

## **A HOSPITAL-BASED PSYCHOACOUSTICS RESEARCH PROGRAMME**

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### **INTRODUCTION**

The psychoacoustics research programme in the Department of Otolaryngology at Mount Sinai Hospital was initiated in 1976. The original focus was noise-induced hearing loss and the questions of interest were the extent to which hearing protectors retarded the progression of impairment (Abel and Haythornthwaite, 1984), the reasons for the observed discrepancy between real-world and laboratory estimates of attenuation and values specified by the manufacturer (Alberti, Riko, Abel and Kristensen, 1979; Abel, Alberti and Riko, 1982), and difficulties with detection and communication encountered by users of personal hearing protectors, particularly those non-fluent in the language of the workplace, and those with pre-existing hearing loss (Abel, Alberti, Haythornthwaite and Riko, 1982; Abel, Kunov, Pichora-Fuller and Alberti, 1985).

In 1985 space was allotted to the programme for the creation of an independent laboratory in the newly opened Mount Sinai Hospital Research Institute. This allowed an expansion of the research in a number of directions, both basic and clinical. These have included a continuation of investigations on hearing protection, in depth study of communication problems in the hearing impaired, and the effect on auditory perception of the site of lesion in the peripheral and central auditory pathway. The following paragraphs provide a brief overview of some of our projects.

### **A. HEARING CONSERVATION AND THE USE OF EAR PROTECTORS**

Our most recent experiments in this stream have investigated the effects of wearing time (Abel and Rokas, 1986) and gender (Abel, Alberti and Rokas, 1988) on attenuation. In the first of these on wearing time, data were collected for 12 normal-hearing adults, each fitted with three types of insert protectors, the E-A-R expandable foam, the Willson premolded vinyl with double flange, and the Bilsom Soft formable polyethylene encapsulated glass fiber. Detection thresholds for one-third octave noise bands centred at 500 Hz and 3150 Hz were measured with and without protectors worn, immediately after fitting by a trained assistant, and again after an intervening lunch period of 1 to 1-1/2 hours. This intervention was designed

to insure head and jaw movements that might induce slippage of the protector in the ear canal. Analysis of the attenuation scores, based on the difference in detection with and without the device, showed reductions as great as 10 dB, depending on the device chosen. The variability in attenuation score across individuals did not increase with wearing time, and the magnitude of the effect was independent of the stimulus frequency.

The second experiment on the effects of gender compared the attenuation scores achieved by 80 males and 80 females with normal hearing randomly assigned to one of four insert protector categories. Two of the devices tested, the E-A-R and Bilsom Soft, are available in one size only. The remaining two, the Willson Sound Silencer and MSA Ear Defender (V-51R), are available in two and five sizes, respectively. The results indicated that attenuation scores achieved by females were less than those observed by males for the former category, i.e., one size only. Across protector, there were wide differences between the mean attenuation achieved and the manufacturers' specifications. These were unrelated to variation in hearing threshold.

In both the wearing time and gender experiments, attenuation scores were derived from headphone detection thresholds. We had some concern that supra-aural earphones might affect the seal and/or fit of the earplug by deforming the concha or canal, thus decreasing the attenuation. Another concern was a spurious increment in stimulus amplitude in the occluded condition due to a reduced volume of air in the space between the headset and device. We addressed this problem by constructing a new test chamber, complete with high-power floor speakers, that met the requirements of both the Canadian and American Standards for the evaluation of ear protectors (Giguere and Abel, 1989). A study conducted in the new booth confirmed that for the E-A-R and Bilsom plugs, the results conformed closely with those previously obtained using headphones. Since the Standards do not specify psychoacoustic paradigm, we went on to compare adaptive and two-interval forced-choice methodologies (Green and Swets, 1966) for two commonly used muffs, the Hellberg No-Noise muff on helmet and E-A-R Model 3000, as well as the two previously mentioned plugs. The results showed that while the forced-choice methodology gave significantly lower unprotected detection thresholds of 2 to 3 dB, the derived attenuation scores did not differ.

In an experiment currently in progress, we are comparing detection and speech perception in impulse noise backgrounds with level-independent and newly-marketed level-dependent (active and passive type) ear muffs. Our previous research had indicated that commonly used level-independent devices might constitute a safety hazard for the hearing-impaired by attenuating important messages and warning signals below the

level of hearing. The current study is testing the hypothesis that the new generation of muffs, designed to attenuate high-level impacts well above 100 dBA with minimal effect on low-level sounds, will provide an effective alternative, enhancing communication while at the same time reducing hazardous noise dosage.

