

THE IMPORTANCE OF AUDITORY COMMUNICATION*

BY

L. FISCH

From the Audiology Unit, Institute of Laryngology and Otolaryngology, London

(RECEIVED FOR PUBLICATION NOVEMBER 27, 1956)

Communication, that is transmission of information to the outside world and receiving information from it, is a vital function of every single living unit.

In the simplest organism the information is also of a simple nature, for example, a chemical reaction, or a tactile sensation. In an organism of higher complexity the information necessary for life will be correspondingly more complicated.

Human beings built for themselves a system of symbols, a language, that helps them to transmit adequately the immense variety of information they require. Sensations of sound were used as the basic material for building this language. That is the chief reason why hearing, in other words 'auditory communication', is of supreme importance to man.

It was not by accident that, when it was necessary to communicate information of great complexity with great speed and economy, sound was used as the most suitable medium available. There were good physical and physiological reasons for it.

The physical reason is the vibratory aspect of sound in air and in the basilar membrane of the inner ear. Frequencies of vibration from 100 to 10,000 cycles per second give a tremendous number of possible combinations. The human ear can distinguish about 340,000 sounds of a certain pitch and loudness. These can be transmitted with speed and little effort. Above all, frequency analysis is that outstanding characteristic of the auditory apparatus which enables us to encode the great variety of information in this type of communication. Other sensations also involve analysis on a frequency basis but only in hearing is it the fundamental operation upon which everything else is overlaid.

The vibratory (physical) aspect of sound is, however, only part of what makes up the complex sensations resulting from it. This becomes clear when the most important of all sounds are considered—that is speech.

The acoustic wave forms of speech can be

measured and analysed in great detail. Various elements of the complex wave form can be studied, and it can be determined which of these elements are most vital for the transmission of the information. It is possible to reduce the highly complex wave form of speech to an infinitely clipped version, yet the speech remains intelligible (Licklider, 1950), and the critical information of the message is still transmitted adequately. It means that the information-bearing elements of speech sound can be, so to say, extracted from the complex acoustic wave form of natural speech. In other words, natural speech has a great redundancy. The brain is adapted to exploit this great redundancy of natural speech to maintain communication under adverse conditions, which usually occur in the form of ever-present surrounding noise. This is one of the important reasons why this type of communication is so efficient, and one of the biophysical reasons for the efficiency and superiority of auditory communication by speech.

We must mention another important reason. Communication of language means transmission of thoughts from brain to brain. Each thought may be broken down into images. Each image corresponds to one word and to one individual visual picture. According to the experimental phoneticians each spoken word may be broken down—on the average—into four elementary sounds, called phonetic elements or phonemes (Dreyfus-Graf, 1950). Western European languages allow for articulation, on the average, of a maximum of 12 such phonetic elements per second. It means that three words can be communicated from brain to brain per second. Individual perception of pictures begins to become confused when the speed exceeds more than three words. This is nearly the speed of thinking. The rhythm of 12 elementary sounds (phonemes) per second allows the spoken language to follow nearly the speed of thinking. Auditory communication is then the best available, most efficient and economic method of communicating language from brain to brain. It has taken a

* A lecture given at the Institute of Child Health, Guy's Hospital, London, in May, 1956.

long time for mankind to develop it. The primary function of the larynx, phylogenetically, is not to produce sound, but to prevent foreign bodies from entering the respiratory tract. Production of speech sounds, and consequently oral language, is, so to say, an artificial addition. It must have taken long in the history of man to develop the fine neuromuscular coordination necessary for the voluntary movements which produce speech sounds, and hearing is the most important feedback control of this neuromuscular mechanism. If hearing is absent from birth or early childhood, and if a child remains untaught, from many aspects he stops at a stage of development comparable to that of the earliest pre-historic stage of man.

If we do not want to leave such a child stuck at that primitive stage, we must give him a language, and preferably teach him in such a way that he should be able to communicate that language orally, by speech. But not only because this is the most efficient method of communication. There is an additional and most important reason. We know that we cannot make out of a profoundly deaf individual a normal person. Our aim should be to make him into a person who is able to communicate in the normal hearing society with a reasonable degree of efficiency, and is reasonably adjusted to his disability without segregating him for ever. It means that we must help him to achieve independence in communication in the hearing society. And the greatest degree of independence in communication in a hearing society is communication orally, by speech.

