A COMPARATIVE STUDY OF THE TEST PERFORMANCES OF BRAIN-INJURED, EMOTIONALLY DISTURBED AND NORMAL CHILDREN*

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This paper is a summary of a study designed to investigate whether the performance of brain-injured children on certain tests differed significantly from the performance of matched groups of emotionally disturbed and normal children.

A secondary purpose of the investigation was to determine the relative efficiency of 3 of the tests in discriminating between the 3 groups, with the object of determining whether it is possible to diagnose brain injury from the results obtained on these tests.

It has long been recognized that global scores on intelligence tests do not give a complete assessment of an individual's capabilities. An intelligence test measures only certain aspects of a sample of behaviour, and two people of the same chronological age and the same mental age are not necessarily equivalent in intelligence, because mental age represents a total score and two numerically equal mental ages are unlikely to be derived from successes on identical items.

This aspect is of particular significance in the case of brain-injured individuals, where the effects of the cerebral damage have been shown, not in terms of mental age or IQ, but in other abnormalities such as perceptual disturbances and behaviour deviations that cause learning difficulties and adjustment problems. A brain-injured child may have a fairly high IQ, because of an adequate vocabulary and good general knowledge for his age, but his school progress may be affected by such handicaps as poor discrimination of form and difficulty in drawing and writing.

Interest in the psychological aspects of brain injury was stimulated by the work of Goldstein, Gelb, Head and Schilder with brain-injured adults after the First World War. Investigations of the psychological effects of brain injury in children are reported much later, and it is only in the last 20 years that interest has grown, mainly as a result of the studies of Strauss and Werner and their associates, who worked for a number of years at the Wayne County Training School in Michigan, USA, training and rehabilitating moron and borderline defective children. They differentiated between two types of mentally deficient children, the endogenous and the exogenous type. Many of the characteristics of the children with the exogenous or acquired type of mental deficiency were found to be similar to those of brain-injured adults. These characteristics were later found in all types of brain-injured children, irrespective of IQ.

Brain injury does not always lead to mental retardation. Hebb, for instance, found no change in IQ in a series of cases after extensive removal, by Penfield, of unilateral and bilateral frontal cerebral tissue.

Some cases in which brain damage has occurred show no neurological symptoms, but it has been suggested that even minimal damage may result in motor, visual-motor or perceptual disturbances, together with difficulties in personality and in social relationships.

It is most important to diagnose brain injury as soon as possible, so that behaviour deviations and particular disabilities may be understood and the person concerned may have specialized teaching and training. A correct diagnosis is more important for children than for adults because they are still in the process of developing.

SOME ASPECTS OF DIAGNOSIS OF BRAIN INJURY

The term 'brain injury' in the literature is used as being synonymous with brain damage, cerebral injury, cerebral damage, head trauma, organic impairment, neurological impairment, and central nervous system dysfunction. No differentiation is made between injury and disease.

Various suggestions have been made concerning the problem of diagnosis in cases of suspected brain injury in children. Bradley, some 10 years ago, enumerated 5 aspects of enquiry in order of importance and suggested that evidence from all 5 areas should be evaluated when attempting a diagnosis:

1. The distinctive patterns of behaviour of the brain-injured child
2. His performance on carefully selected psychological tests
3. Evidence from the past medical history of the child of a presumptive cause of brain damage
4. Neurological findings which would confirm such a diagnosis
5. EEG abnormalities.

1. Distinctive Patterns of Behaviour

Characteristic changes in personality and behaviour have been found even after minimal degrees of cerebral damage. The most common behaviour disturbances found are hyperactivity, extremes of emotional reaction, poor powers of concentration, and perseveration. Other symptoms not so frequently found are clinging behaviour towards adults, over-aggressive or over-affectionate behaviour towards other children, intense responsiveness to any activity engaged in, maladaptive social behaviour, inability to tolerate delay in the gratification of needs and demands, meticulousness and pedantry.

All these behavioural characteristics, either separately or in combination, may have a purely emotional origin. If the cause is psychogenic, the symptoms are modifiable by psychotherapy, but if brain injury is the cause, medical treatment is essential. The correct diagnosis is therefore of the greatest importance.

2. Performance on Selected Psychological Tests

This aspect is the one with which this investigation is concerned. It has been shown that long after physical symptoms of brain injury have disappeared, defects can be shown by psychological tests. Most of the tests used in the diagnosis of brain injury are based on the fact that individuals with cerebral damage have been found to have disturbances in thinking, perception and perceptuo-motor ability.

