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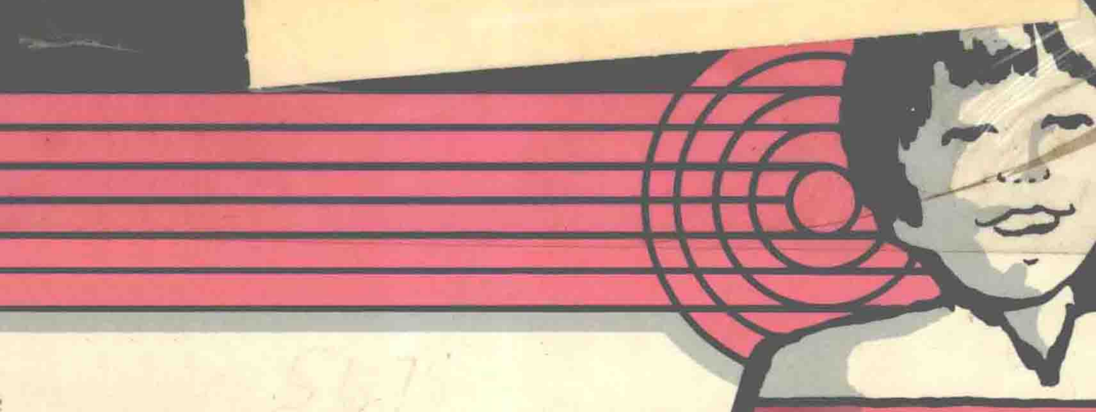

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Preface

This book describes the state-of-art in educational audiology, a main branch of both the audiological and educational professions. The book deals with hearing impaired children, particularly youngsters enrolled in the regular public schools and especially hard of hearing children.

With the passage of the All Handicapped Children's Act in 1975, a need for the specialty of educational audiology became professionally recognized. Since then professional training programs in audiology, education of the hearing impaired, and speech-language pathology have provided increasing coursework and practicum focused on the characteristics and needs of hearing impaired children in the regular schools. The literature of educational audiology has been growing accordingly.

The current book is the third of a series of books on educational audiology written at Utah State University. The first book, *The Hard of Hearing Child,* was printed in 1970. The second book, *Educational Audiology,* was printed in 1976. The present book describes earlier as well as recent developments and sets the stage for a new round of improvements in the state-of-the art.

This book includes eight interrelated chapters. The characteristics of hard of hearing children and the service needs of hearing impaired children in the regular schools are covered in Chapters 1 and 2. A model for the delivery of services by the educational audiologist, based on a recent national survey, is introduced. A new assessment model is covered at length in Chapter 3. In Chapters 4 and 5 audiological considerations and hearing aids for school children are described. Chapters 6 and 7 detail listening and speech programs as well as classroom acoustics and signal amplification and transmission equipment. The final chapter (8) describes the changing roles of parents, teachers, and school administrators in meeting the needs of hard of hearing children in regular classrooms, and the responsibilities of educational audiologists in the change process.

Four educational audiologists have collaborated in the planning and writing of this book. The uniqueness of separate personalities as well as common purpose is hopefully evident. Each contributor is a member of the recently organized Educational Audiology Association.

Contents

Frederick S. Berg

1

Characteristics of the Target Population

This chapter addresses the characteristics and deficiencies of hard-of-hearing students in the elementary and secondary schools of our nation. Initially, the prevalence of this target population and the unsolved problem of identifying students with hearing loss are described. Next, the various underlying ear pathologies are briefly reviewed. The remainder of the chapter covers deficiencies of hard-of-hearing students, beginning with listening problems and ending with vocational problems. The following chapters also focus on hard-of-hearing students, but consider as well the deaf who are mainstreamed.

TARGET POPULATION

Hearing loss is one of the most prevalent handicapping conditions. By the age of two, 75 percent of children have had at least one espisode of otitis media, which is only one of many etiologies which can cause hearing loss (Richardson & Donaldson, 1981). Between kindergarten and 12th grade, approximately one in every five children has a conductive, sensory, neural, or mixed hearing loss in one or both ears, stemming from one of many etiologies.* Table 1-1 presents hearing threshold data on a 38,568-person national sample of males and females; this data was obtained in mobile testing units by audiologists employed by Colorado State University.