It is almost a truism to say that early detection of impaired hearing will influence greatly the success of rehabilitation as defined above. Early detection of deafness is of prime importance for several reasons. If the deaf child is to be expected to communicate with reasonable success in a hearing society, he needs to be exposed to a normal speech pattern. This exposure produces the maximum results when it is begun as early as possible in the child's life (Fry and Whetnall, 1954).

Another reason for early detection is the following one: Apparently some important language patterns are set during the early years and probably much of it before the child enters school. Further training exerts only a modifying influence. It is necessary to fix these patterns for the deaf child as early as possible, and before he starts his schooling. Still another reason is the enormity of the task for a deaf person to achieve independence in communication in a hearing society. To illustrate the difficulty I will borrow an analogy from information theory.

Natural speech is transmitted over a communica-

tion channel of full capacity. As I mentioned previously much of this capacity is redundant. Shannon in his communication theory has shown that perfect transmission is possible over a channel of minimum capacity, admitting no redundancy at all. The price is an elaborate terminal coding equipment. The same happens in communication of a profoundly deaf person. For him, when receiving a signal, the rule of all or nothing applies. He has to communicate over a channel of minimum capacity, without any redundancy, and our task is to provide him with a terminal coding equipment, that is, we must teach him the correct interpretation of the signals which come to him over a communication channel of minimum capacity, admitting no redundancy.

Early Detection of Deafness

What are the chances of early detection of deafness? Naturally, it is easier to detect an almost total or very severe loss of hearing than a partial, less severe one. This is recognized by most people, but the signs, symptoms and serious consequences of partial deafness are less well known, although numerically these cases are more important.

A very severely deaf child will not react to everyday sounds at all; his speech will not start to develop; it will be soon noticed that there is something wrong. It may occur to the parents that the child is deaf.

On the other hand, a child with, let us say, considerable amount of hearing for lower notes but severe impairment for the higher ones, will react to a variety of everyday sounds and he will start to speak; in familiar circumstances he may hear and understand many words and sentences (possibly with the help of spontaneously acquired lip-reading). But when he has to learn a great number of new words and hear them in unfamiliar circumstances he will fail and show various disorders. It may not occur to the parents, or even to various educational, psychological and medical specialists that the trouble is a serious hearing loss. This suggestion may be encountered with scepticism. The child obviously can hear, therefore he cannot be deaf.

The term 'deafness' is misleading. Usually it is associated with the profound hearing loss which used to be labelled by the now obsolete term 'deaf and dumb'. The type of partial deafness, however, which I described, is very much more frequent. Its serious symptoms are not always recognized.

Let us consider how language development is influenced in the deaf child.

A normal child first develops some awareness of happenings; he learns a few everyday situations and

the meaning of his experiences. It takes him eight or nine months to gain this inner language before he begins to use receptive language, that is before he begins to understand a few words spoken by others (Myklebust, 1954). It takes him another four or five months before he begins to use expressive language and speak his first words. No child can learn to speak unless he has learned to understand some of what is said to him. The child understands a limited vocabulary before he is able to use it as a means of oral expression (Pratt, 1950).

This process of developing language in three steps, inner, receptive, and finally expressive language, will be modified in the deaf child according to the type of his hearing loss. First let us consider some of the symptoms in a profoundly deaf child. The profoundly deaf child will not reach the second stage of language development, that is, receptive language. For months nothing abnormal may be noticed. Some parents may observe at a very early age, 4 to 5 months, that the child does not respond to sounds, but frequently the first symptom which arouses suspicion is lack of speech development. The child produced babbling noises in early infancy but he did not form any definite speech sounds at the appropriate time. Later, when the child has a desire to communicate something to his parents but is not able to do so, signs of frustration appear. It may assume forms of tantrum or violence. He may try to communicate more frequently and forcibly by crying or gesticulation. When the stage of babbling has passed, the child may not use his voice any more, and will gesticulate more frequently.

Some other signs suggestive of deafness in infants are response to some noises as opposed to voice; augmented visual vigilance and attentiveness; alertness to gesture and movements; yelling, screeching to express pleasure, annoyance or need.

