THE PEEP-SHOW

A NEW TECHNIQUE FOR PURE-TONE AUDIOMETRY IN YOUNG CHILDREN

BY

M. R. DIX, F.R.C.S. AND C. S. HALLPIKE, F.R.C.P., F.R.C.S.

(From the Aural Department and Otological Research Unit, Medical Research Council, National Hospital, Queen Square, W.C.1)

In the course of the last eighteen months we have been called upon to examine a number of young children, many under the age of 6 years, with a view to establishing the possible role of deafness as a cause of backwardness in talking. Deafness was already suspected in nearly all of them, and, while in many its existence was virtually established, its extent was still a matter of conjecture. In a few the existence of any significant deafness was still in doubt, and in a few others mental deficiency was suggested as a possible cause of the backwardness in speech. Most of the children had already been examined elsewhere; in nearly all no quantitative assessment of their hearing capacity had been achieved, and it was the pressing need for this which caused all of them to be referred to us by school medical officers and others responsible for their care.

From the point of view of the medical officers the assessment was needed as a matter of urgency, in order that arrangements should be made without delay for any special education which might be required. From the parents' point of view, too, the matter was one of urgency. Although in many of the children the existence of some degree of deafness had come to be assumed, no definite decision had yet been made upon its severity and, in consequence, upon the kind of educational programme likely to be entailed. In all cases this decision was anxiously awaited.

In many instances the children were brought from a distance, and it was therefore important that the deafness assessment should not involve the hardship of repeated visits to hospital. The need, in fact, was for a test procedure which would ensure an accurate measurement of hearing capacity in the course of a single attendance.

Two methods are in common use for the quantitative testing of hearing in adults and older children: speech tests (words or sentences) and pure-tone tests.

Both types of test are very difficult to apply in children under the age of 6 suffering from deafness. Speech tests may sometimes be used in a form which calls for a motor response to a command or invitation, and here it is expedient to address the subject by name; but vocabulary is limited and may be quite lacking, and the tests, though often practicable, are always difficult and the results seldom have the requisite quantitative value.

Tests with pure tones are difficult for two reasons. For most young children the hearing of a pure tone is a meaningless experience. Pure tone audiometer tests, as usually applied, offer only a series of such experiences. It is impossible, therefore, to secure the co-operation of children in the performance of these tests.

There is another and even more serious obstacle to the use of pure-tone audiometry in children. Before the tests are applied it is necessary that the child should be given some explanation of the nature of listening and of hearing. With a child defective in speech and hearing such an explanation, however skilfully given, can seldom be effective. Thus, when the test is attempted the responses are inadequate and irregular, boredom speedily supervenes, further responses become meaningless, and the test has to be abandoned.

The procedure may be further embarrassed by the application of a telephone receiver to the child's head. A head-band is not as a rule well tolerated, and if the receiver is held in position by an assistant frequent small adjustments are needed to prevent serious displacement. These distract the child and fatigue the assistant.

A little experience with the earlier cases in our series led us to conclude that vocabulary defects in the children would prove an insuperable obstacle to the use of speech tests for any quantitative assessment of their hearing which would combine the necessary accuracy and ease of application. We were driven, therefore, to attempt instead the development of a pure-tone audiometric technique that would avoid the two major difficulties to which reference has been made.

It was necessary in the first place to give to the pure tones an arresting significance in the consciousness of the children. In the second place it was necessary to secure their co-operation rapidly and by a method which involved no explanation of the listening process.

By way of introduction to a description of the test procedure which we have been able to develop, something may be said concerning certain well-known features of pure-tone audiometry as practised in the conventional manner, in particular on the functional significance of its results.

The Pure-tone Audiogram

In Fig. 1 is shown a conventional type of audiogram. Frequency is plotted along the base line, intensity along the ordinate. Intensity is expressed in decibels above or below the normal threshold value. The decibel intensity scale is a logarithmic one: 10 decibels (1 bel) constitute a tenfold change in intensity, 20 decibels a hundredfold change, and so on. Deafness at any one of the frequencies named is represented by a fall below the zero intensity line at the frequency in question, and normal hearing at all frequencies would thus be represented by a horizontal line at the zero level.

In Fig. 2 is shown an audiogram upon which is inscribed a shaded zone representing the intensity-frequency range

of the speech sounds set up at the tympanic membrane of a listener by a normal conversational voice at a range of 3 ft. (90 cm.). Of this zone, the central portion lying between the frequencies 1,000 and 2,000 c.p.s. is the most important for the understanding of speech.

