Notched-noise and quiet detection thresholds as early indicators of auditory system damage in school-aged children.

Prudence Allen & Cindy Lee Marples
School of Communication Sciences and Disorders,
University of Western Ontario, London, Ontario N6G 1H1.

Abstract: Children may be exposed to harmful levels of environmental and recreational noise, the negative effects of which may be cumulative over the child's lifetime. Early detection is an important component of hearing health promotion programs but audiometric screening methods may be relatively insensitive to early stages of damage. This paper reports on a preliminary study that examined notched-noise detection thresholds and audiometric thresholds at 1000 and 4000 Hz in 30 elementary- and 30 high-school- aged students as indicators of auditory system damage. Damage due to noise exposure, if present, was expected to be revealed by an elevation in 4000 Hz thresholds for the older listeners, especially when the notched-noise thresholds were examined. Consistent with expectations, the notched-noise detection thresholds obtained from the high school-aged students at 4000 Hz largely fell at least one standard deviation above those obtained from the younger children at that frequency. No such differences were found for the notched-noise thresholds measured at 1000 Hz, or for the audiometric thresholds measured at either frequency. These results suggest that auditory system damage may be appearing relatively early and that this damage may be detectable when non-traditional audiometric measures are used.

Introduction

Children are repeatedly exposed to environmental factors that may injure their hearing. Damage from noise and other toxins is cumulative over the individuals lifetime and, while posing no immediate threat to functioning in the early years, may produce significant impairments of communication later in life. But through early awareness and hearing conservation programs many of the ill effects of hearing loss can be significantly reduced. One important component of a conservation program is early identification.

Damage due to noise exposure is most often observed as a destruction of outer hair cells in the 4000 Hz region of the cochlea. Hair cell loss may be substantial before an individuals ability to detect a sound in that region becomes impaired beyond clinically acceptable levels. Our current methods of early identification include audiometric screening procedures in which individuals are asked to detect 20 dB HL tonal signals at frequencies from 1000 to 4000 Hz (American Speech-Language and Hearing Association, *Guidelines for screening for hearing impairment and middle ear disorders,* 1989). This protocol is useful for identifying individuals with substantial hearing losses who may be need of immediate intervention, but it may fail to identify individuals who are only beginning to show the damaging effects of noise and for whom the hair cell loss may not be at levels that would cause large threshold elevations. The current study examined the potential use of notched-noise detection thresholds as an early indicator of cochlear damage. This method was compared to audiometric threshold assessment, a more descriptive procedure than that used in typical screening programs.

Method

Two groups of children, 30 young school-aged, 7-8 years of age (Mean = 8 years, 1 month), and 30 high school aged children, 15-19 years of age (Mean = 16 years, 9 months) participated. Three protocols were administered.

Audiometric thresholds were obtained at 2 frequencies, 1000 and 4000 Hz thus providing more detailed information regarding hearing status than a screening at 20 dB HL. These thresholds were obtained using standard clinical procedures.

Masked thresholds for a 1000 and 4000 Hz tonal signal were measured in the presence of a 30 dB spectrum level notched noise masker centered at the signal frequency, using a computer driven 2-alternative-forced choice procedure with visual feedback. Signals and maskers were 200 msec in duration. Notch width was 0.4*Cf. The flanking noise bands were 0-800 Hz and 1200-3200 Hz for the 1000 Hz signal, and 1200-3200 Hz and 4800-6800 Hz for the 4000 Hz signal.

Children also completed a brief Hearing conservation questionnaire that examined knowledge and practices in hearing conservation.

Results

Audiometric thresholds showed no significant differences by age or frequency. As there was no significant effect of ear, mean thresholds shown in table 1 were averaged across ear. Standard deviations are also shown. Had a criterion of thresholds at 20 dB or less been used, 2 of the high school and 2 of the elementary aged- children would have failed showing no age-related differences.

Table 1. Mean audiometric thresholds and standard deviations.

	1000 Hz	4000 Hz
Younger	11.0 (5.4)	9.0 (6.70
Older	7.8 (4.7)	6.0 (6.3)

Notched-noise thresholds are shown in Table 2. Results are averaged across ear. Results were similar for both age groups at 1000 Hz but there was a trend for slightly higher 4000 Hz thresholds in the older age group when compared to the younger.

Table 2. Mean notched-noise thresholds and standard deviations.

	1000 Hz	4000 Hz
Younger	44.2 (4.4)	55.59 (7.2)
Older	44.6 (4.4)	59.31 (6.9)

Because greater damage due to noise exposure was expected to reveal itself in slightly higher thresholds for the older listeners, the data from these listeners was compared to that obtained from the younger listeners by normalizing all scores relative to the distribution obtained for the younger listeners at each frequency. In this way, the mean and standard deviation of the younger listeners would fall to 0 and 1, respectively, and the data from the older listeners could be evaluated as deviations from the baseline, or younger children's data. When this was done it was seen that the normalized scores for the older listeners fell at or near the mean of obtained from the younger children at 1000 Hz, ± 1 standard deviation, but at 4000 Hz, the data from the older children tended to fall 1 to 2 standard deviations above the mean. This suggested a trend for increased damage in the older children's hearing at 4000 Hz, but not at 1000 Hz, consistent with expectations of greater damage due to noise exposure.

Evaluation of the hearing conservation questionnaire showed that only 36% of the teenage participants reported their intention to

use hearing protection when in noisy environments. This was in contrast to a positive response form 67% of the younger children. Similarly, 80% of the younger children reported that they would take a break from high music levels but only 62% of the teenagers reported this. However, 86% of the younger children and 83% of the teenagers reported that they would turn down the volume of the television if it was too loud. In general, this survey suggests that older school-aged children may be less likely to engage in good hearing health care practices while many of the younger children reported that they would, or at least that at that time of their life, they knew the proper way to respond.

Discussion

The results of this study suggested that while audiometric thresholds failed to show any age-related changes at 1000 or 4000 Hz, the notched-noise thresholds did suggest a potential for greater damage at 4000 Hz in the older listeners. There was no such trend at 1000 Hz further arguing that the increased thresholds at 4000 Hz may have truly reflected greater damage from noise exposure. The trend for elevated notched-noise thresholds at 4000 Hz was also significant in light of the observation that audiometric thresholds were well within the range of clinically acceptable levels.

Over an individual's life time the effects of noise and other toxic agents on hearing are cumulative. High levels of environmental as well as recreational noise can contribute to much of the hearing problems commonly observed in our aging population. It is interesting that if sensitive measures are used, some of this damage may be detectable much earlier than once thought. The responses to the hearing conservation questionnaire from the older listeners, suggest that greater emphasis may be needed in the area of hearing health care. Perhaps if augmented with early detection procedures that are more sensitive to subtle signs of damage, many of the hearing losses commonly encountered in older listeners can be minimized.