Often it is reported that such a child is terrified in the dark. A normal child, when put to bed, and the lights are switched off, hears a variety of ambient sounds. Ambient noises surrounding us day and night are full of meaning, and many have a significant emotional value. A normal child does not usually feel cut off from the outside world in the dark. A deaf child is plunged into complete isolation and loneliness.

These symptoms are not unusual in other categories of children and may have different causes. The important thing is, that when causes are considered, deafness should be at the top of the list. Often it is not on the list at all.

If a child does not speak within reasonable limits of the normal age, it should be always considered

that his hearing is impaired, unless proved otherwise by appropriate testing.

The picture will be different in the child with severe partial deafness. He may arrive at the stage of receptive language but somewhat later than the normal age. He hears a variety of speech sounds, and initially he attaches the correct meaning to some words, but later, when his activities involve him in new situations and he is presented with a greater variety of words, his difficulties gradually increase.

The following will explain the causes of some of the difficulties a partial deaf child has to face:

Normally, acoustic wave forms of different shapes are responsible for significant variations of auditory sensations. They form different patterns of excitation in the appropriate centres of the central nervous system. In the case of the deaf individual, acoustic wave forms of different shapes may produce identical or similar sensations, and discrimination may be very difficult. Different words may sound much the same to the child, but it seems to him that his parents attach on occasions different meanings to what to him sounds the same, *e.g.*, the words 'bottle' and 'water' may sound something like 'o-a' on both occasions. But at one time his mother will present him with a bottle, and on another occasion she will point to water in the bath. Still later, when the child will try to use expressive language, and will ask for one thing, saying something like 'o-a', and meaning water, but will be presented with a thing (that is 'bottle') which he did not want, he will get frustrated, angry and confused.

I have no space to describe this process in detail, and how it is modified according to the various types of hearing loss in the partially deaf child. I can only summarize some of the consequences.

Language development will be retarded, a speech defect will develop, usually an articulation defect (some consonants will be missing, mispronounced or confused with others), the voice may have good intonation (in the almost totally deaf child taught to speak, intonation is lacking, and the voice is monotonous and flat). The child will watch intently the speaker's face, and may acquire a fair amount of lip-reading which will enable him to understand much of speech in tête-à-tête conversation (in some intelligent children surprisingly well). In unfavourable circumstances they may not hear or may not understand what is said. Frequently they are accused of not listening, being inattentive, lazy, and are punished for it. In fact, because of the limitations of their communicating ability, their power of attention to speech is affected. Attention is a function which selects, out of a total mass of incoming signals those which have certain character-

istics, and so doing avoids overloading the mechanism which carried out the final analysis of speech (Broadbent, 1954). A deaf person, communicating through a channel of limited capacity for which the rule of all or nothing applies, cannot rely on a selection from a mass of incoming signals automatically—he must pay attention all the time—and he soon tires. Finally he cannot pay attention at all. At school he remains backward. He may not be able to localize the source of various sounds, and often is puzzled by this, or he may not be able to determine what made what type of sound.

In another case, speech may be unintelligible. The child may use a jargon, perhaps intelligible to his mother but to nobody else. Because of inability to communicate, extreme degrees of frustration may appear, and he also will try to communicate increasingly by crying, shouting and gesticulation. Some will gradually give up listening even to what they can hear, because it does not mean much to them or confuses them. They withdraw into a silent world because a hearing one causes them only trouble. On this account they may be assessed as totally deaf, and sent away to a residential deaf school, in spite of the fact that, with early detection of the true type and degree of their hearing loss and adequate auditory training, they could make satisfactory progress in a normal school and live a normal home life. They may be misdiagnosed altogether and declared mentally defective. The differential diagnosis between mental deficiency, or low mental capacity and deafness is the most important one. No child should be declared mentally deficient without making certain that his hearing is normal.

In summary we can say that the early detection of partial deafness on the whole is much more difficult than the severe, almost total hearing loss. This is important when it is realized that numerically this partially deaf group is larger. The defect may become obvious to a lay person comparatively late. Even to certain specialists the significant symptoms and serious consequences of this type of deafness are comparatively unknown.

