Hearing Evaluation of Brain-Damaged Children

ADAM J. SORTINI

STRAUSS[8] defines a child who has brain damage as one who before, during or after birth, has received an injury to, or suffered an infection of the brain. It is his opinion that defects of the neurometer system may be present or absent and that such a child may show disturbances in perception, thinking and emotional behavior, either separately or in combination. Some time ago, Stevens and Birch[7] proposed the term Strauss Syndrome. They felt that the child with a central nervous system impairment illustrated any one or more of the following observable characteristics: (1) erratic and inappropriate behavior on mild provocation, (2) increased motor activity disproportionate to the stimulus, (3) poor organization of behavior, (4) distractability of more than ordinary degree under ordinary conditions, (5) persistent faulty perceptions, (6) persistent hyperactivity, (7) awkwardness and consistently poor motor performance.

There is inevitable overlapping of problems in the area of the brain-damaged child, since a child who has cerebral palsy may be mentally retarded as well, or a child who is aphasic may be emotionally disturbed. The most important diagnostic fact to remember is to work with the child and not the problem. The child who is brain-damaged may be considered as the hub of a wheel with the diagnostic and therapeutic team as spokes on the wheel. The wheel will roll most efficiently to an accurate diagnosis with a complete set of diagnostic spokes, *i.e.,* the family physician, the otologist, the audiologist, the psychologist, etc.

Dr. Sortini is director of the Hearing and Speech Clinic, The Children's Hospital Medical Center, Boston. The accompanying paper was part of a presentation given by Dr. Sortini in October 1959 at the University of Miami for the Miami Cerebral Palsy Association. Part II of the paper, "Rehabilitation of Brain-Damaged Children," will appear in a later issue of the Volta Review.

Techniques Employed

In determining the ability of the brain-damaged child to hear and understand several different techniques may be employed. The most widely used are: (1) noisemakers, (2) tuning forks, (3) speech audiometry and (4) pure-tone audiometry, both subjective and objective. In testing the hearing of children who are brain-damaged, it is often said that one must have special tools or pieces of equipment. Perhaps the most basic and essential piece of equipment needed is the tester, and the best tools this tester may have are experience and clinical ability. A test is as good as the tester and this is especially true when testing a child who has brain damage. Whenever feasible, it would be to the best interests of the child to refer him to a diagnostic center which employs the approach of a battery of tests in order to determine hearing status.

Noisemakers. Noisemakers have been used in the past and are still being used as a diagnostic aid in evaluating the hearing of an individual. At the Boston Children's Hospital, noisemakers may be used to attempt to ascertain the presence—or absence—of hearing, as one of a battery of diagnostic tests. A number of visitors from different centers have mentioned that they use noisemakers of a specific frequency and intensity in evaluating the hearing of a child. In some areas, no other test of any kind is used for the young child.

Clark[2] refuted the use of noisemakers in testing the hearing of children, concluding that most noisemaking toys cannot be calibrated subjectively. If one wishes to use noisemakers to simply establish if the child hears or does not hear, they may be considered in the total battery of tests. Otherwise, it would appear on the basis of the evidence presented by Clark, that to use the information obtained through the use of noisemakers for any other purpose may be questioned.

Tuning Forks. The use of a tuning fork in the hands of a capable and experienced person can be a valuable diagnostic tool. However, it presents obvious difficulties. A 500 cycle tuning fork will not tell the extent of the loss a child may have at 4000 cps. Also, the fork begins to lose its original intensity as soon as it is struck. This presents a serious problem in obtaining reliable responses from many children who are brain-damaged and have a short attention span.