Currently only a minority of the entire school population is systematically tested for hearing loss. Equipment, facilities, and techniques could be made

*Personal Communication from J Willeford, Colorado State Universtiy, Fort Collins, Colorado, January 25, 1971.

Table 1-1.
Number of school-age children with varying unilateral and bilateral hearing impairment for each 1000 youngsters from a 38,568-child sample of all youngsters in the elementary and secondary schools of the United States

dB Loss	Unilateral	Bilateral
11–25 (slight)	154+	34
26–45 (mild)	13+	5
46–100+ (moderate-severe-profound)	3+	2

available for accomplishing a mass program for evaluation of hearing losses in the schools, but educational resources have not been marshalled for such a task. Consequently, only the children with the most obvious hearing losses tend to be earmarked for special support. Data from Table 1-1 indicates that more than 8 million of the 39.5 million children in the schools have hearing loss, but national summaries of handicapped children receiving special education and related services reveals that only about 41,000 hard-of-hearing children and 41,000 deaf children have been singled out for extra consideration. Only about one child in every 100 hearing impaired children in the regular and special schools of the country is therefore receiving special educational support (Feistritzer, 1983, p. 7; United States Department of Education, 1980†).

The most frequently occurring hearing problem among school children is conductive loss from active ear disease, but this problem is not being uncovered on a widespread basis. Every other child with a conductive hearing loss is missed when tested by the traditional 25-decibel (25-dB) pure-tone screening often exclusively used. A newer technique, recommended for use together with pure-tone screening, is impedence screening, but it has yet to reach the schools in a major way. Consequently, the great majority of children with hearing loss, particularly those with the least unilateral and bilateral involvement, are often left unidentified. Without comprehensive hearing screening and testing, the task of identification is very difficult.

> The hearing impaired child has the same physical appearance as his friends who have normal hearing; he also behaves essentially as they do. Even his disabilities may be easily misunderstood as merely negative variations of normal behavior. For example, when the teacher of a child with a hearing defect speaks to him one time, he may be watching her and—with what he receives from hearing reinforced by what he receives from sight—responds correctly. Another time when she speaks, the background noise may cover too much of what she says for him to decode the message correctly, or he may miss some of the

†Personal Communication from J. Rosenstein. Report of handicapped children receiving special education and related services as reported by state agenices under P.L. 94–142 and P.L. 89–313, school year 1979–80. July 21, 1980.

> essential cues from her face if it is turned away from him. This time he misunderstands and responds erroneously. His behavior is thus erratic depending upon such factors as the auditory characteristics of his hearing and of the background noises, manner with which the teacher speaks, and her position relative to his view, in addition to the random variations found in any child. But then, the child with normal hearing is often inattentive or distracted by other events and, therefore, is erratic in his responses to spoken language. For this reason the teacher is likely to interpret the intermittency in performance of the hard-of-hearing child to lack of self-descipline. When he does "pay attention," he seems to "get along fine." (Fletcher, 1970, p.4.)

Parents and teachers may know that the child has had an ear infection or another etiology that can lead to hearing loss, but may not really know if a temporary or permanent hearing loss exists unless regular audiometric testing is performed. When a child has a severe or profound hearing loss, a parent typically makes the diagnosis of hearing loss before the child is 2 years old, although the family doctor or pediatrician might tend to negate this finding (Fellendorf, 1975, p. 11). The child with a less severe hearing loss poses a more difficult identification problem, particularly during the early years of life and school. This child responds to sound, but inconsistently, and develops speech and language, but slowly and imperfectly. When parents and teachers are not oriented to the differences between deaf and hard-of-hearing children, they behave as does the general public and tend to think of deafness as an all-or-nothing phenomenon (Boothroyd, 1982, p. 66).

The problem of identifying hard-of-hearing children extends from the preschool years through the elementary and secondary school years. The specific task is to distinguish the hard-of-hearing child from the normally hearing child and from the deaf child. One purpose of this recognition is simply to take a first step in providing appropriate educational services for the hard of hearing. In the past, the hard-of-hearing child has tended to be educated as either a normal hearing youngster or as a deaf child, without due consideration being given to the varying communication abilities of these 3 populations. Communicatively, the hard-of-hearing child is more like the normal hearing child than like the deaf child, because both use audition rather than vision as the primary mode for speech and language development and usage. However, the hard-of-hearing child will be neglected in both the regular class and the special class for the deaf unless recognition is given to that child's unique communication problems.