What are then, under present conditions, the chances of early detection and correct diagnosis of deafness? Theoretically there are three, so to say, lines of defence: (1) Screening all children without exception; (2) screening those in whose history there is a possible cause of deafness; (3) observation and testing children with a definite symptom known to be associated with deafness.

(1) The first case, that is routine testing of all children at an early age, is not practicable as yet. Screening of schoolchildren soon after their entry to infant school is carried out, as a routine, in many

counties. About 1% to 2% of these are found with some degrees of significant hearing loss. Some of these have a serious hearing loss, and at this stage already much valuable time has been lost, and frequently much harm has already occurred.

A satisfactory screening test for infants has not been worked out yet. They can be tested, but this needs a special set-up and experience.

Attempts are made in some places to train health visitors and teach them to apply simple tests, but on the whole it is not satisfactory. There is always a danger that the severe or moderately partially deaf child will be missed. One of the contributions health visitors can make is education of the public. When they visit homes, they can draw the attention of mothers to the possibility of deafness.

The knowledge of the public in these matters is surprisingly limited. Authors of numerous books, meaning to give various types of advice to parents of young children, show complete ignorance of this problem almost without exception.

We must admit that there is no satisfactory screening test available for the early detection of these types of hearing loss. There is a positive danger in applying crude screening tests at this stage. Partial deafness may not be recognized. When its effects become apparent at a later stage of development, the fact that the child has been previously labelled (as a result of a crude screening test) as of 'normal hearing', or 'not deaf', may lead to the alternative diagnosis, that is mental backwardness. The child may remain labelled as such for a long time before the true nature of his troubles is disclosed.

(2) Screening of children with a known possible cause of deafness in their history is a more practicable approach. If there is a definite history of some of the causes of deafness, one should not wait till pronounced symptoms appear. This is considered, and with some justification, an ideal which cannot be achieved in practice. Still, it could be achieved provided the cooperation of everyone concerned with the welfare of the child would be forthcoming, and I would include the obstetrician, the paediatrician and the medical officer of health.

If there is a history of deafness in the family; if a child's mother had rubella or any other virus disease during a critical stage of pregnancy; if the child suffered from anoxia at birth, or from asphyxia in a premature child, or the labour was unusually protracted, and the delivery was complicated; if the child had haemolytic disease of the newborn or was jaundiced as a result of premature birth or had kernikterus, in all these cases the offspring should be tested without exception at an appropriate time.

This approach has great possibilities from the practical point of view of detection, and also it would add significantly to our knowledge of the incidence and pathology of certain types of deafness. Studies have been, so far, almost exclusively retrospective. The above approach would provide us with valuable prospective types of investigation.

(3) The third type of approach, the one practised, is testing children with a symptom or sign known to be associated with deafness. Lack of speech; retarded language development; speech defect; sigmatism (that is, mispronunciation of 's' or any similar confusion of speech sounds in a similar range of frequency); lack of speech comprehension; serious emotional frustration combined with various degrees and types of speech defect; general backwardness at school; those who suffer from a condition known to be associated frequently with a hearing loss, such as paralysis of cerebral origin; post-meningitic and post-encephalitic conditions; history of fractured skull or severe head injury; cleft palate, and of course various types of middle-ear disease. But even this approach is not as yet fool-proof. For example, not all children with cerebral palsy have their hearing tested, and not all who had a cleft palate, a speech defect, or those who survived after cerebrospinal or tuberculous meningitis. They all should have, without exception, their hearing fully tested.

I must mention now a few principles concerning hearing tests:

(1) There is no single form of testing which will give a complete picture of the total hearing capacity of an individual.

(2) One should not draw any far-reaching conclusions or make final decisions on the basis of observations carried out on one single occasion.

(3) Hearing tests are subjective tests requiring cooperation. There is no mechanical device which would enable us to test a child without gaining his confidence or cooperation. The handling of the child is decisive.

(4) A test should be of such a nature that it should not be associated with unpleasant or frightening experiences. A procedure which is associated with such experiences is, from our point of view, no procedure at all. The child's cooperation will be required in increasing degrees for future testing and rehabilitation. Destroying it at the very beginning in any way defeats the purpose of his attendance for examination.

