THE INTELLIGENCE OF EPILEPTIC CHILDREN.

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Although epilepsy was known to Hippocrates, there is a strange lack of precision in our knowledge, not only of its ætiology, but of the mental disturbances associated with it. Carver³ has suggested that anatomical, physiological, psychological and other factors may all contribute to the production of the epileptic syndrome. In what we know of the mentality of epileptics there is much that seems contradictory. On the one hand, it is a common belief that some of the most distinguished figures in history, as, for instance, Napoleon, Julius Cæsar, Mahomet, and Byron, suffered from the 'falling sickness': on the other, it is well-known that subnormal mentality is common among epileptics. It is true that the meagre information we have of these cases suggests that some of them do not answer to what is now commonly called epilepsy. Mahomet's symptoms, for example, were those of hystero-epilepsy, and Cameron³ has suggested that Byron suffered from a mild form of spastic paraplegia; but it is probable that some of them were genuine epileptics.

Many writers have commented on the high frequency of mental abnormality among epileptics, and a few have measured it by means of intelligence or other tests. Shanahan¹⁰ found that of those in Craig Colony, New York, only 10% were mentally normal or approximately so; 15% he thought had deteriorated from apparent normality, while 75% were from the first defective. Lowenstein⁸ tested 16 cases with the Yerkes-Bridges intelligence tests and found only 6 subnormal; some were distinctly superior, and three showed the typical epileptic constitution, in that they were emotional, suspicious and irritable. Cookson⁵ in a study of 100 children between the ages of 6 months and 11½ years found a more or less marked mental deficiency in 26. He writes:—

Where mental deficiency was present, it had been noticed as early as the fits; in two cases mental impairment was stated to be progressive: of the mentally defective cases eight were born precipitately, six had spastic diplegia, one was a mongol, one was regarded as a post-encephalitic mental defective, and two were microcephalic.

It should be remembered, however, that the occurrence of epileptiform seizures in most types of mental deficiency is well known; they depend on some gross cerebral lesion and must be distinguished from idiopathic epilepsy which is the condition forming the subject of the present communication.

Fox⁷ examined 150 epileptic children of ages 5 to 17 in Lingfield Epileptic Colony, using a large battery of tests—the Binet tests, Burt's reasoning tests, Porteus's maze tests, and educational tests—and found the median intelligence-ratio (mental ratio or intelligence quotient) of the boys to be 71 and that of the girls 65, which is distinctly subnormal. 130 of the children he examined twice at intervals of a year and concluded that some improved, others deteriorated, and others were erratic in their progress, but that the general tendency was towards deterioration, which in 8% of the cases was severe. It should be remarked, however, that the figures given by Fox in his article show in his patients no greater average deterioration at their second test and no more variability than in the normal children examined by Terman.

In some cases deterioration is progressive: Walsh¹² says that in a great many cases epilepsy is a progressive and degenerative disease in which a state of lowered mentality eventually develops, but adds that in some cases it does not seem to affect intellectual life. It has been thought that the deterioration varies with the frequency and intensity of the fits and with the age of onset of the disease. What is needed, in addition to detailed case histories, is a systematic enquiry, on a scale large enough for statistical purposes, into the mental histories of epileptics for the purpose of finding whether the disease is inherited, to what extent intellectual and emotional deterioration appear, and whether the degree of deterioration varies with the age of onset or the frequency and intensity of the fits.

Clark⁴, MacCurdy⁹ and others have maintained that idiopathic epilepsy is endogenous, that it is traceable to an affective defect, that, just as the feeble-minded are retarded in their intellectual development, so epileptics suffer from an arrest of the instincts underlying their emotional life, and that this inherent defect expresses itself in ego-centricity and heightened sensitiveness, and may lead to ultimate mental deterioration, intellectual as well as emotional. The practical importance of this theory lies in the corollary that, if it be true, the treatment must be psychological, it must take the form of training, and that the physician in his onslaught on the convulsions is attacking the symptom and not the cause.