The measurement of hearing contributes to the differentiation of the hard-of-hearing child from the normal hearing child and from the deaf child. If the child has a hearing loss for speech in the better ear of 15 dB or less, that child often can be considered a normal hearing child. If the hearing loss is 16 dB or greater, the child can be called hard of hearing, unless the loss is so great that audition is no longer the primary communicative input mode. On the average, 95–100 dB is a dividing line between being hard of hearing and being deaf (Ross, 1982, pp. 3–4). When hearing loss is great, however, determining whether a specific child is hard of hearing or deaf depends on more than reference to the 95–100 dB cutoff. In schools or classes for the deaf, for example, about half of the children have less than a 95-dB hearing loss, and yet these children tend to function as deaf children because their residual hearing has not been fully utilized (Ross 1982, p. 3; Wedenberg, 1981). If we do not identify which children can function as hard of hearing rather than deaf, we are ignoring a potential for speech and language development and functioning that can expand the communicative world for many hearing-impaired children. This is not to put down the deaf child who must rely primarily upon vision (lipreading, visual cues, or manual communication) for communication, and who often can use audition as a significant secondary or supplementary communicative mode. Currently, however, we are not tapping the residual hearing capabilities of either the deaf or hard of hearing to the extent that is possible and even practical. Educators should not neglect either of these subpopulations of hearing-impaired children.

EAR PATHOLOGY

Hearing loss is organic or functional. An organic hearing loss has a physical basis, whereas a functional hearing loss is psychological in origin. Organic hearing loss constitutes nearly all hearing loss among children (Newby, 1979, p. 62). A specific pathology or lesion of organic hearing loss affects one or more of the 3 components of the hearing mechanism: conductive, sensory, or neural. The conductive component includes the outer and middle ears, the sensory component the 2 cochleas, and the neural component the auditory nerves and all those parts of the brain concerned with the processing of auditory information. The outer and middle ears conduct sound from the surrounding air to the cochleas and protect them from the effects of loud noises and direct physical damage. Each cochlea, called an end organ of hearing, converts the physical characterisitcs of sound into corresponding neural information which the brain can process and interpret. Each side of the brain receives information from both the right and left ears. (Boothroyd, 1982, pp. 13–16).

Hearing pathology or disorder results from various genetic defects, diseases, drugs, or traumas. These general causes and specific examples have been summarized (Boothroyd, 1982, p.50). The type of loss (conductive, sensory, or neural), time acquired, degree of loss, stability, and occurrence of additional impairments are specified. Almost twice as many specific etiologies result in sensory (cochlear) hearing loss than in either conductive or neural hearing loss. The most common causes of conductive hearing loss, namely impacted wax in the outer ear and otitis media, result in lesser degrees of hearing loss which fluctuate over time. Most other etiologies, including genetic factors and rubella, result in mild-to-profound hearing impairment. Most hearing loss is acquired rather than congenital. About half of the etiologies resulting in hearing loss can lead to additional impairments, including perceptual or symbolic dysfunction. The population of hearing-impaired children, both hard of hearing and deaf, presents a wide variety of characteristics and needs.

DEFICIENCIES OF THE HARD OF HEARING

The hard-of-hearing child presents a bewildering complexity of problems to consider. These problems encompass listening, speech, language, cognition and academics, emotions and social relations, parental and societal reactions, and vocational performance.

Listening Problem

Broadly defined, listening is the decoding of any auditory stimulus, whether it be an environmental sound or a person speaking. The definition needs to be broadened to encompass the perception of speech through audition, vision (speech-reading or lipreading), or both in combination. We have all had the experience of having to look at a person in order to understand what was being said when the person was speaking from a distance or in the presence of noise (Berg, 1978, p. 1).

Listening efficiency depends upon many variables of the speaker, listener, environment, and speech code. Whereas the normal hearing child can usually perceive the entirety of speech if it is not too faint or too far away, the hard-of-hearing child typically decodes less of the spoken message. If the child has a conductive impairment, speech will be faint or may not be heard.