Speech Audiometry. Speech Audiometry can be very useful in attempting to determine hearing levels of a child who is brain-damaged. There are instances where it is not possible to do subjective pure-tone audiometry, and yet the child consistently gives responses with monitored speech reception threshold testing at free field levels of 10 to 15 db suggesting that the hearing, in the better ear at least, is within a normal range. This may be very deceiving in some cases. Further testing with pure-tone audiometry may reveal losses in the better ear of 10 db at 250 cps, 10 db at 500 cps, 40 db at 1000 cps, 50 db at 2000 cps, and 70 db at 4000 cps. Speech audiometry with the mentally retarded child may be used to significant advantage since many such young children up to at least 10 years of age may be extremely difficult and many times impossible to test by subjective pure-tone audiometry. Yet, these children will consistently respond to monitored speech reception threshold testing, free field and monaural as well, at normal levels of 0-15 db. These results coupled with normal speech patems and normal inflections all give us important diagnostic information. For some aphasic children, speech audiometry is not possible, but for others it can be used to great advantage. The child with expressive aphasia is able to pick up the test item presented at monitored levels and readily demonstrate his ability to hear and understand what is asked of him. Speech audiometry, as used at the Children's Hospital Medical Center for the past several years employs a tray of spondee toys. The toys are given to the child, and he is asked with monitored speech reception threshold testing being used, to identify and pick them up.[6] Sometimes no response of any kind is elicited. Sometimes a child may spend thirty minutes or longer in the clinic without saying one word, yet pick up the correct test item at monitored levels within a normal range, demonstrating an ability to hear and understand. Important diagnostic information may be obtained although the child may not pick up the toy, if he consistently repeats the test item mentioned by the clinician on a monitored basis within a normal range.

Objective Pure-tone Audiometry. Pure tone audiometry is divided into two major approaches—subjective and objective. The most widely used objective method is psycho-galvanometry. The psycho-galvanometer has been used in the Children's Hospital Medical Center since 1952. After having conducted several thousand tests using this technique, we believe it is a valuable diagnostic tool in the total evaluation of the child who is brain-damaged and can be used with great advantage as one of a battery of tests. In and of itself, it should not be considered infallible, especially in the testing of cerebral palsied children. It has been found to be of value in excluding deafness as an etiological factor in an existing speech delay with mentally retarded children, and in aiding the diagnosis of aphasia. GSR testing has been used to exclude deafness as a significant factor in an existing speech delay with emotionally disturbed children—as well as assisting us in the diagnosis of malingerers and psychogenic deafness.

Table I shows 15 cerebral palsied children seen over a five-year testing period. The test re-test reliability is poor in a significant number of cases. There is a good correlation between objective and subjective test results in seven out of the 15 cases. GSR was accurate for this group 47 percent of the time. It is interesting to note that of the seven subjects where good correlation existed between objective and subjective test results, five were spastic and two athetoid. All the subjects were seen for an otological examination before each test with negative findings and no child was tested if there was evidence of an upper-respiratory infection at the time of the test. Also, the same clinician did all the testing for the five-year period, using the same equipment and physical facilities. The use of the psycho-galvanometer in evaluating the hearing of a child who is cerebral palsied should not be discounted. However, it is preferable to conduct a series of tests to establish a pattern of responses, rather than to accept the results of one test as conclusive.

Goodhill, *et al.*[4] in 1954 suggested the possibility that brain damage might be detected by changes in the psycho-galvanometric pattern. He pointed out that the peaks are sharper and of shorter duration with the brain damaged. Figure 1 illustrates this point and consists of a psycho-galvanometric pattern of a cerebral palsied child superimposed over that of a normal hearing handicapped child. The pattern with the peaks of short duration and with a very erratic, sharp pattern is one obtained with a cerebral palsied child. When a psycho-galvanometric pattern of this type is obtained, we may at least suspect the possibility of brain damage and this is pointed out to the referral source. There have teen a number of instances where the family physician who referred the child was unaware of brain damage and after our suggestion that he might wish to investigate further, did so, with brain damage being established.