Wiersma¹³ on the other hand has thought that non-activity and imperception, i.e., absent-mindedness, a state of lowered consciousness in which impressions from the outer world are neglected so that things are seen but not recognized, are the fundamental characteristics of the epileptic mind. He compared the behaviour of 48 epileptics with that of 2,523 normal people as shown by answers to a questionnaire which was addressed to all the medical practitioners in Holland. As compared with the normals, they were on the whole more narrow-minded, cautious, vain, egotistical, self-satisfied, affected, false, stubborn, unstable in mood, inconsistent in thought and action, given to flattery, grumbling and talking about themselves, to verbosity, complexity, repeating themselves and echoing the ideas of others; they were clumsier, quieter, more reserved, less intelligent, less practical, less witty, less observant, and their memories were poorer. All these traits, including the egotistical tendency, he traces to their absent-mindedness and non-activity.

PRESENT INVESTIGATION.

As the slowness, the inattentiveness, the change in emotional and temperamental disposition and the general narrowing of the mental horizon of epileptics, tend to obscure their mental deterioration and give the impression that they could if they would, we propose to set forth in this paper an account of the results of testing the intelligence of 49 children who were examined in the Royal Hospital for Sick Children, Glasgow, in the course of an enquiry into the intelligence of sick children, undertaken under the auspices of the Medical Research Council and with the collaboration of Dr. Leonard Findlay. The results of these tests are offered, not in the belief that they will help to a decision between these theories, but in the hope that they may be of use to others who are working along similar lines. They have the advantage of an objectivity which cannot be claimed for the most carefully answered questionnaire or the most pious of opinions.

The children varied in age from 4 to 12 years. Some of them were examined twice at intervals of 8 months to nearly 5 years. The healthy brothers and sisters of some of them were also examined. The tests used were those of Binet as translated by Burt¹.

The intelligence-ratios (I.R.) of these patients at their first test were :—

117, 117, 113, 104, 103, 100, 99, 98, 98, 96, 93, 92, 90, 89, 89, 88, 87, 87, 85, 84, 83, 82, 81, 81, 80, 79, 78, 77, 77, 77, 77, 77, 76, 75, 74, 72, 71, 71, 68, 65, 63, 60, 58, 58, 57, 54, 52, 51, 49.

The mean of the whole group is 80.65 ; its probable error is 1.43. This is appreciably and significantly below the average of the rest of the hospital children examined (991), which is 90.57 ± 0.31 . When patients suffering from diseases of the ductless glands and of the brain are excluded, the mean I.R. of the rest of our patients is 91.76 ± 0.35 , which is still more above that of the epileptics. Hence these are as a class distinctly below the rest of the hospital population in intelligence.

Their intelligence ranges from feeble-mindedness up to a grade above the average of the other children. There is, however, no sign of that superlative native ability which tradition has associated with this ailment. The variability of this group, as measured by the standard deviation, is about equal to that of the rest of the patients. The standard deviation of the epileptics is 14.87, while that of the others is 14.66. Since the means of these two groups are different, the coefficient of variation, which is the standard deviation expressed as a percentage of the mean, gives a better measure of variability than does the standard deviation itself. This for the epileptic group is 18.43 ± 1.33 , while for the others it is 16.18 ± 0.26 . The difference (2.25 ± 1.36) is not significant.

As it has been maintained that epilepsy is inherited and that the mental defect that so often goes with it is innate, we have tested the brothers and sisters of some of the patients and re-tested the patients themselves. The numbers, unfortunately, are small, but the results are interesting and suggestive,

The intelligence-ratios of the patients whose brothers and sisters were examined and those of the healthy siblings were :—

<i>Patient</i> (1st test)	117, 117, 100, 98, 92, 88, 84, 81, 79, 78, 77, 77, 76, 71, 68, 65, 58, 58, 57, 71
<i>Sibling</i>	93, 134, 93, 96, 97, 83, 102, 87, 92, 83, 83, 101, 67, 106, 90, 91, 76, 84, 77, 79

Thus, 15 of the 20 healthy children have a higher I.R. than their epileptic brothers or sisters. The mean I.R. of the 20 patients is 80.60 ± 2.56 , that of their 20 healthy brothers and sisters is 91.20 ± 2.05 . The difference between the means, 10.60 ± 3.28 , is significant, in spite of the smallness of the number of cases. The average of the healthy siblings is practically the same as that of the whole hospital population. They are, therefore, apparently normal in respect of intelligence. This, of course, proves little with regard to the inheritance of epilepsy, but it suggests that, whatever may be the grade of their own mentality, epileptics come from stocks which, as far as intelligence is concerned, appear to be quite normal. If the healthy members of these stocks have inherited epileptic potentialities, these are not correlated with any defect of intellect. It follows, too, that the intellectual deterioration of the patients must be an effect of their epileptic condition, and is not itself directly inherited.