Now it may be taken that for speech to be readily understood the speech sounds should have an intensity at least 20 decibels greater than that at which they can just be

tone audiogram, whatever its limitations, makes possible a clear answer to the vital question: To what extent is the subject capable of hearing the sounds of ordinary conversation?

If the threshold curve falls below the 60 decibel level at the central frequencies we can say with certainty that the disability is severe, if below 80 decibels that it is substantially complete.

FIG. 1.—Typical audiogram chart.

heard. Fig. 2 shows that between 1,000 and 2,000 c.p.s. the speech sounds of normal conversation at 3 ft. are some 60 decibels above the normal threshold, and that conversation is therefore heard and understood without difficulty. With a 40-decibel loss of hearing at these central frequencies the 20-decibel margin required for easy understanding of speech is partially lost, and with this degree of loss some difficulty in understanding conversation can often be noticed.

With a 60-decibel loss understanding for conversation is always severely impaired, while a loss of 80 decibels or more is generally considered to constitute a total loss of serviceable hearing. It will therefore be seen that the pure-

FIG. 2.—Audiogram showing the intensity-frequency of speech sounds set up by a normal voice at a distance of 3 ft.

The Peep-show Test Apparatus

The apparatus consists of two parts: one, shown on the left of Fig. 3, consists of a wooden box with a picture at the back well suited to the taste of young children. This picture can be seen through a viewing hatch when illuminated by means of an electric-light bulb, which is also shown inside the box. Above the viewing-hatch is another 8-volt bulb, which can be seen through a shuttered orifice, and above this orifice is a loud-speaker. The bulb is a signal lamp, and is used with the loud-speaker to give synchronized visual and auditory signals in the manner to be described.

FIG. 3.—Diagram of the peep-show test apparatus

This first part of the apparatus is used by the subject, the child, who is seated on a chair in front of the viewing-hatch. In this position the child is separated by a screen from the second part of the apparatus, which is shown on the right of Fig. 3 and is used by the tester. The screen has a hole in it through which the tester can view the subject at a range of some 5 ft. (1.5 m.) or more without himself being observed.

The tester's part of the apparatus consists of a pure-tone generator and attenuator, together with a mains transformer giving an output of 8 volts. The output leads of the tone generator and of the transformer pass to the double rotary switch B, operated by a single handle as shown on the right of Fig. 3. From the switch the two pairs of leads pass respectively to the loud-speaker and signal lamp of the subject's part of the apparatus. These accordingly give synchronized impulses of sound and light when the handle of switch B is rotated by the tester. An additional 8-volt tapping from the mains transformer supplies the illumination bulb in the picture box. The leads reach it by way of two press-button switches arranged in series. One of these, switch A, is controlled by the tester; the other, switch C, is placed by the right hand of the subject near the viewing-hatch. It follows that the picture is illuminated only when both switches are pressed at the same time.

The Peep-show Test Procedure

The child is first engaged in play with a few simple toys, and as soon as its co-operation has thus been secured it is seated in a comfortable chair with its face 2 ft. (60 cm.) or so from the viewing-hatch. The position of the child is so arranged that switch C is within easy reach of its right hand. An instructor, whose function is a vital one, sits on the left of the child and focuses its attention, by pointing, on the signal lamp. Meanwhile the tester is observing the child from the opposite side of the screen. The general arrangement of the test procedure is shown in Fig. 4. As soon as he observes that the child's attention is focused upon the signal lamp he rotates switch B and simultaneously presses switch A. Synchronized impulses of light and sound are then emitted from the signal lamp and loud-speaker. The tone frequency used for this initial signal is 1,024 c.p.s., with an intensity some 80 decibels above the normal threshold as previously determined by a normal hearing subject with his head in the test position of the child. It will be understood that while this dual signal—auditory and visual—is being given with switch A closed, it is possible for the child, by pressing switch C, to light the lamp inside the box and be rewarded by the spectacle of the illuminated picture.