A simple test for experiencing the listening impact of just a slight conductive bilateral hearing loss has been described by Downs (1981):

> With your fingers extended, press the tabs in front of your ears into the ear canals, occluding the ear canals completely. Press tightly. You have just given yourself a 25 dB HL average hearing loss. . . Try carrying on a normal conversation with this hearing loss, or try listening to someone talk in a crowd. You will find that you have to strain a great deal in order to catch what people are saying. (Downs, 1981, p. 177).

When sensory (cochlear) impairment exists, speech might not only be difficult to detect but to discriminate, even if made loud enough. Likewise, if the neural mechanism is damaged close to the cochlea, loss of sensitivity and discrimination might be evident. With a mild discrimination problem, similar words such as *track* and *trap* sound alike. When a discrimination problem is severe, words as dissimilar as *pig* and *doll* may not be differentiated, nor might two very different environmental sounds. If the lesion is in the brain stem or at a still higher level, the child may have difficulties also with auditory attention, awareness, memory, or association (Boothroyd, 1982).

Speech reception can break down at various listening levels: detection, discrimination, identification or recognition, and comprehension.

> Detection is the ability to perceive the presence of an acoustic event; discrimination, to hear the difference between one sound and another; identification, to recognize one sound pattern as distinct from all others; and comprehension, to understand the meaning of the speech signal (Ling, 1981).

Listening levels or subprocesses are clarified if related to questions such as: "Was there a sound?" (detection); "Was this sound different from that sound?" (discrimination); "What was the sound like?" (sensation); "Where did the sound originate?" (localization); "What made the sound?" (recognition); and "Why was the sound made?" (comprehension) (Boothroyd, 1982, pp. 17–20).

Hard-of-hearing children often do not comprehend speech because they do not have the potential for detecting, discriminating, sensing, localizing, or recognizing as much information as do normal hearing children. Hard-of-hearing children are more dependent upon a redundancy of information being provided by the speaker, the speech signal, or the environment to counteract breakdown in speech reception. For example, room noise may need to be reduced or lipreading may need to be added to residual hearing in order for the hard-of-hearing child to comprehend speech (Sanders, D., 1982, pp. 27–30).

Normally there is a comfortable redundancy of clues for decoding speech messages.

> When we listen under favorable conditions, the clues available are far in excess of what is actually needed for satisfactory recognition. Indeed, general context is often so compelling that we know positively what is going to be said even before we hear the words. This is why under normal conditions we understand speech with ease and certainty, despite the ambiguities of acoustic cues. It is also the reason that intelligibility is maintained to such an astonishing extent, despite the variability of speakers, in the presence of noise and distortion (Denes & Pinson, 1963, p. 146).

Many professionals have previously held the widespread view that children with unilateral hearing loss have problems localizing where sound is coming from, but that, with preferential seating, they compensate for speech recognition problems. A recent study by Bess (1982) challenges this basic assumption. Bess compared both the localization and syllable recognition performance of 25 children with moderate-to-profound unilateral hearing loss to that of a matched group of normal hearing listeners. The children with unilateral hearing loss not only made more localization errors than did their normal hearing counterparts, but they also scored lower in syllable recognition tasks. The lower recognition scores occurred under conditions simulating regular seating and preferential seating. In the first condition, noise was presented to the good ear and speech to the impaired ear. In the second condition, which simulated preferential seating, the syllables were presented to the good ear and noise to the poor ear. Bess concluded that-(1) the greater the hearing loss the poorer the localization ability; and, (2) the more adverse the listening condition the poorer the speech recognition.

Children with either unilateral or bilateral hearing loss may have problems listening in typical school classrooms. Competing noise and, at times, excessive reverberation interfere with speech reception by masking and smearing speech, respectively. The classroom acoustics problem will be discussed further in Chapter 7.

While a unilateral hearing loss presents a definite listening problem to the child, a bilateral hearing impairment results in a more extensive listening breakdown. A bilateral loss causes part of the sound environment to be shut out of both cochleas and both auditory nerves. Bilateral hearing loss has such an evident impact upon listening that classifications of hearing handicap in the literature are based almost entirely upon the assumption that a lesion exists in both ears (Davis, H., 1978). A hearing handicap classification should reflect, however, various degrees of both unilateral and bilateral hearing losses. An example of such a classification based on speech detection appears below.