(5) The child's obvious reaction to certain sounds or his understanding of familiar speech sounds in tête-à-tête conversation does not mean that the child could not have a hearing loss. When deafness

is suspected, only a complete test is conclusive. The all or nothing rule applies to hearing tests, *e.g.*, when hearing for pure tones is tested, we obviously do not test only for isolated frequencies in a haphazard manner. When hearing for speech is tested, a haphazard collection of words or sentences cannot give a conclusive result. A list of phonetically balanced words and sentences must be used, and acoustic conditions of the room must be considered.

There is a variety of testing methods available: Observation of reactions to percussion instruments, to speech sounds, or pure tones; audiometric tests for pure tones; live voice tests consisting of phonetically balanced, specially selected, word and sentence lists. The child can be observed in a play situation or conditioned to perform certain simple actions to a definite sound stimulus. With infants, instructions can be given to the parents how to condition a child to certain sounds at home, or how observations should be carried out and recorded over a period of time.

At a very young age we can always give a reliable answer at least to the following questions; Is this child totally deaf? Is he severely deaf? Is he moderately deaf? Is his hearing within normal limits? This is enough for the necessary urgent measures to be taken for treatment, if this is indicated. Gradually one can obtain more information, and within a reasonable time one can get a complete picture about the child's capacity to hear and measure his hearing loss exactly.

When the effect of the hearing loss on a child and prognosis is considered, one should not do so on the basis of the hearing loss alone. A careful study of the learning ability is of greatest importance. Mental ability, personality, and emotional condition of the individual modify the hearing disability. On the other hand the hearing disability, which affects a growing organism, will influence the intellectual and emotional development of the child. In fact it is essential to consider the child as a whole.

Associated symptoms may necessitate a modification of testing procedures, and also they can be an important guide in our search for possible causes and pathology of deafness. For example, a slight muscular incoordination, which might have been overlooked because it did not cause a marked disability, may disclose the cause and pathology of deafness in that child, that is kernikterus. Similarly physical examination may disclose, for example, an abnormally wide nasal bridge, combined with a deformity of the inner angle of the eyelids (epicanthal fold, occasionally combined with different coloured eyes, or a white forelock) and so disclose the special type of hereditary deafness associated with these signs.

This points to what I said previously, and even at the cost of repetition I want to emphasize again, namely, that it is important to study not an isolated symptom, but the individual as a whole. It cannot be otherwise with a symptom like deafness, which is basically a communication disorder and has such a profound influence on the whole person. This also indicates another important necessity: the study of the individual as a whole can be carried out only by a clinician. That is the reason why I would emphatically say that the answers to the fundamental problems of deafness will not be given by technicians but by clinicians. Obviously this work cannot be done by an individual or a single speciality. It requires the work of a team. Individuals interested in special aspects of deafness joined to form such teams, and this was the foundation of audiology. The otologist, teacher of the deaf, physicist, audiology technician, experimental phonetician, educational psychologist, school medical officer, are part of such a team. I think, however, that representatives of some other specialities are still missing,

and one of the most important members of an audiology team should be a paediatrician.

I will end by quoting the words of an eminent worker in the sphere of child health, Gesell (1956), who said:

'It is not normal to be deaf, but the deaf can be remarkably normal as individual personalities if we guide them into the right methods of managing their handicap. Our aim should not be to convert the deaf child into a somewhat fictitious version of a normal hearing child, but into a well adjusted, non-hearing child, who is completely managing the limitations of his sensory defect.'

REFERENCES

- Broadbent, D. E. (1954). *Attention and Memory in Listening to Speech*. (Paper for symposium on speech, Acoustics Group, Physical Soc., London.)
- Dreyfus-Graf, J. (1950). *J. acoust. Soc. Amer.*, 22, 731.
- Fry, D. B. and Whetnall, E. (1954). *Lancet*, 1, 583.
- Gesell, A. (1956). *Volta Rev.*, 58, 117.
- Licklider, J. C. R. (1950). *J. acoust. Soc. Amer.*, 22, 820.
- Myklebust, H. R. (1954). *Auditory Disorders in Children*. New York.
- Pratt, K. C. (1950). 'Child Development—Early Infancy.' In Monroe, W. S., *Encyclopedia of Educational Research*, rev. ed. New York.