The first move is made by the instructor (M. R. D.). As soon as the signal appears she leans forward and, ostentatiously pressing switch C, points to the illuminated picture, now visible through the viewing-hatch. This the child scrutinizes with interest. The tester then stops the rotation of switch B and simultaneously opens switch A. The synchronized signals at once cease and the illuminated picture disappears. At this point the instructor withdraws her finger from switch C, indicating by a shake of her head that it no longer works. She then again focuses the child's attention on the signal lamp by pointing. As before, the synchronized signals are again given by the tester. Again the instructor leans forward and presses switch C, and again the picture is illuminated and observed with approval by the child. The signal is then withdrawn once

more and again the picture disappears. By this time the child has usually learnt that the moment to press the switch and be rewarded by the appearance of the picture is when, and only when, the signal lamp is flashing. Consequently, when the signals appear for the third time the child does not usually wait for the instructor to press the switch; instead he leans forward and presses it himself, and usually evinces considerable satisfaction at the appearance of the picture. Once this point has been reached the success of the critical hearing test procedure is assured, and it is then applied. The rationale of this is as follows.

So far as the test has gone, the synchronized light and sound signals will have been seen and, in the case of a child with hearing, heard. The two sets of signals promptly acquire a close association in the child's mind, each announcing with equal effectiveness the time to press the switch. It follows that when one set of signals (the visual) is withdrawn, the other set (the auditory) continues to act. In effect this means that the light signals can now be withdrawn and the test then becomes a test of hearing.

The withdrawal of the light signal is simply effected by closing the light shutter. This is done by the instructor. In the case of a child with a hearing loss of less than 80 decibels the response to the signal, which now consists of sound pulses only, is unchanged. He leans forward at once, presses the switch with unabated alacrity, and again displays his satisfaction with the result. The further steps of the test follow in logical sequence. The tester repeats the signal with rapidly decreasing intensities of sound (20-decibel steps), and a point is quickly reached at which the child fails to respond by pressing the switch. The signal intensity is then raised in steps of 10 decibels until the response again appears. As already stated, the equipment is calibrated for intensity in decibels above the normal threshold in the head position of the child. In consequence, the final threshold reading, which is of course for binaural hearing, can at once be inscribed in terms of decibels of

FIG. 4.—The apparatus in use.

hearing loss on the usual audiogram chart. The same procedure is then repeated at 2,048, 4,096, 8,192, 512, and 256 c.p.s. These frequencies are used in the sequence given, and with each the test starts with the light shutter open. With the dual signal the child responds as usual by pressing the switch. The light shutter is then closed and the test proceeds, as already described, as a test of hearing. At each frequency it is usual to change the picture in the box, a simple procedure which is carried out by the instructor.

The full test procedure at each frequency seldom lasts more than two minutes; often it is much less. The entire test is generally completed in 10 to 15 minutes. The

children show no signs of fatigue or boredom provided the pictures are changed as described, and the significance of the test results is strikingly shown by the alacrity of the responses and the regularity with which the threshold readings can be repeated.

It is necessary to add a final word of warning upon the need for care in regulating the intensity of the sound stimulus used to begin the test procedure. As described in the text, the figure is given of 80 decibels above normal threshold. In the case of a child with normal or near normal hearing such an intensity would be likely, of course, to prove unpleasantly high, and for this reason its use might bring about a complete breakdown of the test procedure. When, therefore, there is reason for suspecting that the deafness is slight, it is usual to begin with an intensity of 50 to 60 decibels above the normal threshold.

The age distribution of the 31 children tested with the peep-show was as shown in the table below.

Age in Years	No. of Children	Age in Years	No. of Children
2-3	1	5-6	6
3-4	4	6-7	15
4-5	5		

In addition, a few older children were seen with speech defects associated with mental deficiency.

Selected Case Reports

J. J., a male child aged 2 years 4 months, could at the age of 10 months say "dad," "mum," and "baba." He then had bronchopneumonia followed by frequent colds with a little ear discharge. His speech has since deteriorated, and he expresses his wants by gestures, does not respond to calls or noises, and is thought to be deaf. The tympanic membranes are opaque but intact. There is no response to gong or hooter. He co-operates well with the peep-show, but does not respond at all to sound alone. *Diagnosis*: Hearing absent (or below the maximum intensity obtainable with the peep-show loud-speaker).

R. C. and D. C., uniovular twins aged 11, were low-grade mental defectives and had never developed speech. They were active, played football, and made many inarticulate noises. There were no neurological abnormalities, and psychological tests showed a mental age of 2 years 10 months. There was

FIG. 5.—Audiogram of R. C.

FIG. 6.—Audiogram of D. C.

no abnormality of the ears, nose, and throat. With the peep-show both responded fairly well and gave responses which were very near to normal. Their audiograms appear in Figs. 5 and 6. *Diagnosis*: Speech defect with aphasia; low-grade mental deficiency; hearing normal.