If children cannot detect sound, they cannot localize, recognize, or comprehend it. Detection is the lowest level of the auditory reception hierarchy. Detection loss is expressed in decibels and occurs when a lesion is in any site of the auditory mechanism, or when hearing loss is conductive, sensory, neural, or central in origin. The effects of just a detection or decibel loss are below hypothetically related to categories of unilateral and bilateral hearing loss. It is assumed that the child is listening in a typical classroom environment at 12 feet distant from the sound source and without a hearing aid.

- *Slight unilateral, 11–25 dB.* Faint sounds from impaired-ear side of head tend not to be detected.
- *Mild Unilateral, 26–45 dB.* Faint sounds from impaired-ear side of head are not detected.
- *Moderate to profound unilateral, 46–100+ dB.* Conversational level sounds from impaired-ear side of head tend not to be detected.
- *Slight bilateral, 11–25 dB.* Faint sounds from better-ear side of head tend not to be detected.
- *Mild bilateral, 26–45 dB.* Faint sounds from better-ear side of head are not detected.
- *Moderate to profound bilateral, 46–100+ dB.* Conversational level to loud level sounds from better-ear side of head tend not to be detected or are not detected.

The speech detection problem of unilateral and bilateral hearing loss is accompanied by corresponding loss of environmental awareness. Normally, the lead senses of audition and vision reach out to intercept acoustic and optical stimuli and keep a child in homeostasis with the close and distant environment as needed (Myklebust, 1960, pp. 46–48). Binaural hearing, a benefit of an intact auditory mechanism, is particularly adept at scanning the environment for meaningful events because of its multidirectional and depth-perception capabilities. With hearing loss, the child loses contact with certain sounds of the surrounding environment and loses the capacity to localize the origin of other sounds. Typically, with unilateral or bilateral hearing loss, the two ears of the child differ in speech detection sensitivity. Often, the less sensitive the child's hearing, the smaller the environmental field that can be detected or localized by the auditory mechanism. Pure-tone and speech detection thresholds for each ear are measured to provide data for estimating loss of environmental input in general and speech input in particular.

The pure-tone thresholds in decibels are plotted on an audiogram form for both ears of a child. Thresholds are often obtained for 7 octave intervals from 125 to 8000 Hertz (Hz), spanning the frequency range of the speech signal. The thresholds for the frequencies 500, 1000, and 2000 Hz may be averaged to arrive at a single decibel hearing loss for each ear. Based on this procedure, ranges of average thresholds have been arbitrarily determined, such as 0–15, 16–25, 26–40, 41–55, 56–70, 71–90, and 91–110 dB. The better-ear average threshold is used to affix corresponding terms expressing normal hearing or hearing loss of various degrees: *within normal, minimal* (slight), *mild, moderate, moderately severe, severe,* and *profound,* respectively (Rupp & Stockell, 1980).

The audiogram is the single most valuable audiometric data kept on a child; of all measures of hearing level that can be obtained, the audiogram seems to correlate most highly with the other measures. It is not, however, really closely correlated with any other single audiometric measure. Ling (1976, pp. 23–26) states that the audiogram merely indicates the dividing line between detecting the presence of sound and not detecting it, much as a shoreline divides land from water. A shoreline, however, does not describe the water behind it, just as an audiogram does not describe how well a child hears at suprathreshold intensities.

Often, we attempt to determine how well a hard-of-hearing child can perceive speech at a suprathreshold comfortable loudness level. The measurement of speech discrimination, recognition, or comprehension is, however, often clouded by the child's deficient speech and language and limited ability to write responses to speech stimuli. The speech perception data that we do have on hard-of-hearing children reveal that if they have nonconductive impairment, they do not discriminate, recognize, or comprehend speech as accurately as do normal hearing children, even when it is comfortably loud enough for them. In one study using the Word Intelligibility by Picture Identification (WIPI) test for children (Ross & Lerman, 1970), 21 children with moderate-to-severe hearing loss achieved a mean discrimination score of 59 percent. In another study using more conventional monosyllabic word lists, 12 children with mild-to-moderate loss achieved an average recognition score of 66 percent (Byers, 1973). The difficulty level of these 2 measures is, however, different because the WIPI test provides a measure of speech discrimination and the more conventional test provides a measure of speech recognition or identification. It is easier to point to a picture corresponding to a spoken word, from 6 options for each item on the WIPI test than to repeat each of 50 words of a monosyllabic list. Both test scores, however, measure generally depressed speech perception performance.

