Some causes and effects of hearing loss.

Cochlear damage at very high sound levels. Sound can be a hazard to our hearing when its source is too powerful. High sound levels can damage a part of the ear called the cochlea. This is where a sound's physical fluctuations are transformed into signals in the auditory nerve. In one extreme case a student accidentally heard a 'flashlight' firecracker explode 15 inches from his ear, and immediately experienced a dramatic loss of hearing. His hearing thresholds were measured one week after the accident and they showed a pattern typical for high frequency hearing loss, where high frequencies are more affected than lower frequencies. At 4kHz for example, his loss was found to be 50 dB(HL) one week after the accident, and this loss was the same when he was retested 2 years later. This indicates that the accident had caused immediate and permanent damage to the cochlea (Ward and Glorig, 1961).

Moderately high sound levels. The hearing loss suffered from exposure to environmental noise is not always quite so dramatic. Some exposures can have only temporary effects, indicating that the hearing loss is not entirely due to permanent damage to the cochlea. In an investigation of these effects, Postman and Egan (1949) exposed themselves to a loud noise, at 115 dB(A), for 20 minutes. This gave them a high frequency hearing loss immediately afterwards, but their hearing recovered over a four day period. At 3 kHz, for example, they had 50 dB(HL) half a minute after the noise exposure, 40 dB(HL) 15 minutes later, 30 dB(HL) 5 hours later, and no discernible hearing loss at this frequency after 4 days. People who have spent the evening at a loud concert or disco may experience similar temporary effects.

Repeated exposures. The effects of repeated exposures to moderately high sound levels accumulate over time and can eventually bring about permanent damage to the cochlea. In the past this kind of effect could be quite considerable for people whose working environment was extremely noisy. This is because the practice of wearing ear defenders to protect the ears in noisy working conditions was not then a part of routine safety precautions as it is now. One particularly noisy type of workplace is the large weaving shed. Taylor et al. (1965) measured the hearing thresholds of weaving-shed personnel in a factory where jute is woven to make the backing for carpets. On average, these people showed the typical pattern of high frequency hearing loss, and the extent of this loss increased with the number of years that a person had been working as a weaver. For example, the average loss at 2 kHz for a group who had been working for 20 years was 20 dB(HL), while the average loss at this frequency for a group who had been working for 40 years was 50 dB(HL). However, these averages conceal a considerable amount of variation in hearing loss from one person to another. For example, one person who had been working as a weaver for over 40 years had only 10 dB(HL) at 2 kHz, while another person who had worked for less than 24 years had a severe 70 dB(HL) at the same frequency. This kind of variation shows that there are other factors involved, and that the different factors affect each other's contribution to cochlear damage.

Asymmetrical exposure. The involvement of different factors in cochlear damage complicated initial attempts to pin down the causes and to take appropriate steps. One way to point the finger more firmly at noise exposure is to study individuals where one ear has been exposed to higher sound levels than the other. Factors other than the noise are likely to affect both ears equally, so that if hearing loss is greater in the more exposed ear then the noise is the likely cause. Such studies tend to show that the more exposed ear does indeed have a greater hearing loss. For example, Taylor and Williams (1966) measured the hearing of sports hunters who used rifles regularly. The noise from the rifle is more intense at the left ear when shooting from the right shoulder, a difference that might be as much as 20 dB. This is due to a sort of 'shadowing' effect by the head that reduces the level of sound at the right ear because it is turned away from the gun's barrel. These hunters had high frequency hearing losses in both ears, but greater losses in the left ear than in the right. The average threshold in the left ear of this group, measured at 3 kHz, was over 30 dB greater than the average threshold at this frequency for a group of non-shooters of a similar age. At the same frequency, the shooters' average hearing loss was over 15 dB worse in the left ear than it was in their right ear.

The impulsive noise from a rifle is a powerful sound, perhaps as great as 140 dB(A) at the ear nearest the barrel, but repeated exposures to less powerful sounds can also cause small but measurable indications of cochlear damage. This was shown in a study by Royster et al. (1991) who measured the hearing thresholds in both ears of concert violinists and violists who were members of the Chicago Symphony Orchestra. The sound level from the instrument for these players is again asymmetrical at their ears due to the way that these instruments are held, and here again, the left ear receives a more powerful sound than the right. This asymmetry appears to have been sufficient to produce more hearing loss in the left ear than in the right ear for this group. The difference was fairly small, being a maximum of 6 dB at 4 kHz, but no such effect was found for players from the same orchestra whose instruments give similar sound levels at each ear.