Subjective Pure-tone Audiometry. The last type of hearing testing technique which may be used is subjective pure-tone audiometry. Subjective audiometry with children who are brain damaged is, at best, extremely difficult even in the hands of the most experi-

Table 1. Results of GSR tests with cerebral palsied children over three year period, compared with subjective testing over two year period (average loss, 500-2000 cps better ear)

No.	Initial Age	GSR 1954	GSR 1955	GSR 1956	GSR 1957	Sub. 1958	Sub. 1959	Present Age	Type CP
1.	4.5	85	35	55	40	15	20	9.5	Ath.
2.	3.11	40	55	35	50	15	15	8.11	Ath.
3.	3.8	15	15	35	25	65	70	8.8	Spas.
4.	3.7	15	25	30	15	15	15	8.7	Ath.
5.	4.6	15	15	15	15	15	15	9.6	Ath.
6.	3.3	80	50	90	30	15	20	8.3	Ath.
7.	4.0	55	40	35	55	15	15	9.0	Ath.
8.	2.9	80	75	60	50	15	15	7.9	Spas.
9.	3.11	20	15	25	20	15	15	8.11	Ath.
10.	4.3	45	70	80	50	15	15	9.3	Ath.
11.	3.6	70	25	80	30	40	55	8.6	Spas.
12.	3.8	75	60	80	70	75	70	8.8	Spas.
13.	4.1	75	75	90	75	85	85	9.1	Spas.
14.	4.9	65	55	70	65	65	70	9.9	Spas.
15.	4.1	15	25	15	15	15	20	9.1	Spas.

enced and qualified clinician. A basic and essential requirement is the ability of the clinician to establish rapport with the child so that we may at least, for a limited time, hope to have the attention span of the child being tested. A major consideration which is sometimes ignored by some clinicians is the failure to allow sufficient time between presentation of the stimulus and the response by the child. In the presentation of the stimulus itself, it has been our experience that with the cerebral palsied child, for example, the tone should not be presented for one or two seconds, but at least four to five seconds (and even longer), then wait x number of seconds for a response. The actual time one waits depends on the child being tested and cannot, of necessity, be a set number of seconds for each patient.

At the Children's Hospital Medical Center, an approach has been adopted which has proved satisfactory in the testing of normal pre-school children and all children who are known or suspected of having brain damage. Instead of using the conventional techniques in obtaining a subjective pure-tone audiogram, a routine attempt is made to obtain the response at 500 cps in one ear and then 4000 cps for that same ear and to obtain 500 cps for the contralateral ear followed by 4000 cps for that ear. Then 250 cps, 1000 cps and 2000 cps are each tested bilaterally. 125 cps is not tested because it is not considered of clinical significance. Whenever attention span allows, 8000 cps is also tested; but for the school age child, we test 6000 and 8000 cps.

Regarding the rationale for the technique mentioned above, it is universally agreed that the behavior and attention span of a child who is brain-damaged is quite unpredictable. It would thus be preferable to have thresholds at 500 and 4000 cps (for at least one ear and preferably two ears). If the child's attention span is lost, we at least have both ends of the important speech range as opposed to having 1000 and 2000 as per the conventional method and not know what is happening at either end

