Rehabilitation

Hearing and Acoustical Handicaps

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THE PROBLEMS attending the failure to hear normally can hardly be understood without some grasp of what normal hearing is like. This understanding must go beyond the physical characteristics of sound and beyond the organic reception of auditory stimuli. It must include an awareness of the psychological and social effects of audition. Apparently it is difficult to establish the concept that hearing may differ not only in degree but also in kind. Every clinician concerned with hearing is familiar with reports that a patient can hear "real well" and yet fails to understand much of what is said to him. Most of us know of persons who literally can hear a pin drop but still have difficulty in oral communication. Such instances, along with observation and study of persons with severe loss of hearing, point to the important fact that deafness brings about a qualitative as well as a quantitative change in the total pattern of sensory perception (*1*).

Sound Heard by the Normal Ear

A brief description of how we hear will illustrate some of the possibilities for difficulty in the function of hearing. Although its performance is taken for granted, the normal ear actually is one of Nature's most remarkable creations. Physicists tell us that the normal ear is capable of detecting changes as small as 1-billionth of the atmospheric pressure on the eardrum (*2*). For the convenience of avoiding the large numerical differences that would be involved if measurements were made in actual acoustic pressures, the measurement of sound intensity usually is expressed in logarithmic units known as bels and decibels. This system has no fixed quantity, but rather it expresses a ratio of two quantities such as double, triple, tenfold, and so on. On such a scale the intensity range of the normal ear for a 1,000-cycle tone is approximately 120 decibels. On most audiograms the zero-decibel level represents the intensity at which normal ears can just detect a tone. Loss of hearing then is expressed as so many decibels above that intensity.

The range of audible frequencies for normal human ears extends from approximately 20 to 20,000 cycles per second. It may orient our thinking to remember that the pitch of middle C on the musical scale is approximately 250 cycles per second. The range of frequencies that are important for conveying a speech signal is from about 300 to 3,000 cycles per second. The frequencies ordinarily measured by an audiometer are from 125 to 10,000 cycles per second.

The total number of pure tones that most ears can distinguish on the basis of both frequency and intensity is on the order of 340,000 (*3*). We know, of course, that most of the sounds we hear are not of a single frequency nor at a single intensity. Instead they are combinations of many frequencies and intensities that change almost continuously. The result is that the normal ear is responsive to a practically infinite variety of sound patterns. This is possible because of the highly specialized and delicate structure of the human ear.

Structure and Functioning of the Ear

For purposes of study and description, the ear may be divided into three parts: the outer ear,

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the middle ear, and the inner ear. The outer ear of man is not very complex. It consists simply of the visible auricle on the side of the head and the external auditory canal that forms an unobstructed passageway of air to the eardrum.

The middle ear is more complex, both structurally and functionally. It serves as a mechanical transducer of sound vibrations from the surrounding air to the fluid of the inner ear. The eardrum (tympanic membrane) separates the outer ear from the middle ear. Attached to this membrane and extending across the space of the middle ear to the wall of the inner ear are three small bones (ossicles) known as the hammer (malleus), anvil (incus), and stirrup (stapes). These tiny bones function as a kind of lever mechanism in transmitting the motion of the eardrum to the inner ear. The airspace of the middle ear is connected with the nasal cavity by the eustachian tube. This opening provides ventilation of the middle ear and permits equalization of air pressure inside and outside the eardrum.

Between the middle and inner portions of the ear are two openings in the bony partition: the oval window and the round window. The footplate of the stirrup fits into the oval window in such a way as to respond with a rocking motion when vibration causes movement of the drum membrane and ossicular chain. The round window is closed by a flexible membrane which permits movement of the fluid in the inner ear when changes in pressure occur at the oval window.

The inner ear is a highly complex and delicate structure embedded deep within the temporal bone. It occupies a space that is shaped like a snail shell and is known as the cochlea. Within the cochlea is an intricate arrangement of cells that make up the organ of hearing. This organ is supplied with nerve endings from the eighth cranial nerve, which carries auditory impulses to the brain. Adjacent to the cochlea and continuous with it are the vestibule and three semicircular canals. These chambers also have special sensory structures that are supplied by a branch of the eighth nerve. Their function is to provide the sense of equilibrium.

In addition to the specialized structures of the inner ear, the whole labyrinthine chamber is filled with fluid that serves as the medium for conveying vibration or movement to the enclosed sensory organs.