A breakdown of speech discrimination errors often made by children with moderate-to-profound bilateral hearing losses is presented below. Children with moderate or severe losses usually discriminate prosodic features, most vowels, voicing versus non-voicing, and manners of articulation. They confuse, however, consonants within articulatory groups or places of articulation. For example, when responding to words with initial /p/ within the Fairbanks Rhyme Speech Discrimination Test, Byers subjects substituted /t/ 16 percent, /k/ 15 percent, /f/ 7 percent, /s/ 8 percent, and /h/ 7 percent, for a total of 59 percent. In contrast, children with profound loss often have great difficulty in auditory discrimination of any of the prosodic or articulatory features of speech, with the exception of distinguishing nasal from non-nasal sounds and changes in speech intensity as a function of time (Erber, 1982, pp. 21–24).

A child with moderate-to-profound bilateral hearing impairment typically hears sound in a distorted way, particularly when not using an appropriate hearing aid. Often the child has an audiogram that indicates relatively less-sensitive hearing at the higher frequencies. In addition, intense speech input may be perceived as disproportionately loud. In the first instance, there is frequency distortion, and in the second instance, harmonic distortion. Both conditions interfere with speech discrimination and are evident with nonconductive hearing impairment.

Speech Problem

There is a lower incidence of speech problems than listening problems among the hard-of-hearing population. This is because most hard-of-hearing children have unilateral loss, or, if they have bilateral loss, they can still hear themselves well even if they cannot hear others as well. Speech development is somewhat delayed but not necessarily defective by the time the hard-of-hearing child has completed elementary school. The hard-of-hearing child has enough opportunities to hear others speak at close range to compensate for missed opportunities to listen at a distance. Distance, competing noise, and reverberation factors that continue to complicate the listening process do not have nearly as much impact upon speech development. Once speech behavior has been developed, it can be maintained through habit patterns that have been laid down in the brain, and it is minimally dependent upon sensory feedback (Ling, 1976, p. 4, pp. 66–73).

The presence or extent of a speech problem in a hard-of-hearing child is also influenced by whether hearing loss is congenital or adventitious, and by whether it is temporary or permanent, and by whether or not it is progressive. The more hearing the child has and the longer the child's hearing is at full capacity during the early years of life, the better the child's speech will be. With these considerations in mind, the absence or presence of a speech problem will be discussed for several categories of unilateral and bilateral hearing loss described earlier.

If a child has a unilateral hearing loss, ordinarily there is no speech problem manifest. The one good ear provides the needed signal input for speech modeling, development, and maintenance.

Most children with slight or mild bilateral hearing loss also learn to speak precisely or nearly so, although usually they are delayed in the acquisition of speech. When these children have conductive hearing loss, their final speech prognosis tends to be better than for those with other types of loss because they can discriminate and recognize sounds accurately when they can hear them. A child with sensory, neural, or central hearing loss may still ultimately exhibit blurred speech.

It is the children with moderate-to-profound bilateral deficit who account for most speech problems among the hard of hearing. These children have sensory, neural, or central hearing impairments that interfere substantially with the speech developmental processes during early childhood. In special education programs of the United States, intelligibility ratings have been used to judge the speech of hard-of-hearing children in this subcategory and comparison has been made to speech ratings of deaf children. In a 1974 study of 978 hearing-impaired children, for example, 90 percent of children with a hearing loss of 55 dB or less in the better ear were rated intelligible or very intelligible, whereas only 3 percent of children with hearing loss greater than 91 dB were rated very intelligible (Trybus, 1980).

DiCarlo (1968) studied the speech errors of 15 hard-of-hearing teenagers with a mean hearing loss of 60 dB and a mean speech recognition score of 34 percent. Remediation from early age had enabled these youngsters to develop normal sentence skills. Table 1-2 summarizes the percentages of 15 types of speech errors made by this hard-of-hearing sample. The three most common types of errors were misarticulation of consonant blends, misarticulation of arresting consonants, and nasalization of vowels.