To test this suggestion it would be necessary to examine the patients in the very early stages of their illness : if their I.R. at that time approximated to those of the rest of the population, the theory would be established. It will probably take a long time to collect sufficient data of this kind. At present we have only presumptive evidence, namely, that just given and some drawn from the following results of re-tests.

Twenty-one cases were re-tested at intervals varying from 8 months to 4 years 8 months. The I.R. of the patients at the two tests are shown below :—

<i>First test</i>	117, 113, 104, 98, 92, 89, 88, 87, 87, 85, 81, 81, 78, 77, 77, 76, 68, 60, 58, 57, 51
<i>Second</i> ..	102, 92, 80, 85, 39, 86, 84, 64, 87, 74, 85, 31, 75, 81, 64, 76, 64, 49, 28, 54, 37

The mean at the first test is 82.09 ± 2.51 ; at the second test it is 66.52 ± 3.06 . The difference, 15.57 ± 3.96 is significant. In ten cases there is little difference between the results of the two tests, but the general tendency is towards deterioration which in some is very serious. This supports the suggestion already made that the epileptic condition tends to produce mental deterioration.

A more detailed examination of our records taking account of the interval between the tests, points in the same direction. Table I shows for each of these 21 patients the intelligence-ratio at each test, the interval between the tests, the chronological and mental age at the first test, the actual and expected increase in mental age, a figure (index of development) which shows whether development is normal, the interval between the first fit and the first test, the severity and frequency of the convulsions at the time of first admission to hospital, and the improvement in general condition at the time of the second test.

TABLE I.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
S.A.	117	102	51	6:1	7:1	41	60	0.68	0.3	S.	N.F.	I.
A.J.	113	92	42	8:10	9:11	17	47	0.37	1.0	M.	F.	N.I.
G.M.	104	80	51	11:6	12:0	14	53	0.26	0.3	M.S.	N.F.	I.
P.D.	98	85	36	10:10	10:8	13	35	0.38	2.0	S.	F.	I.
H.H.	92	39	39	8:10	8:1	-41	36	-1.14	0.2	M.	F.	N.I.
R.T.	89	86	15	8:5	7:6	9	13	0.70	0.6	M.	F.	N.I.
C.J.	88	84	27	6:9	6:0	19	24	0.82	2.7	M.	F.	I.
B.R.	87	64	40	9:6	8:3	-1	35	-0.03	2.6	S.	F.	N.I.
M.E.	87	87	19	12:0	10:5	17	17	1.02	0.0½	S.	F.	I.
K.H.	85	74	8	14:2	12:1	-14	7	-2.06	12.0	S.	F.	N.I.
M.J.	81	31	27	8:4	6:9	-41	22	-1.88	6.0	S.	F.	N.I.
M.R.	81	85	45	3:1	2:10	36	37	0.97	0.0¼	S.	F.	I.
M.P.	78	75	25	8:1	6:4	11	20	0.56	0.1	M.	F.	I.
S.H.	77	81	8	9:3	7:2	10	6	1.62	4.6	S.	F.	I.
P.C.	77	64	9	11:9	9:1	-13	7	-1.88	0.6	M.	F.	N.I.
M.A.	76	76	18	5:1	3:10	13	14	0.95	0.0¼	S.	N.F.	I.
D.C.	68	64	37	11:7	7:10	18	25	0.73	10.0	S.	F.	N.I.
W.J.	60	49	53	11:3	6:10	10	32	0.31	1.0	S.	N.F.	N.I.
R.W.	58	28	45	4:0	2:4	-2	26	-0.08	0.6	M.	F.	N.I.
C.W.	57	54	23	8:3	4:9	6	13	0.46	2.0	M.	N.F.	I.
W.C.	51	37	56	8:3	4:2	7	29	0.26	0.8	S.	F.	I.

