

# Audio for the Elderly\*

EDWARD W. HEROLD

Princeton, NJ 08540, USA

It is suggested that audio equipment designers should consider the changes in hearing which accompany increase in age in persons with normal hearing, that is, hearing not so impaired as to justify a hearing aid.

## 0 INTRODUCTION

Aging changes hearing. Approximately 30 percent of persons over 65 have enough hearing impairment to justify the use of a hearing aid, and much research has gone into such aids [1], [2]. The hearing impairment of the majority, the other 70 percent, is less severe and may be described as "normal" for their age. We are concerned here with this "normal" group, which in the United States consists of about 19 million individuals.

Unfortunately, the audio systems provided in radio and television receivers, in motion-picture theaters, and in public-address apparatus are often designed by younger engineers for persons in their age group. In addition, the "normal" hearing change that occurs with age is so gradual that an individual is often unaware of any hearing difference. If loud enough, music and voice, subjectively, do not sound *that* different. The older person, therefore, does not complain about what the engineer provides because he or she doesn't know that it *could* be better.

For the "normal" older person, hearing at low frequencies, up to about 400–500 Hz, shows little change from younger years. At high volume, the upper discomfort threshold stays about the same at most frequencies. The major change is a very large decrease in sensitivity with frequency at the lower threshold of hearing. Accompanying this is a large decrease in the range between the weakest noticeable sound and the upper discomfort threshold, that is, a reduced dynamic range. The result is that, at high volume, intelligibility and sound sensation are not too different from that remembered from younger years. It is at low volume,

and under conditions when the volume fluctuates between low and high, that almost every "normal" older person shows impairment brought on by age. The purpose here is to describe the changes in more detail and to suggest what the audio engineer might do to help.

## 1 FREQUENCY RESPONSE

The classic study of threshold hearing ability as affected by age was done by Bunch in 1929 [3]. The data were on persons with no abnormal hearing loss, that is, on "normal" individuals. Five age groups were measured, between 20 and 30 years, between 30 and 40, between 40 and 50, between 50 and 60, and over 60 years of age. Fig. 1 shows the threshold hearing difference between the mean of the 20–30-year group (plotted as 0 dB throughout) and the means of the others. As can be seen, the over-60 persons have a mean loss at 2 kHz of 23 dB and at 4 kHz of 36 dB, as compared with the 20–30-year group. An approximation to the over 60 threshold is flat up to 500 Hz and decreasing 10 dB per octave above this point. Individual variations, however, are very large; for example, at 4 kHz the average deviation from the 36-dB mean was  $\pm 16$  dB.

Obviously, reproduced speech and music at low volume will sound very different to the average older person than it will to persons under 30. In fact, intelligibility of speech from the ordinary radio or television set at low volume becomes markedly poorer; the "normal" senior citizen, at home, increases the volume to compensate. In a motion-picture theater, he or she will sit closer to the screen. The tone control provided in most home equipment is of no help because it alters the response in the wrong direction, that is, it reduces the high frequencies.

\* Reprinted with permission from *IEEE Technology and Society Magazine*, vol. 6 no. 2, pp. 24–25 (1987 June).

For radio and television receivers, the best tone control system for older users should permit enhancement of the higher frequencies and severe reduction of the low ones, particularly for speech. The 500-Hz-and-below band contributes almost nothing to speech articulation but may contain much of the energy of distracting background sound, so often broadcast along with speech.

If persons under 30 and over 65 are exposed to the same reproduced sound, a frequency response that improves intelligibility at low volume for the older person is going to sound far too "tinny" to please the younger person. Today, many of the over-65 persons live by themselves and associate much of the time with contemporaries. The over-65 group is about 12 percent of the U.S. population and, by the year 2025, is predicted to rise to approximately 19 percent. Although these older people are not initial purchasers of electronic equipment, they are factors in replacement purchases. Perhaps it is time for product designers to recognize their special needs.

## 2 REDUCED DYNAMIC RANGE

Along with the loss of threshold high-frequency hearing is a narrowing of the range between barely perceptible sound and uncomfortably loud sound. The 80–90-dB volume range of the new digital sound recordings, such as Compact Discs, is not only lost on the older listener but is a decided disadvantage. If the loud portions are at a tolerable sound level, the soft portions are unheard. Such listeners need a volume compressor to cut the range down to perhaps 40 dB. An even better design would combine volume compression with a changing frequency response; for example, at low volume, a rising response above 500 Hz, and at high volume, a more nearly flat one. The engineer who wants to design equipment useful for the old as well as the young would be well advised to consider both dynamic range and frequency response.