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(*a*) *Thinking disturbances*. Goldstein claims that the fundamental change in the behaviour of the brain-injured individual is his impairment of the abstract or categorical attitude. In the abstract attitude we are concerned with the category of which the object is an accidental sample, whereas in the concrete attitude we are concerned with the object itself. The normal person can adopt either attitude.

A number of investigators, using sorting tests with both adults and children, have confirmed Goldstein's claims, but others have contradicted him and have criticized his work, not only on theoretical grounds, but also for methodological reasons.

Thinking disturbances have been revealed also in the defective memory shown by brain-injured individuals in tests, involving both verbal and visual stimuli.

(*b*) *Perceptual and perceptuo-motor disturbances*. These are probably the most characteristic disturbances found in both adults and children who are brain-injured. Many of the investigators of perceptual disturbances in brain-damaged individuals have been influenced in their attitude by the Gestalt psychologists. When we look at something, one thing, a 'whole', is selected from all the stimuli which impinge upon us and is perceived as a foreground, with everything else as the background. The brain-injured child has been shown to have difficulty in distinguishing foreground from background.

Strauss and his co-workers have reported on numerous tests involving perceptual or perceptuo-motor ability. Disturbances of perception were found in the tactual and auditory fields, as well as in the visual field. A central disturbance in the individual's ability to organize relationships was suggested as the cause of these disturbances.

3. Evidence from Past Medical History

Evidence of a presumptive cause of brain damage from past medical history is useful only as a conjunctive method of diagnosis, because it is not very reliable except in the case of definite characteristic changes after known injuries or infections.

4. Neurological Findings

According to the literature, neurological examination does not always show positive diagnostic results and is therefore of limited value, particularly in the case of a young child. It has often been demonstrated that minor cerebral damage could not be detected in neurological examination, yet impairment in the function of the individual existed.

The transience of minor neurological signs adds to the difficulty, for it has been shown that after neurological signs have disappeared, abnormal behaviour characteristics and disorders of function may remain.

5. EEG Abnormalities

Interest in the use of electroencephalography as a diagnostic technique arose because of EEG findings in disturbed children, which were reported as being different from those of normal children.

A number of reports have shown, however, that normal EEGs have been found in cases of diagnosed cerebral pathology, and abnormal EEGs have been found in individuals who seem clinically normal.

THE PROCEDURE

(*a*) *Subjects*

Three groups of subjects were used in this study, a brain-injured group, an emotionally disturbed group and a normal group, matched according to mental and chronological age and sex.

Group I—the brain-injured group—consisted of 28 children, 17 girls and 11 boys, all of whom had been diagnosed as brain-injured and were attending special schools, namely, the Forest Town School for Spastics and the Orli School for Brain-Injured Children. No child was included in the investigation if the diagnosis was doubtful, if the child was aphasic, if he had a motor disability so severe as to interfere with the manipulative ability required for the tests, or if there were uncorrected visual defects.

The chronological age ranged from 6½ to 15 years, with a mean age of 10 years. The Terman Vocabulary mental age ranged from 6 to 16 years with a mean of 9 years. The verbal IQ ranged from 60 to 127 with a mean of 90·9.

Group II—the emotionally disturbed group—also consisted of 28 children, 17 girls and 11 boys. They had been referred to the Johannesburg Child Guidance Clinic for various behaviour problems. All had been fully investigated and had been diagnosed by the medical director as emotionally disturbed and in need of psychotherapy. They were all on the waiting list for treatment. In no case was there a history suggestive of brain damage or a verbal disability.

The chronological age ranged from 6 years 5 months to 15 years 7 months with a mean of 10 years. The Terman Vocabulary mental age ranged from 6 years 4 months to 15 years 5 months with a mean of 9 years 2 months. The verbal IQ ranged from 61 to 111, with a mean of 93·4.

Group III—the normal group—also consisted of 28 children, 17 girls and 11 boys, all rated as well adjusted by the principals and teachers who knew them.

The problem of defining what is normal is acknowledged to be difficult, and it is conceded that some of this group might have been emotionally disturbed and some might even have suffered minimal, but as yet undetected, brain damage.

The chronological age of this group ranged from 6 years 1 month to 15 years 5 months, with a mean of 9 years 10 months. The Terman Vocabulary mental age ranged from 6 to 15 years, with a mean of 8 years 11 months. The verbal IQ ranged from 73 to 112, with a mean of 92·1. Statistical analysis showed that there were no significant differences between the verbal IQs of the 3 groups.