- (1) Patient.
- (2) Intelligence-ratio at first test.
- (3) Intelligence-ratio at second test.
- (4) Interval between the tests (in months).
- (5) Chronological age at first test (in years and months)
- (6) Mental age at first test (in years and months).
- (7) Increase in mental age (in months).
- (8) Expected increase in mental age (in months).
- (9) Index of development, *i.e.*, (7)/(8).
- (10) Interval between first fit and first test (in years and months).
- (11) Severity of fits on admission to hospital. S. = severe, M. = mild, M.S. = moderately
- (12) Frequency of fits on admission to hospital. F. = frequent, N.F. = infrequent.
- (13) Improvement in general condition. I. = improved, N.I. = not improved.

There is good reason for believing that under normal conditions the intelligence-ratio remains constant, hence the increase in the mental age of a child which is expected after a given interval will depend partly on this interval and partly on the magnitude of the ratio itself. The mental age of a child whose I.R. is 75 will in 12 months increase by 75% of 12 months, *i.e.*, by 9 months, whereas that of a child with a ratio of 100 will in the same time increase by 12 months. This expected increase is given in column 8. The ratio of the actual increase to this expected increase gives a measure of the stability of intelligence; this is shown in column 9. Where it is unity, the development is normal; where it is between 0 and 1, there is retardation; where it is 0 or negative, there is stagnation or retrogression (Fig. 6).

Our numbers are so small and the conditions so variable that these records do little more than offer suggestions. Of the 21 cases 4 show serious retrogression (indices of development -1.14, -1.88, -1.88, -2.06), and two

complete stagnation (indices -0.03 , -0.08), five have developed at from a quarter to about a third of their normal rate (indices 0.26 , 0.31 , 0.26 , 0.38 , 0.37), five at from about a half to three-quarters (0.68 , 0.70 , 0.56 , 0.73 , 0.46), and the remaining five have apparently developed at their normal rate (1.02 , 0.97 , 1.62 , 0.95 , 0.82). In two of the cases of retrogression the interval between the tests was only 8 or 9 months, so the indices in these cases are not so reliable as in the others.

Diagram 1 shows the relationship between (a) the interval between the tests (col. 4) and (b) the difference between the first and the second I.R. (col. 2 and 3).

DIAGRAM I.

The points seem to lie roughly along a line from the upper left-hand corner to the lower right-hand corner of the page, suggesting a correlation between these two sets of values. The calculated correlation is -0.378 ± 0.126 . This is barely significant, but suggests that retardation in mental growth varies directly with the length of the interval between the tests. It must be remarked, however, that the number of cases is small and that this calculation is concerned with absolute increase in the intelligence-ratio; it takes no account of mental growth relative to initial capacity.

When we plot the interval between the tests against the index of development, which, as shown above, indicates whether development is normal or not, we get the following scatter-diagram (Diagram 2) :—

DIAGRAM II.

Diagram 2 shows much less correlation than Diagram 1. The correlation coefficient here is $+0.17 \pm 0.14$, which is not significant. Hence the higher correlation between (a) the interval between the tests and (b) the difference between the first and second I.R. is due to neglect of the partial dependence of this difference on the magnitude of the ratio itself. The signs have actually been reversed. This is due obviously to the exceptional values in the lower left-hand corner. When these are eliminated the remaining values suggest a slight negative correlation. It follows, then, that our observations prove no significant correlation between the length of the interval between the tests and the degree of mental deterioration. It must be repeated, however, that such a correlation might be found in a bigger group of cases and after a more comprehensive examination than we have been able to make.

Nor is there any relationship between the age at which the first convulsions appeared and the subsequent intelligence-ratio of the patient. If the whole of the 49 cases be divided into two groups, one containing those whose I.R. was 80 or more at their last test, the other containing those with an I.R. below 80, the mean age at which the first fit appeared is practically the same in the two groups, namely, about $5\frac{1}{2}$ years.