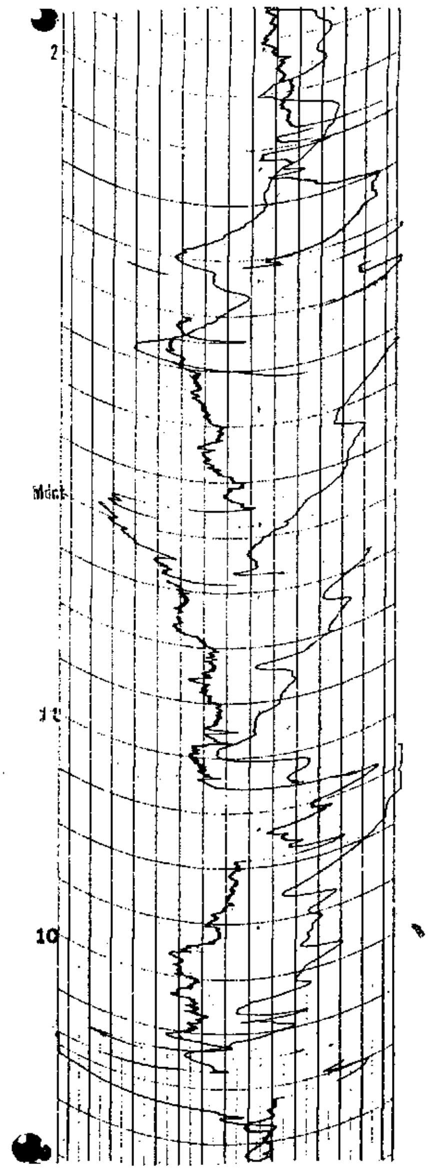

Fig. 1—The above psycho-galvanometric patterns consist of a normal hearing handicapped child's being superimposed over that of a cerebral palsied child. The pattern with the slow, long bending curves is that of the normal child, while the pattern which is very irregular with sharp curves of shorter length is that of the brain-damaged child.

of the important speech range. 250 cps is next tested because it is an important frequency for the hearing and understanding of speech. Finally, 1000 and 2000 cps are tested as important segments of the speech range. At our clinic half octaves are not tested except when there is a 20 decibel dip (or greater) between full octaves. We also did not test 6000 cps until recently. A few years ago, it was discovered that there had been several cases where a child tested in school had failed the school hearing test at 6000 and he was referred to our clinic for a complete hearing evaluation. The child had been screened from 250 cps-8000 cps bilaterally at 15 decibels, 6000 cps had not been tested and normal hearing was found. The parents then returned to the school to tell the audiometrist that she was incompetent because we had found normal hearing. In order to protect the school audiometrists in those cases where an aviator's notch may be present and there is a dip at 6000 cps, all school age children are now tested at 6000 cps bilaterally with the other frequencies.

In testing the hearing of young children, especially young children with brain damage, there are no set procedures to follow, and each child presents a completely different diagnostic picture from the last one tested. The clinician should not expect the child to come up to his level but instead must always attempt to go down to the child's level and reach him in any possible way that he can. The ideal response is to have the patient point to which ear hears the tone. With many children who have cerebral palsy, however, this approach is impossible. Many are intelligent enough to understand what you expect of them but cannot respond in a conventional manner. In such instances, one may ask the child to blink his eye whenever the tone is presented. Some children are even able to blink the eye on the same side the tone is presented. Some children may stamp their feet as a response to the presentation of a tone. The diagnostician must attempt to elicit a valid response in any and every way possible and go to whatever reasonable lengths may be necessary in order to obtain results.

The diagnostician must make every effort to validly ascertain the hearing status of these children and thus utilize every possible means at his disposal. Even with the greatest care and effort, the original diagnosis may at some later date need modification. Through a battery of tests conducted periodically, however, one may hope to establish a basic pattern of threshold responses so that one may feel with greater certainty whether or not a hearing loss must, or must not be reckoned with in trying to help these children.

1. Bender L., *Psycho Pathology of Children with Brain Disorders.* Springfield: Charles C. Thomas, 1956.
2. Clark, J. T., "Testing hearing of children with noisemakers—a myth." *Except. Child.*, 22, 1956, 326-27 and 341.
3. Fouracre, M. H., "Learning characteristics of brain damaged children." *Except. Child.*, 24, 1958, 210-212 and 223.
4. Goodhill, V., Rehman, I., and Brockman, S., "Objective skin resistance audiometry." *Ann. Otol., etc. St. Louis*, 63, 1954, 22-38.
5. Sheer, D. E., "Is there a common factor in learning for brain-injured children?" *Except. Child.*, 21, 1954, 10-12.
6. Sortini, A. J., and Flake, C. G., "Speech audiometry testing for pre-school children." *Laryngoscope*, 63, 1953, 991-997.
7. Stevens, G. D., and Birch, J. W., "A proposal for clarification of the terminology used to describe brain injured children." *Except. Child.*, 23, 1957, 346-349.
8. Strauss, A. A., and Lehtinen, L. E., *Psychopathology and Education of the Brain-Injured Child.* New York: Grune and Stratton, 1947.
9. Street, B. S., "Hearing loss and aphasia." *J. Speech Hearing Dis.*, 22, 1957, 60-67.