The decision to use the Terman Vocabulary mental age and IQ as the main matching criteria was based on indications in the literature that vocabulary mental age is likely to provide a more accurate assessment of intelligence in brain-injured children than a non-verbal scale or a mixed verbal and non-verbal scale. This view is not generally held, however, as it has been found that when the area damaged is that concerned with the understanding of language or the production of speech, verbal ability is affected more than non-verbal ability.

It has been suggested that the IQs obtained for brain-injured children should be regarded as a basal estimate because intelligence tests are standardized on a population having a fairly homogeneous background of interaction with the environment. A brain-injured child has usually not had the same environmental experiences as the normal child because of his restricted movement and difficulties in social interaction.

(*b*) *Testing Procedure*

Each child was tested on the following 5 tests:

(i) Terman Vocabulary Test
(ii) Individual Scale of the National Bureau of Educational and Social Research
(iii) Marble Board Test
(iv) Ellis Visual Designs Test used as a copying test
(v) Archimedes Spiral

The first 2 tests are intelligence tests. As stated above, the 3 groups were matched according to sex, chronological age, mental age and IQ obtained on the Terman Vocabulary Test.

The Individual Scale of the National Bureau of Educational and Social Research is a mixed verbal and performance scale. It was selected so as to ascertain whether there is in fact a significant difference between the IQs obtained by brain-injured children on verbal and mixed verbal and performance scales.

The last 3 tests were chosen because of indications in the literature that they are useful in discriminating between brain-injured and non-brain-injured individuals.

The Marble Board Test was first used by Werner and Strauss as an attempt to observe the overt expression of the perceptual process, i.e. visuo-motor performance.

The apparatus consists of 2 identical grey wooden boards, 11 in. square, and 2 boxes each containing 100 black marbles (Goldenburg's modification of the original test was used). Each board contains 10 rows of 10 holes each. There are 8 designs, which have to be reproduced, one by one.

The first design was prepared with marbles on one of the boards and placed in front of the subject's chair before he was admitted to the testing-room. He was then asked to copy the design on the second board. The performance was carefully recorded, taking into consideration the order of placement of marbles and any corrections made. After the design had been copied with marbles, the subject was asked to draw the pattern on a blank sheet of paper.

The other 7 designs were presented in the same way, except that the investigator's model was always constructed on the examiner's lap so that the method of construction could not be observed by the subject.

Quantitative and qualitative aspects of performance were taken into consideration in scoring, which was done in terms of accuracy, procedure and organization.

The Ellis Visual Designs consists of 10 geometrical designs, each of which is drawn in black India ink on a white card 5 in. square.

The test was originally used as a 'memory-for-designs' test, but several investigators have suggested that the defective performance of brain-injured individuals on 'memory-for-designs' tests may be due not to faulty memory, but to other factors such as perceptual disturbances.

The designs were presented to each subject one by one in standard order, and had to be copied on blank pieces of white paper, the same size as the cards.

The Archimedes Spiral Test consisted of two spirals of 920° or $2\frac{1}{2}$ circuits about the centre, drawn in black India ink on white circular cards, 6 in. in diameter. Spiral A produced in normal individuals an illusion of expansion during rotation of the spiral and a negative after-effect of contraction, on cessation of rotation.

Spiral B was the exact reverse of Spiral A, and produced in normal individuals an illusion of contraction during rotation and a negative after-effect of expansion, when rotation ceased.

The spirals were attached to the shafts of apparatus usually used for colour-mixing experiments. The speed of rotation was 78 revolutions per minute. The subjects were seated 8 ft. away from the apparatus and were asked to report on what they saw during rotation and also after rotation ceased. Two trials were given on each spiral.

RESULTS AND DISCUSSION OF RESULTS

1. *Comparison of Terman Vocabulary and Individual Scale Results*

	Group I	*Group II*	*Group III*
Terman Vocab. mean IQ	90·9	93·4	92·1
Range	60 - 127	61 - 111	73 - 112
Individual Scale mean IQ	94·8	99·2	96·8
Range	64 - 141	83 - 119	80 - 112

As can be seen from the above results, the mean IQ obtained by each of the 3 groups in the Vocabulary Test is slightly lower than the mean IQ obtained by each group in the Individual Scale, although some children in each group obtained better results on the Vocabulary Test than on the Individual Scale.

