency of hearing loss, i.e., 4000 Hz, likely because its perceptual effect was diminished. Mild hearing loss did not affect consonant discrimination in quiet, although it did result in a greater decrement in noise than normal. This same result was evident for word recognition in noise, especially with poor contextual cues. The audiometric and detection thresholds at 2000 Hz were highly correlated with measures of speech perception. Although the audiometric threshold ranged only between -5 and 30 dB HL, word recognition with poor contextual cues and low S/N ranged from 36% to 8% - - an important finding because it shows the detrimental effect of a borderline hearing loss on intelligibility under adverse listening conditions. The predictive value of the 8000 Hz threshold supports further study of loss this region as an index of handicap.

The relationship between hearing and speech perception is not well-understood. There are reports of wide intersubject variability in the latter given similar hearing loss [7]. The trends in the present study are in line with findings that the main determinant of speech recognition in the hearing-impaired is the average threshold at 1000, 2000 and 4000 Hz [8]. Noticeable handicap has been reported for those with a PTA of 30 dB HL [9].

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