Beyond the stage of cochlear reception hearing becomes a function of nerve and brain activity. For the most part this process defies simple description. However, some of the significant biological functions of hearing can be presented briefly (*4*). In its simplest form hearing is unconscious. The hearer reacts to the background of sound in his environment without being aware of most of it. Any sudden change or unusual pattern of sound is likely to raise hearing to the signal or warning level. At still higher levels of function it permits communication by language and appreciation of auditory beauty. Each of these functions is important to the comfort and well-being of the person. Even the unconscious perception of background noises establishes a sense of contact and unity with the environment; lacking it, one is likely to feel isolated and uneasy. At the signal level hearing serves the practical purposes of protecting the person and directing much of his activity. The most important aspects of this function in humans are at the intellectual and social levels, where hearing permits easy acquisition of language and fluent oral communication.

Medical Treatment

I will not attempt to review the problems of medical treatment and restoration of hearing in patients whose auditory handicap is temporary. Among children this group is large. It constitutes an area in which programs for the conservation of hearing are highly fruitful. Much of the deafness caused by infections in the middle ear or other obstructions to the transmission of sound can be corrected or alleviated by surgical or other medical treatment (*5*). With prompt and proper care most children having conductive deafness can be treated successfully. This is true for adults as well as children, but conductive impairments in adults are not so commonly without complications.

A significant cause of conductive deafness in adults is a change in the bony wall of the inner ear known as otosclerosis. Certain pa-

tients with this condition are suitable candidates for the fenestration or the mobilization operations. If such treatment is successful, these patients usually regain sufficient hearing to understand speech satisfactorily although the acuity for sound is not likely to be entirely normal.

A significant number of children and the majority of adults with difficulty in hearing have some degree of perceptive deafness. This means that either the inner ear or the auditory nerve fails to respond normally to sound. In most instances this type of deafness cannot be corrected by any type of treatment, and for many of this group, compensation by the use of hearing aids and educational rehabilitation are particularly important.

Compensatory Skills

The variations that may occur in auditory impairments are many. However, there are basic principles that apply to deafness in general. The problems of each individual may be expected to vary not only with the type and degree and age at onset of his deafness, but with other physical and mental characteristics and with the environment in which he functions.

Despite some misconceptions about the more subtle problems that are created by deafness, there is general cognizance of the basic nature of the handicap. Most enlightened persons now realize that deafness is primarily a sensory deprivation and an obstacle to communication rather than an intellectual defect as it was once thought to be. Most people know that deafness usually can be compensated for to a successful degree by the development and utilization of other senses and skills. They know that most deaf persons can and do take responsible and productive places in society. It is doubtful, however, whether many people are aware of all the means by which this compensation is achieved. Probably few understand the pervasive psychological and social significance of deafness. The very fact that the communicative handicap looms so large tends to obscure other aspects of the problem.

In the normal person, hearing and vision work together in a supplementary relationship to orient him to both his immediate and his distant environment. Vision is directed primarily to the foreground, while hearing is nondirectional, encompassing the background as well as the foreground. Vision is limited by darkness and by obstructions and is essentially nonfunctional during sleep. Hearing functions keenly in the dark, around corners, through most doors and walls, and even to a substantial degree during sleep. If this comparative analysis of the two major senses were to be continued into every detail of our lives, we would understand why Helen Keller has said that she regrets the lack of hearing more than she does the lack of sight.

In the absence of hearing, vision must carry most of the burden of perceiving things at a distance, although the tactile sense may be employed for this to some extent. For example, most deaf persons are able to feel the vibrations produced by an airplane overhead or a clap of thunder or the stamp of a foot on the floor. From time to time speculations have arisen as to whether the deaf as a group possess keener visual acuity and sharper powers of observation than do those with normal hearing. Although this supposition has not been demonstrated conclusively, it has a sound underlying premise. It acknowledges that the security of the individual is threatened by the sensory defect and the individual thus threatened is challenged to mobilize his remaining resources more effectively. He develops compensatory skills in order to meet the demands of his environment.

In addition to visual and tactile impressions, the deaf person may develop an acute awareness of kinesthetic sensations. This helps him to feel and interpret his own movements more effectively and becomes an important gauge for controlling the production of speech. Individuals differ in the extent to which the kinesthetic sense develops naturally, and no method is certain to produce efficient kinesthetic control of speech muscles. However, if a patient is properly encouraged to attempt speech and to pay close attention to the visual and tactile clues, he can usually establish some muscular feeling for speech (*6*).

Persons who lose their hearing after speech has developed usually retain much of their articulatory skill, but over a period the quality of their voices is likely to change considerably.

Their speech usually remains intelligible to most listeners, although it may lack proper intonation and rhythm. Early attention to visual, tactile, and kinesthetic sensations should do much toward maintaining adequate speech after loss of hearing.