The technique of analysis of variance was applied to the IQ results obtained and the differences between the 3 groups were found to be insignificant in both tests.

The results obtained in this investigation thus do not confirm the assertion that verbal tests are a more accurate assessment of the intelligence of brain-injured subjects than non-verbal tests. Nor do they confirm the view put forward by Hebb that children whose brains have been injured at, or soon after birth, do better in non-verbal tests than in verbal tests. All the brain-injured subjects of this investigation were brain-injured either from birth or soon after.

These results suggest that the Individual Scale and Terman Vocabulary Tests are equally accurate in assessing the intelligence of certain groups of brain-injured as well as emotionally disturbed and normal children.

2. *Marble Board Test*

The results of the Marble Board Test were assessed quantitatively in terms of accuracy and qualitatively in terms of procedure and organization.

(*a*) *Accuracy*. The mean scores for accuracy obtained by the 2 non-injured groups were higher than the mean score obtained by the brain-injured group (27·4 and 22·5 as compared with 15·3), but the differences were not statistically significant.

It was found that accuracy scores were highly correlated with both mental and chronological age in all 3 groups, but the correlation coefficient was lower in the case of the brain-injured group than in the non-brain-injured groups. Each group was then divided into 4 sub-groups according to age, and the sub-groups were compared. The differences in age were found to contribute more to the variance in the statistical examination than did group membership.

(*b*) *Procedure*. Three methods of procedure were distinguished for scoring purposes. In the continuous method, the design was constructed of continuous lines of marbles proceeding in a single direction of movement. In the segmental method the sides were not completed in a continuous manner, but each side was completed before the next one was begun. In the incoherent procedure, isolated placements of marbles were made, or one or more series of placements not composed of complete sides of figures were made.

The chi-square test was used to evaluate the differences in procedure used by the 3 groups, and the differences were found to be significant far beyond the chance level. It was found that the differences between the groups decreased with the increasing age of the children.

In all cases the scores obtained by the 2 non-brain-injured groups were almost identical, so it was clear that emotional instability did not affect the performance on this test.

Strauss and Lehtinen state that one of the difficulties of the Marble Board Test is caused by the nature of the task in relation to the material. The child is expected to construct a continuous pattern from elements which are discrete and separate, to achieve a figure whose unity and organization depend upon subjective perceptual experience rather than the objective fact of continuity. Non-brain-injured children do not seem disturbed by the disparate marbles and the spaces between them, and are able to organize the lines into a continuous figure. Brain-injured children, however, seem to have difficulty in organizing the marbles into a pattern, being disturbed by the number of empty holes, and in their construction of the design insert the marbles in an incoherent manner, jumping from one part of the board to another, even though an objectively correct or nearly correct result may finally be obtained. Werner suggests that confusion on the fundamental relation of figure to ground prevents them from attaining unity of pattern.

This would explain why the mean accuracy score of the brain-injured group did not differ significantly from the accuracy scores of the non-brain-injured groups, yet the differences in procedure were significant.

A further aspect investigated was the frequency with which subjects received three or more assessments of incoherent approach. Twenty of the brain-damaged group, none of the emotionally disturbed group and 6 of the normal group received this rating. The chi-square test showed statistically significant differences between the groups.

(*c*) *Organization*. Four different methods of organization were distinguished. When the whole pattern was built out of its component sub-forms, the performance was called *articulate* and indicated that the child saw clearly the relation between the sub-forms and the fact that the design was made up of two sub-forms, e.g. when a design consisted of a square and a triangle the child first completed the square before beginning the triangle (or vice versa).

In the *global* type of organization, the child followed the outline of the whole design, ignoring the sub-forms and placing into it the remaining marbles, to complete the design.

In the *aggregate* type, the subject was guided by relatively self-contained parts of the whole design and did not perceive the relationship between the sub-forms.

Form is the determining factor in the above 3 types of organization. When lines rather than form determined the performance, the organization was called *linear*.

The chi-square technique was used to examine the differences in the organization of the 3 groups, and these differences were found to be significant at the 1% level of confidence. Again the brain-injured group's scores were significantly different from those of the 2 non-brain-injured groups.

When the 4 sub-groups were compared, significant differences were found between the brain-injured group and the other 2 groups in the 3 youngest age sub-groups but not in the oldest sub-groups.