West and Weber (1973) describe the phonology of a 4-year-old girl with a 58-dB loss in her better ear. The speech analysis was made from spontaneous language samples. Half of the utterances were intelligible. The /b/, /m/, /p/, /w/, /n/, /k/, and /h/ were correct more than 75 percent of the time;

Table 1-2.
Percentages of speech errors among hard-of-hearing teenagers

Type of Error	Percentage of Occurrence
1. Consonant omission	2.5
2. Regular consonant substitution	8.3
3. Breath-voice consonant substitiution	7.9
4. Consonant blend	20.8
5. Abutting consonant	3.1
6. Releasing consonant	3.0
7. Arresting consonant	24.1
8. Nasalization of consonant	1.6
9. Substitution of vowel	9.0
10. Dipthong fractionization	8.3
11. Diphthongization of vowel	2.2
12. Neutralization of vowel	0.4
13. Nasalization of vowel	34.4
14. Abnormal rhythm (prosody)	8.0
15. Arythmic sentence	1.3

the /d/. /tʃ/, /f/, /r/, /y/, /l/, and /t/ more than 50 percent but less than 75 percent of the time; and the /g/, /d/, /v/, /ð/, /z/, /ʃ/, /ʒ/, /ŋ/, /s/, and /θ/ were not present. Clearly, visible sounds occur often among the first group, tongue-tip sounds among the second group, and the normally most difficult articulations dominate the third group. This child showed a normal pattern of development in moving from easier to more difficult articulations, but speech acquisition was substantially retarded.

The order in which consonant sounds occurred in the phonology of the child with a moderate hearing loss just described may be compared with the order of normal consonant sound acquisition. Table 1-3 summarizes the order of normal consonant sound proficiency based on 50 percent of correct articulation for a sound in two out of three word positions (Sanders, E., 1972). By 4 years of age, the normal phonemic system is well on its way to being established (Eisenson & Ogilvie, 1983, pp. 161–162).

Children with moderate-to-profound bilateral hearing loss also tend to have some problem with vowel targets. The greater the hearing loss the

Table 1-3.
Normal order of consonant sound acquisition

Age in Years	Consonant sounds
2	h, m, n, w, b, p, t, k, g, n, d
3	f, y, j, s, r, l
4	tʃ, ʃ, dʒ, z, v
5	θ, ð
6	ʒ

greater the difficulty, as a rule. Depending on the severity of ear pathology, these children have more difficulty perceiving the frequency location of vowel formants and so more often perceptually confuse either (1) vowels produced in neighboring articulatory positions or (2) front and back vowels with similar first formants. Examples of these 2 problems are the confusion of /i/ and /ɪ/ or /i/ and /u/, respectively (Erber, 1980).

When a hard-of-hearing child has a speech problem, it characteristically involves articulation, sometimes involves nasality, and still less often involves refined control of intonation. Nasality reveals that velopharyngeal valving is defective, which can result from absence of the refined auditory feedback needed to regulate the fine nuances of nasality control. An intonation problem characteristically results from poor frequency discrimination. A 1–2 percent frequency discrimination is required to discriminate between two neighboring tones. Children with severe bilateral hearing losses in the 70–90 dB range vary in frequency discrimination from 2 to 30 percent, which is normal to moderately poor (Risberg, Agelfors, & Boberg, 1975).

In contrast to the child with the type of hearing loss just described, the deaf child has a greater articulation, nasality, and intonation problem, and, additionally, voice and timing and rhythm deficits, even after speech intervention (Nickerson, 1975). At the same time, a normally hearing child between five and seven years of age has precise timing and rhythm, pitch and intonation, velar control, articulation, and voice quality. The speech behavior of the hard-of-hearing child tends therefore to be more like that of the normal hearing child than that of the deaf child.

In summary, the speech of children with bilateral hearing loss who are not deaf is often characteristic of the speech of much younger normally hearing children (Ross, p. 17 1982). In contrast, "the speech of deaf children differs from normal speech in all regards" (Black, 1971). The speech of the hard of hearing nevertheless constitutes a formidable problem in that it may interfere with communication, may call attention to itself, and may cause its possessor to be maladjusted (Van Riper, p. 18 1963). Speech intervention is critically needed and will be described, together with listening intervention, in Chapter 6.

Language Problem

We have stated that hard-of-hearing children have listening problems and, in certain instances, speech deficits, both interfering with interpersonal communication, and the former also negatively affecting environmental homeostasis. Complicating these problems is the presence of a third communicative deficit found among hard-of-hearing children—namely, language delay or linguistic deficit. Since unilateral and especially bilateral hearing loss result in less sound input during the formative years of life, beginning in infancy, language learning opportunities are accordingly reduced. Environ-