In a public-address system for older listeners, re-

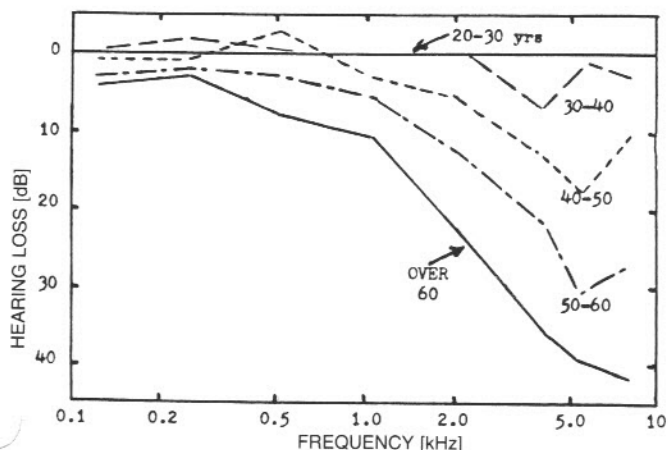


Fig. 1. Comparative average lower threshold of audibility at various ages of groups with "normal" hearing. Data from Bunch [3], here plotted with the 20–30-year group at 0 dB throughout.

sponse up to 400 Hz need be of little concern because there is so little difference in this range over a younger audience. However, for the same reason, extraneous low-frequency noise is more annoying to the older person because of the comparative deficiency in higher frequency hearing. In general, it is important to emphasize high frequencies in spite of the temptation to reduce them to eliminate acoustic feedback. Operators should also understand the potential loss of intelligibility when a live speaker moves away from a podium microphone, or tilts his or her head up with a lapel microphone. If a volume indicator and manual control are not used, a limited amount of volume compression, together with an automatically rising frequency response, may help. Such a design in a public-address system greatly increases the problem of acoustic feedback, so that microphone directivity and loudspeaker placement are much more critical. Alternatively, sophisticated means to prevent acoustic feedback are becoming less costly and are likely to become more common.

## 3 DISCUSSION

We have touched upon only two aspects of audio for the elderly, frequency response and dynamic range, because there appear to be design changes and operating changes that the audio engineer can make.

There are other hearing changes with age which are not so easily susceptible to electronic improvement. One of them is a reduction of frequency selectivity in the human hearing system with aging [4]. This deterioration strongly affects speech comprehension in the presence of noise or other masking sound and is separate from loss of sensitivity under quiet conditions. This factor is the cause of the most common hearing complaint of the older person, "It's loud enough—it's just that I can't understand the words." The one thing the audio engineer can do is to persuade associates in motion pictures, television, and radio production not to add background music, street sound, and so forth while performers are speaking important lines. Such background is very common and tolerable to younger persons but disastrous to the elderly.

Individual variations often intensify with age, particularly with physiological, neurological, and psychological factors not yet fully understood in their effect on audio comprehension. It is not yet feasible to design adaptive equipment for every individual hearing difference. Nevertheless, if the audio engineer takes into consideration the various hearing changes that occur with age, this will benefit the older listener.

## 4 REFERENCES

- [1] M. C. Pollack, Ed., *Amplification for the Hearing Impaired*, 2nd ed. (Grune & Stratton, New York, 1980).
- [2] H. Levitt et al., Eds., *Sensory Aids for the Hearing Impaired* (IEEE Press, New York, 1980).

[3] C. C. Bunch, "Age Variations in Auditory Acuity," *Arch. Otolaryngology*, vol. 9, pp. 625-636 (1929).

[4] R. D. Patterson, I. Nimmo-Smith, D. L. Weber,

and R. Milroy, "The Deterioration of Hearing with Age: Frequency Selectivity, the Critical Ratio, the Audiogram, and Speech Threshold," *J. Acoust. Soc. Am.*, vol. 72, pp. 1788-1803 (1982).

#### THE AUTHOR



Edward W. Herold was born in New York City in 1907. He received a B.Sc. degree from the University of Virginia in 1930 and an M.Sc. and D.Sc. (Hon.) from Polytechnic University in 1942 and 1961, respectively. He worked in research on electron devices at RCA from 1930-1959, was vice president of research at Varian Associates, 1959-1964, and returned to RCA

on its corporate research and engineering staff (1965-1972). Since then, he has been a consultant in electronic and patent matters. He is author of 55 technical articles and holder of 47 U.S. patents.

Dr. Herold is a member of Phi Beta Kappa, Sigma Xi, a fellow of the IEEE and was awarded its Founders Medal in 1976.