## **B. COMMUNICATION HANDICAP**

The focus of interest in this second stream of research is the change that occurs in basic auditory function (e.g., detection, discrimination and frequency selectivity) and speech perception--particularly in noise, with ageing, noise sensitivity and progressive bilateral sensori-neural hearing loss. In a recently completed study, (Abel, Alberti and Krever, 1988; Abel, Krever and Alberti, 1989), the data for five groups of fifteen subjects, defined by audiometric configuration, age and clinical complaint, were compared on ten different procedures which included detection of pure tones in quiet and in a background of continuous 90 dB SPL low-frequency helicopter noise, frequency and duration discrimination, frequency selectivity, consonant recognition and word perception. For the speech tests, the effects of type and level of background noise were explored.

The results of this study showed that subjects complaining of sensitivity to noise, but who had otherwise normal hearing, had a significantly greater upward spread of masking for detecting pure tones in the low-frequency helicopter noise than either age-matched normal control subjects or individuals diagnosed as having hearing loss. However, they did not perform more poorly in the speech in noise tests. The effect of ageing, with normal hearing comparable to that of the younger control group, was an increase in the difference limen for frequency whether 500 Hz and 4,000, and for duration using a relatively short 20-msec standard. Hearing loss, not confounded by ageing, resulted in a significant decrease in the effectiveness of masking noise, especially for those with moderate to severe loss (because the noise was less audible), poor frequency discrimination at 4,000 Hz and poorer frequency selectivity for a 4,000 Hz probe. The difference limen for duration was no different than that obtained for age-matched normal hearing listeners. Speech intelligibility showed a precipitous decrease with increments in background noise, whether white, speech spectrum or multi-talker babble. Across the basic tests of auditory stimulus encoding the best predictor of speech perception in noise decrement for the hearing-impaired was the detection threshold in noise at 4,000 Hz.

A study in progress is assessing the feasibility of using a shorter version of the test battery described above for

screening hearing in Canadian Forces personnel. Clinical tests in current usage do not assess decrements in speech intelligibility in noise, an essential measure for pilots and air traffic controllers, who may listen in noise over noisy headsets. The extent to which listening experience may counteract hearing deficit in this population has not been previously studied and is currently under review.

We are also focusing more effort on the study of frequency selectivity, the ability of the auditory system to separate out the frequency components of a complex sound (Abel, Cheskes and Giguere, 1989). The relationship between the breakdown of frequency selectivity and decrements in speech perception capability in the hearing impaired listener is well-documented (Patterson, Nimmo-Smith, Weber and Milroy, 1982). Our own interest is the understanding of those factors underlying the characteristic flattening of the tuning curve in the presence of hearing loss.

### **C. EFFECTS OF LESION LOCATION**

An ongoing programme of special interest is the effect of lesion localization, peripheral or central, on auditory information processing. In the first experiment of a series, the subject of an M.Sc. thesis (Papsin and Abel, 1988), temporal auditory summation, the trade between intensity and duration in determining loudness, was compared in groups of listeners with normal hearing, and hearing loss due to middle and inner pathology, (otosclerosis and sensorineural hearing loss) and eight nerve lesions (i.e., acoustic neuroma). Typically, in normal hearing listeners, as the duration of a sound increases over a range of about 20 to 200 msec, the intensity required for threshold detection will decrease. The results of the study indicated that there was a progressive failure of summation, i.e., the slope of the function relating the detection threshold and duration decreased, as the site of the peripheral lesion moved toward the brainstem.

In a second experiment nearing completion, the subject of a Ph.D. dissertation (Thompson, Abel, Wortzman and Freedman, 1988) detection in quiet, frequency and duration discrimination, and consonant recognition in quiet are being investigated in patients with radiologically-confirmed acoustic neuroma and pathology of the right and left auditory cortex, as well as age-matched normal control subjects. The rationale for choice of the basic tests was the finding reported in the literature that acuity for a change in frequency and time underlies speech intelligibility. Consonant recognition provided a means of analyzing for type of linguistic error. Preliminary results are demonstrating unique differences in information processing for

right and left cortical areas that contradict previously held views concerning the hemispheric dissociation of such functions as speech and musical perception.

Behavioural studies of the type reported above extend our understanding of the role and function of nuclei at various levels of the auditory pathway. Possible byproducts are the development of new non-invasive tests for the early diagnosis of pathology, and suggestions for new therapies to diminish handicap, based on strategic listening exercises. The success of such studies has largely followed the advent of advanced neuroradiological techniques which allow precise definition of locus and size of lesion. In turn this has contributed to more powerful experimental designs for clinical research.

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