The speech of persons with partial deafness may be expected to vary with the type, degree, and conditions of onset of deafness. The partially deaf person most commonly hears the vowel sounds and most of the rhythm patterns while missing many of the consonants and much of the inflection of the voice. Frequently this results in articulatory difficulty and some degree of monotony in vocal quality. Partially deaf persons are likely to be unaware of their speech disorders because they reproduce speech as they hear it. The first step in treatment for this group is to determine whether amplification will improve the auditory signals that are desired. The majority of those with moderate to severe deafness can learn to use a hearing aid to some advantage. Occasionally the use of a hearing aid is the only requirement for adequate rehabilitation of a partially deaf person; more often it is necessary or at least desirable to provide training in auditory, visual, tactile, and kinesthetic perception.

Use of the Hearing Aid

It is impractical to lay down a rigid set of standards for the determination of benefit from a hearing aid. Most of the values are relative. That which is significant to one person may be unimportant to another. Even two individuals whose audiograms are identical may not benefit equally from amplification. One may distinguish sounds well enough to derive considerable help in understanding the speech of others, while another may benefit primarily by the increased sensation of his own voice. No person with perceptive deafness should expect complete compensation. A hearing aid does not improve the ability to hear; rather it may improve the signal to be heard. Despite this fact and despite all the limitations and problems imposed by hearing aids, they have been a tremendous boon to millions of people with partial deafness. Certain general principles and guideposts may be used in helping to determine who should wear a hearing aid.

It is appropriate to consider a hearing aid for most persons with a permanent loss of hearing in the better ear of between 35 and 95 decibels for speech frequencies. The greatest degree of benefit and satisfaction from amplification is likely to be experienced by those with hearing losses for speech of from 35 to 75 decibels. Most persons in this group can learn to use a hearing aid well enough to permit satisfactory communication under favorable circumstances. The majority of them can develop and maintain intelligible speech. With a combination of personal initiative, proper training, and use of a hearing aid, the handicap produced by moderate degrees of deafness can be reduced to a minimum. In most instances it need not interfere with pursuit of normal vocational and social activities.

It is not uncommon to find individuals with losses of from 75 to 95 decibels who cannot tolerate enough amplification to do any important good. This is the usual circumstance for those with losses greater than 95 decibels in the speech frequencies. Nevertheless, if any hearing for speech remains, it is advisable to try a hearing aid and to provide training in the use of residual hearing. As a general rule, those who have heard enough to acquire normal speech and language before their loss of hearing will derive greater benefit from amplification than those who have never been accustomed to interpreting sound patterns. Also, those whose audiograms are relatively flat may expect better results than those with markedly falling curves or other highly irregular patterns of auditory threshold.

The physical inconvenience of hearing aids has always been a factor in discouraging people from using them. This, combined with false pride and the substantial expense of the instruments, has deterred their acceptance to a considerable extent. The fact that a moderate impairment of hearing is not readily apparent seems to promote the tendency to hide it, or even to deny its existence. This obstacle and that of inconvenience have been reduced greatly in recent years by the development of small, highly efficient, inconspicuous instruments. It is obvious that consumers have paid for this development by numerous and ex-

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Auditory training in speech discrimination with background noise.

pensive purchases of hearing aids. It is no secret that many users of hearing aids have bought 2 or 3 or even more instruments before they learned to use one effectively. The justification for the usual price of a hearing aid is that the agent is supposed to provide extensive service to those who find it difficult to learn to use the instrument. Part of the adjustment of a person who wears a hearing aid includes an understanding of the operation and maintenance of the instrument (*7*).

Auditory Training

Auditory training and practice in listening can play an important part in the adjustment to a hearing aid. Many new sounds are introduced by the use of an instrument, and virtually all sounds are changed in quality. It is difficult for many persons to become accustomed to these changes. Although they receive more sound than they did without amplification, it may have little value until they learn to interpret it. This learning may be facilitated by instruction and systematic practice. In a complete program of auditory training, opportunity is provided to progress from relatively easy distinctions between sounds that are grossly different to finer and more complex discrimination. The stimulation may range from the booming of a drum or blaring of a siren to the rustle of leaves or

the production of a voiceless consonant. When it is attainable, the emphasis in discrimination is placed on interpretation of speech. Listening for pleasure is encouraged by using rhythm and music for auditory stimulation.

Both the starting points and end results of auditory training vary widely for different individuals. Some may never achieve more than gross discrimination, while others can learn to distinguish words effectively. Although the degree and type of deafness and the effectiveness of auditory training usually are related, no fixed rule can be applied to determine the exact value of such training. It must be assumed that all persons with some residual hearing have the potentiality for utilizing it to advantage. An extensive program in auditory training is recommended particularly for children who have never heard well enough to acquire normal speech and language and for all those who experience unusual difficulty in adjusting to a hearing aid. Hopkins and Hudgins (*8*) have suggested that even though it is not possible to predict from the audiogram how much a child will profit from auditory training, all acoustically handicapped children seem to derive some benefit from it and should have every opportunity to continue training throughout their school lives.