P. M., a girl aged 6, was normal as a baby and babbled freely. She had meningitis at 10 months, did not walk until 2 years, and speech has never developed properly. She attends ordinary school but is unresponsive, and her teacher thinks this is due to deafness. The girl appeared intelligent but was

FIG. 7.—Audiogram of P. M.

FIG. 8.—Audiogram of J. P.

remarkably shy. She repeated numbers spoken behind her at 1 ft. (30 cm.). No responses were obtained from caloric tests of vestibular function. She co-operated well with the peep-show. Fig. 7 shows her audiogram. *Diagnosis*: Incomplete deafness, probably due to meningitis. She was recommended for a special school.

J. P., a boy aged 3 years 9 months, was normal up to the age of 12 months. He then had pertussis and his speech has not developed properly. An intelligent child, he repeated numbers spoken close to his ear and responded well with the peep-show. (Audiogram, Fig. 8.) Caloric responses of vestibular function were normal. *Diagnosis*: Incomplete deafness due to bilateral neurolabyrinthitis.

R. R., a boy aged 6, was brought by his parents on account of inattention following brief attacks of earache two years ago after measles. Tuning-fork tests showed middle-ear type of deafness. Pure-tone audiometry was attempted and found

FIG. 9.—Audiogram of R. R.

impossible. He reacted well with the peep-show. (Audiogram in Fig. 9.) *Diagnosis*: Catarrhal deafness. Surgical removal of tonsils and adenoids recommended.

Discussion

The peep-show technique described here certainly appears to overcome the two main difficulties of pure-tone tests in young children. By this we mean that the usually meaningless sound stimuli are given an arresting significance in the child's consciousness, while the still greater difficulties which arise when it is offered an explanation of the nature of listening and hearing are completely evaded by coupling the sound stimulus used to test the doubtful sense of hearing with a synchronized visual signal upon the effectiveness of which full reliance can be placed. In this way the child is induced, with no explanation other than a simple dumb show, to use any hearing it possesses to respond with vivid alacrity to pure-tone stimuli which are accurately controllable for frequency and intensity.

Perhaps the best-known of previous attempts to adapt pure-tone audiometry for use with children is the so-called tunnel test described by Ewing (1930). Its technique was not, however, designed to overcome the difficulty of explaining to the child the nature of the listening procedure, and the test is not stated to have been applied to children under the age of 6 years. Since it was first described no further reports of its use seem to have been published. Perhaps the most striking tribute to the increase in effectiveness of pure-tone audiometry in young children which can be achieved by the use of the peep-show procedure is to be found in a more recent paper in which the Ewings (1944) review very fully their present methods of testing the hearing of children. This paper includes a detailed account of the test procedures used for a group of some 72 children, most of them suffering from deafness, between the ages of 3 and 5 years—the age group in which we find the peep-show procedure to be of particular value. These authors rely chiefly upon drums, pitch-pipes, and spoken voice tests; pure-tone audiometry, applied according to the conventional technique, is not considered as a practical possibility. In this respect their opinion, with which we are in complete agreement, is given in the following terms:

"Pure-tone audiometric tests.—We found that some of the older children among those who proved to be either not deaf

at all or partially deaf, like the older children in the war nurseries, learnt quickly to respond to loud or fairly loud pure-tone stimuli, but that they were not interested in listening to such meaningless sounds. The audiometer in itself roused little or no interest and the children's attention was apt to wander. Our experiments showed that except in three or four cases of very intelligent partially deaf children it was not possible to obtain threshold readings."

Pure-tone audiometry accurately applied as by the peep-show procedure certainly yields a quantitative assessment of hearing which is considerably more accurate than anything which can be achieved by means of pitch-pipes, drums, or the spoken voice. In addition, these latter tests also demand for their successful application the services of testers of high skill and long experience. Furthermore, it would seem inevitable that the test procedures must extend, not infrequently, beyond the scope of a single interview.

In contrast, it can be said of the peep-show procedure that great skill and experience are not required. The apparatus itself is simple, and the observational conditions for the tester very good. The responses of the child, too, are quite straightforward and can be inculcated by anyone able to secure his co-operation in simple play. As stated, too, the total time for the test procedure seldom exceeds fifteen minutes, while its results are, with very few exceptions, decisive.