Sociacusis and presbyacusis . Loss of hearing caused by the wear and tear on our ears by environmental factors such as noise has been called sociacusis (Glorig and Nixon, 1962). A different term, presbyacusis, is used to describe loss of hearing with age. Most people will experience presbyacusis to some degree or other, so that in general, older people have higher hearing thresholds than younger people. The typical pattern is high frequency hearing loss that increases steadily with age (Schow and Nerbonne, 1980). This deterioration can be detected with threshold measurements in early adulthood, where it becomes evident at an earlier age in men than in women (Corso, 1963). In fact, a small amount of cochlear damage can be found to occur very early infancy, indicating that there is some 'biological' ageing factor that contributes to hearing loss (Johnsson and Hawkins, 1972). However, given the prevalence of noise in our daily environments, and the evidence of its effects on our hearing, it has seemed generally likely that at least part of the cause of presbyacusis is actually sociacusis.

The Mabaan tribesmen. An attempt to separate the effects of ageing from the effects of environmental noise was undertaken by Rosen et al. (1962) who measured the hearing thresholds of people who have a quiet environment. These were the nomadic Mabaan tribesmen who live their lives in the Sudanese desert where there is hardly any environmental noise. The tribesmen were found to have excellent high frequency hearing and showed little sign of presbyacusis. However, before concluding from this that sociacusis is entirely the cause of presbyacusis there are biological factors that should also be considered. One such is the importance of a good blood supply for the maintenance of the cochlea's function, and the possibility of cochlear damage if the supply is less than optimal. Thus, factors such as a fatty diet, which can impair our blood-supply and which increases the risk of coronary heart disease, also have the effect of impairing our hearing. The diet of the Mabaan is virtually fat-free and they were found to have an extremely healthy blood circulation, so it may be that they have their general physical fitness to thank for their good hearing. One other problem with this sort of cross-cultural study might also be important, and this is the difficulty in establishing how old the participants are. The Mabaan, in common with perhaps the majority of the world's population, are unlikely to have had an accurate idea of their own age.

Effect of diet. Diet can actually be shown to have an influence on hearing loss. Rosen and Olin (1965) persuaded 136 institutionalised mental patients to go on a low-fat diet for 5 years. These people were physically healthier after this time as they were found to have lower blood cholesterol levels than 142 patients in the same institution who had eaten its usual food. The low-fat group also had significantly better hearing. A complex mixture of factors thus brings about Cochlear damage.

Speech in noise. Hearing loss is only one of a number of effects that cochlear damage has on the perception of sound, and cochlear damage is not always the cause of such a loss. Another problem that arises from a damaged cochlea is that there is an increase in the effects of background noise on the perception of other sounds. This problem affects the perception of all types of sound, so that it is particularly troublesome when the perception of speech is impaired. This effect on speech is shown in a study by Festen and Plomp (1990) who asked listeners to write down the number of words that they heard after spoken messages had been played. When background noise was introduced, at a level that was 4 dB above the level of the speech, listeners who had damaged cochleas heard only 4% of the words correctly. On the other hand, a group of listeners with normal hearing heard 80% of these words correctly in spite of the high level of noise.

Notice that it is the level of noise relative to the level of the speech that has been specified for the above experiment. This is called the signal to noise ratio, or the speech to noise ratio in the case where speech is the signal that listeners are trying to detect. The ratio is found by obtaining the levels of the noise and the signal in dB(SPL), and then subtracting the noise level from the signal level. This is the crucial factor in determining the intelligibility of the speech, and it does not change when sounds are amplified by a conventional hearing aid. This is because the levels of the speech and the noise are both increased by this type of amplification, so the signal to noise ratio is unchanged.

Lip reading. A strategy that can be used when listening in noise is to look at the face of the talker. This 'lip reading' improves speech reception for both normally hearing and impaired listeners, but the benefits are limited at higher noise levels. For example, Grant and Braida (1991) found an improvement in speech reception by normal listeners when the face of the talker was made visible. The degree of improvement depended on the noise level and the listener. For example, when the speech to noise ratio was -10dB most listeners heard only around 10% of the words correctly, but when listeners could see the talker's face some of them were able to identify more than 70% of the words correctly. Other listeners, however, seemed to be less able to lip-read effectively, and scored less than 30% correct at the same noise level. A very similar range of abilities is found for listeners with cochlear damage. Walden et al. (1975) played spoken messages in otherwise quiet conditions to listeners who had had mild to moderate hearing losses for some years. In these conditions most listeners correctly identified only around 10% of the words, but speech reception improved when the face of the talker was made visible. This improvement varied considerably from listener to listener, with scores ranged from around 20% correct for some, up to 90% correct for the best 'lip reader' in the group.

It appears then that impaired listeners use some strategies, such as lip-reading, about as well and about as much as normally hearing listeners, and that there is a wide range of abilities. The difficulties of impaired listeners might thus seem less apparent in quiet listening conditions. These difficulties will however become more apparent in noisy conditions that are not so troublesome for normal listeners. In social situations it is often necessary to hear speech when interfering voices and other sounds are at high levels, so it can be appreciated that people with damaged cochleas can often feel that they are in some ways isolated from others.

Further reading. Goldstein, E.B. (2002) Sensation and perception, 6th edition. (Wadsworth, Pacific Grove CA) Chapters 10, 11, 12, 15, & 16 Main Library, Short Loan Collection, 152 GOL

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