It is possible that the ability of the oldest brain-injured sub-group to achieve organization scores not significantly different from those of the non-brain-injured sub-groups may be due to the fact that nearly all the children in this sub-group had had specialized teaching for a number of years. The average time at the Forest Town School for this sub-group was 7 years 1 month. This specialized teaching may have reduced the perceptual disturbances usually experienced by children with cerebral damage.

Articulate organization was found to increase steadily with chronological age in all 3 groups.

The linear type of organization decreased considerably with increasing chronological age in the brain-injured group (from 25 in sub-group A_1 to 7 in sub-group A_4). In the emotionally disturbed group the decrease was from 12 to 5 in the comparable groups, and in the normal, the decrease was only from 4 to 3.

The frequency of 3 or more ratings of linear organization was examined, and it was found that 15 of the brain-injured children, 3 of the emotionally disturbed group and none of the normal children received this assessment. All the children who received this assessment were below the age of 11 years.

From the results obtained, it can be stated that the Marble Board Test does significantly differentiate between brain-injured and non-brain-injured children, but the discriminatory ability appears to decrease as the age of the children increases.

3. *Ellis Visual Designs Test*

The differences in the scores obtained by the 3 groups were found to be statistically significant for the groups as a whole and also when the groups were divided into sub-groups according to age. As in the Marble Board Test, the chi-squares tended to decrease with increasing chronological age.

Performance was found to correlate fairly highly with both chronological and mental age in the brain-injured

group, but with chronological age only in the emotionally disturbed and normal groups.

When the scores on each design were examined, significant differences between the brain-injured and non-brain-injured groups were found for all but one of the designs.

The difficulty experienced by the brain-injured children in reproducing the designs from copy was felt to be due to difficulty in concentrating, inability to apprehend the designs, or inability to reproduce designs that have been apprehended.

4. *Archimedes Spiral*

The results of previous investigations with the Archimedes Spiral have not been consistent. Some investigators indicate that the test has high validity in differentiating individuals with cortical damage from those without damage, but others cast considerable doubt on its utility for differential diagnosis, and the results of this study confirm this doubt.

Two methods of scoring were used and in both cases the differences were not statistically significant.

When the criterion for passing the test was taken as 3 or more experiences of the after-effect in the 4 trials, the number of successful subjects in group I was the same as that in the normal group. When each trial was considered separately, the chi-square obtained was significant at the 5% level of confidence, but the difference between the scores of the emotionally disturbed and normal groups was greater than the difference between the scores of the brain-injured group and either of the non-brain-injured groups.

CONCLUSIONS

It seems that certain aspects of the Marble Board Test and the complete Ellis Visual Designs Test could be used as a screening device in the diagnosis of possible brain injury in children, but the claims of some investigators of their use as a reliable diagnostic tool appear unfounded.

When the results of both tests were examined together, it was found that 10 of the brain-injured children received 3 or more ratings of both incoherent procedure and linear organization on the Marble Board Test and a score of 4·5 or less on the Ellis Visual Designs Test, whereas none of the children in the other 2 groups received this score on both tests taken together. Thus the use of the Marble Board Test and the Ellis Visual Designs Test together would seem to yield useful information in cases where brain injury is suspected.

One would like to know, however, why 18 of the brain-injured children did not obtain this score, and why many of them were able to perform as well as any of the non-brain-injured children.

Probably the explanation lies in the localization and severity of the cerebral damage, but information on these aspects was not available. Even if this information was available, however, its value in predicting performance is doubtful. Meyer suggests that with the present state of knowledge of brain organization and functioning, it is almost impossible to predict the outcome of a specific brain injury on psychological functioning.

Three main psychological theories of brain functioning and organization have been put forward. The first theory is the anatomistic theory expounded by Henschen, Kleist, and more recently by Nielsen. This theory asserts strict localization, not only of the primary sensory and motor functions, but also of the higher mental functions. The evidence for this point of view comes from studies of aphasic patients and from studies in electrical stimulation of the cortex in conscious human subjects.

Aphasia or language disturbances were found to be related to lesions of the left or dominant hemisphere, so the conclusion was reached that specific types of intellectual function are selectively impaired by lesions in different places. Cortical stimulation of conscious humans produced effects in the primary sensory and motor areas and in the temporal lobes.

Meyer criticizes the conclusions reached from these various studies, as the strict localization shown was of simple sensory and motor functions only, which are generally accepted as being localized in very limited parts of the brain, and one cannot generalize from these findings to the higher mental functions.