Schools for Children

Children with deafness of less than 60 decibels for speech usually can adjust and make satisfactory progress in the regular classroom if they have learned to wear a hearing aid and are given a moderate amount of special help in the development of communicative skills. Those with losses of between 60 and 75 decibels are likely to need a substantial amount of special help, but many can participate profitably in the program of the regular school. If proper instruction is available and if adequate adjustments are made, it is desirable to keep these children in the regular classrooms. When circumstances are not favorable for a partially deaf child in the regular classroom, or if he fails to adjust to this environment, it may be necessary to provide a special class or special school environment. For children whose deafness for speech is greater than 75 decibels, it usually is best to provide a special school that is large enough for appropriate grouping and is staffed by teachers who are highly trained for teaching the deaf (*9*). Those whose losses of hearing for speech are greater than 75 decibels usually have considerable difficulty in learning; the results are limited even after a period of training and adjustment.

Speech Reading

When hearing is absent or nearly so, the principal means of compensation is visual perception. Regardless of the degree or kind of deafness, lip reading—or more properly, speech reading—can play a vital role in the process of rehabilitation. For countless numbers of persons with mild impairments of hearing, the practice of speech reading permits adequate adjustment for normal activities. For those who are severely deaf it is the chief means of understanding the speech of others. For those with moderate degrees of deafness it complements the auditory function in a remarkable way. Fortunately, the elements of speech that are weakest in acoustic power, and therefore are heard poorly, have distinctive positions or movements that are readily visible.

All persons who see adequately can read speech to some extent. Every gesture and expression that a speaker exhibits gives the listener certain information. As gestures of the hands and body can come to have meaning, so can motions of the lips, tongue, and face. Interpretation of these motions is, of course, the skill known as speech reading. It must be borne in mind that by no means all the positions and movements of the speech structures are visible to the observer. He sees only partial patterns and those only fleetingly. There are several pairs of consonant elements in which positions and movements are visibly the same. This causes many words and phrases to appear identical. Often the speech reader must rely on context and a sense of appropriateness to determine what has been said. Differences in the way people speak also contribute to the problems of the speech reader. People who talk with little movement of the lips with cigarettes and pipes in their mouths are difficult to understand. Extremely rapid or unusually slow speech is hard to interpret. Unique skill

and artistry is required for becoming highly proficient in speech reading. On the other hand, nearly everyone can do it to some degree; but often the main task in teaching speech reading to adults is to convince them that it is within their power to grasp it.

The ability to read speech varies just as other abilities do. In some it develops naturally, even without special training. Others require laborious teaching, and still others never become proficient. It seems to depend more on an inherent knack or aptitude than on general intelligence or diligent study (*10–12*). The person who can seize partial clues instantaneously and synthesize them into meaningful patterns is likely to be adept at reading speech.

It is difficult, if not impossible, to assess or predict the degree of accomplishment that will result from instruction in speech reading. Nevertheless, it is appropriate to provide well-planned programs of instruction and practice for all those with a significant impairment of hearing. Practically all educational programs for acoustically handicapped children should and do include training in speech reading. Many programs of instruction for adults as well as children are made available by the chapters of the American Hearing Society and by other agencies such as university clinics for speech and hearing therapy and community evening classes. There is need for expansion of these services, but an ever greater need is for the acoustically handicapped themselves to learn of the benefits that can be gained by a determined effort to overcome their handicap.

Comment

Important as oral communication is, it is not the only means of communication and it is not a prerequisite for acceptable behavior or competent performance of many tasks. The deaf or hard of hearing person should be encouraged and guided in the development of appropriate compensations that will provide a sense of security and satisfaction. Frequently, this may be done most effectively by emphasizing activities and abilities that are not directly dependent on hearing. The deaf person who excels in his work or play, whatever it be, will find that the communicative problem is lessened. Actions do indeed speak more strongly, if not louder, than words. An accurately drawn blueprint, or a finely tailored garment, or a beautifully prepared meal will speak eloquently for itself. The producer need not give nor listen to an oration on its merits.

Auditory impairment of any degree need not interfere with acceptable behavior and development of a child nor with useful and happy adjustment of an adult. Acceptance of this premise should not be interpreted to mean that deafness is no handicap. On the contrary, it must be recognized that any significant degree of deafness imposes a serious deprivation. Only by acknowledgment and careful assessment of the handicap can proper adjustments and appropriate compensations be made.

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