From the administrative point of view there seems good ground for expecting that the peep-show test will prove of considerable value. According to the Education Act of 1944 the Ministry of Education is now called upon to provide special educational facilities for deaf children under the age of 5 years. Children are, of course, not infrequently sent to day schools at the age of 3 or 4 years, and an increasing interest is being taken by teachers and parents in the need for the early recognition of deafness. Young children are therefore likely to be referred in increasing numbers to otologists for confirmation and quantitative assessment of their deafness. No procedure at present in use would appear to possess the accuracy and ease of application of the peep-show test, and in this respect, therefore, we hope that its value will prove to be considerable.

Summary

A new technique is described which greatly increases the efficiency of pure-tone audiometric tests in young children. By its means reliable threshold curves can be obtained in deaf young children of average intelligence down to the age of 3 years.

The equipment is simple and robust and the test procedure is rapid and easily applied.

Grateful acknowledgments are made to our colleagues at the National Hospital and to others who have referred patients to us for examination.

REFERENCES

- Ewing, A. W. G. (1930). *Aphasia in Children*, Oxford Med. Publ.
— and Ewing, I. R. (1944). *J. Laryng.*, 59, 309.

The Medical Sciences Committee of the Association of Scientific Workers has issued a memorandum on pathology in the National Health Service. It envisages a service covering the whole country, able to perform routine pathological examinations when demanded by medical practitioners and to provide consultants to visit patients in their homes. The service could be extended to more remote parts by means of mobile laboratories. Five to six years' hospital training is suggested for the specialist in pathology, during which time he would take a university diploma or higher degree. The report suggests that academic societies might admit to their membership laboratory technicians who had done good original work. The report concludes by saying that "quite large numbers" of demobilized medical men are being trained as pathologists in a somewhat haphazard way, and that there is a need for the Ministry of Health to indicate the likely demand for pathologists and to establish criteria for their training.

SOCIAL SURVEYS MEDICAL AND PSYCHIATRIC ASPECTS*

BY

C. P. BLACKER, D.M., F.R.C.P.

Social surveys make a difficult subject to discuss interestingly and profitably. Descriptions of individual surveys, which perforce deal with problems of sampling and of method, with figures, and with the interpretation of findings, are apt to be difficult to follow, and general principles and conclusions are easily lost in mazes of detail. On the other hand our subject is a large one, extending into many spheres other than the medical. We are here concerned with social medicine and psychiatry. Where is the common ground between these subjects? How is our knowledge of their joint problems furthered by social surveys? How can we discuss this matter most usefully at an international conference?

I shall begin with a word about the evolution of social surveys; I will then pass on to something about medical terminology, which must be internationally intelligible for surveys in different countries to be comparable; and I will conclude with some remarks about the objectives of those surveys which are primarily concerned with problems of health.

History of Surveys

Medicine and psychiatry are by no means necessarily a primary concern of social surveys in general, though they enter prominently into many and are tacitly recognized as important in most. In their valuable *Bibliography of Social Surveys*,† to which I am much indebted for what follows, Allen Eaton and Shelby M. Harrison bring out the fact that social surveys are essentially developments of the twentieth century. The earliest surveys figure as delayed expressions of a growing awareness of the evils of urbanization. Social surveys in general are attempts at social self-assessment whose beginnings were delayed because, like the individual's strivings towards self-knowledge, they mark the transition from boisterous adolescence to critical maturity.

Throughout the nineteenth century the populations of the United States and of most European countries were rapidly expanding. American towns were extending their range and attracting immigrants from Europe as well as many people from the countryside. The first surveys were inspired by the deplorable conditions which prevailed in towns. An early indication of this awareness in the United States was a book on slum conditions entitled *How the Other Half Lives*, by Jacob Riis, published in 1890, wherein is depicted from first-hand experience the insanitary conditions which prevailed in the most crowded sections of New York; other American works were Lincoln Steffens's *The Shame of the Cities* (1904), the Hull House Maps and Papers concerned with Chicago, and the report of the New York State Tenement House Commission, appointed in 1900 by Theodore Roosevelt. Early and important studies in this country, inspired by a similar concern about how the poor were living in big cities, were Charles Booth's *Life and Labour of the People in London* (1902) and Seebohm Rowntree's *Poverty: A Study of Town Life*, of the year before.

Noteworthy in the history of surveys for its breadth of conception and thoroughness of execution was the survey

*Read at a joint meeting of Sections of Social Medicine and Psychiatry of the International Conference of Physicians on Sept. 11, 1947, at the London School of Hygiene and Tropical Medicine.

†Russell Sage Foundation, 1930, New York.