A second theory is the Field Theory or Theory of Equipotentiality, expounded by Goldstein and, at one time, by Lashley. According to this theory, the brain functions in a unitary fashion, and there is no localization of the higher mental functions in the cerebral cortex. Only the primary sensory and motor functions are localized.

The third theory, which is the one most generally accepted, is the Theory of Regional Equipotentiality or Functional Equivalence, supported by Head, Hebb and Lashley (who modified his earlier views as far as human beings are concerned). According to this theory, a higher mental function may depend more on one area of the brain than another, but almost any higher function involves many aspects of the activity of the brain as a whole.

Many studies have been reported on experiments with people after injury to occipital, temporal, frontal and parietal lobes, but the results are inconsistent and often contradictory. The only conclusions to be reached are that primary sensory and motor functions are accepted generally as being fairly well localized in the brain, but the localization of the higher mental functions has not been established.

The results of the present investigation demonstrate that not all brain-injured children display the same characteristics and abilities in test performance. Many were able to do as well as the normal and emotionally disturbed children, and some of the children in the 2 latter groups performed in a manner often regarded as indicative of brain injury.

The typical diagnostic problem in clinical practice is not between normality and brain damage, but rather whether a child who has learning difficulties or behavioural disturbances or both, is brain-injured or emotionally disturbed. The fact that he has learning difficulties is probably the fundamental problem.

An interesting suggestion has recently been put forward by Cruickshank and his associates, who question the need for a definite diagnosis in cases of possible brain injury. They report on a 2-year experimental study conducted in the USA, in which a group of brain-injured children and a group of hyperactive, emotionally disturbed children without brain injury were subjected to special educational methods. All these children had shown difficulties at school and were unable to adjust to the typical school situation. The clinical history, medical and neurological

examinations (including EEG interpretations) showed no evidence of brain injury in the emotionally disturbed group, but 5 years of informal classroom experimentation showed that they had learning difficulties and were unable to adjust to school.

When subjected to special educational methods which involved a non-stimulating classroom environment, special teaching materials and highly-structured teaching techniques, all the children in this study were able, for the first time, to adjust satisfactorily to the group situation and showed slow but consistent academic improvement.

Cruickshank and his associates recommend that behavioural patterns suggestive of organic damage should be interpreted in terms of learning problems rather than as indications of brain damage *per se*.

It is possible that in the present investigation the success demonstrated by many of the brain-injured children in the tests was related to the special educational methods employed at the schools they attended. This might explain why the differences between the groups was reduced as the ages of the children increased.

Because an accurate diagnosis is so difficult and cannot be verified in doubtful cases, and because the fundamental problem does appear to be the learning problem, with behaviour and personality disturbances as secondary factors, Cruickshank's findings may provide a solution. Perhaps schools at present used for the training and education of cerebral palsied or other brain-injured children could be extended to provide facilities for underachieving children, who are emotionally disturbed and hyperactive, and are unable to adapt to the ordinary school situation, although they are not retarded.

BIBLIOGRAPHY

Bradley, C. *in* Hoch, P. H. and Zubin, J. eds. (1955): *Psychopathology of Childhood*. New York: Grune & Stratton.
Cruickshank, W. M., Bentzen, F. A., Ratzeberg, F. H. and Tannhauser, M. T. (1961): *A Teaching Method for Brain-Injured and Hyperactive Children*. New York: Syracuse University Press.
Goldstein, K. (1944): J. Psychol., **17**, 187.
Hebb, D. O. (1939): J. Genet. Psychol., **21**, 73.
Idem (1941): *Ibid.*, **25**, 257.
Idem (1942): Proc. Amer. Phil. Soc., **85**, 275.
Idem (1945): Arch. Neurol. Psychiat., **54**, 10.
Hebb, D. O. and Penfield, W. (1940): *Ibid.*, **44**, 421.
Meyer, V. (1957): J. Ment. Sci., **103**, 80.
Strauss, A. and Kephart, N. C. (1955): *Psychopathology and Education of the Brain-Injured Child*, vol. II. New York: Grune & Stratton.
Strauss, A. A. and Lehtinen, L. E. (1947): *Psychopathology and Education of the Brain-Iniured Child*, vol. I. New York: Grune & Stratton.
Strauss, A. A. and Werner, H. (1941): Amer. J. Psychiat., **97**, 1194.
Werner, H. and Strauss, A. A. (1941): J. Abnorm. Soc. Psychol., **39**, 236.