As it has often been maintained that deterioration is greatest in those patients in whom the convulsions are severest and most frequent, our cases were classified by Prof. L. Findlay as severe, mild, moderately severe, frequent and infrequent, according to the severity and frequency of the fits at the time the patients were admitted to the hospital. The results of this classification are shown in columns (11) and (12) of the Table I. Here S means that the fits were severe at that time, M. mild, and M.S. moderately severe; F. indicates that they were frequent and N.F. infrequent. In the last column the letter I indicates that the patients had improved in general condition at the time of the second test, N.I. that there had been no improvement.

Twelve of the cases were severe, 8 mild, and 1 moderately severe. In 16 cases the attacks were frequent, in 5 they were infrequent. Eleven improved, and ten showed no improvement. Only one case was both mild and frequent, and it improved in general condition by the time of the second test. Of the 12 severe cases 7 improved and 5 did not. Of the 9 cases in which the attacks were both severe and frequent 5 improved, and 4 did not. Of the 8 mild cases 3 improved, and 5 showed no improvement. This does not support the view that improvement in the general condition depends on the mildness of the attacks.

Of the 5 cases in whom the fits were infrequent at the time of the first test, 4 improved, and 1 did not. Of the 16 whose attacks were frequent, 7 improved. This also suggests that there is no relationship between the frequency of the convulsions and subsequent improvement in general condition. The observations, then, suggest that from the severity and frequency of the fits one cannot make any reliable inference as regards the subsequent progress of the condition of the patient.

Let us now look into the relationship between these factors and the intelligence of the patients. This is indicated in the following table which gives the mean index of development between the tests (with its probable error) and the mean intelligence-ratio at the first test of the severe, mild, frequent, infrequent, improved and not improved cases together with their differences.

TABLE II.

	No. of patients	Mean index of devt.	Difference	Mean I.R. at first test	Difference
Severe	12	$+ 0.24 \pm 0.21$	0.22 ± 0.30	80.7 ± 3.14	0.8 ± 5.18
Mild	8	$- 0.02 \pm 0.22$		81.5 ± 4.12	
Frequent	16	$+ 0.02 \pm 0.19$	0.51 ± 0.20	81.9 ± 2.43	0.9 ± 7.60
Infrequent	5	$+ 0.53 \pm 0.08$		82.8 ± 7.20	
Not improved	10	$- 0.50 \pm 0.23$	1.23 ± 0.24	81.0 ± 3.31	2.1 ± 4.99
Improved	11	$+ 0.73 \pm 0.08$		83.1 ± 3.72	

As regards the severe and the mild cases there is no significant difference between the two groups either in respect of the intelligence ratio at the first test or of the subsequent mental progress as shown by the index of development; the mean index of the severe cases is positive while that of the mild cases is slightly negative, but this difference is small as compared with its probable error. Similarly, the difference between the means of the frequent and the infrequent groups is not significant, although the index is higher in the infrequent group, which suggests that the frequency of the convulsions may be more important than their severity in determining mental deterioration.

It is very different when we compare the indices of development of those whose general condition had improved with the indices of those in whom there was no improvement. The mean of the 11 who improved was $+ 0.73 \pm 0.08$,

i.e., about three-quarters of the normal, while that of those who showed no improvement was -0.50 ± 2.23 , *i.e.*, in them there was actual retrogression. The difference between these means is quite significant, being three times its probable error. It should be noted that the difference between their intelligence-ratios at the first test was not significant.

It follows, then, that these observations indicate that there is no relationship between the severity of the fits and the subsequent improvement in general condition or subsequent mental progress, that there may be a correlation between their frequency and arrest of mental development, but that there is a very significant correlation between general improvement in the condition of the patients and their mental progress. If this improvement can be placed to the credit of medical treatment—and the physician naturally claims that it can—it follows that such treatment, while arresting the convulsions, at the same time promotes normal mental development.

Returning to the psychological theories already alluded to, it should be remarked that a general enfeeblement of intelligence will in itself to some extent explain the inattentiveness, the distractibility, the slowness of thought and reaction, the ego-centricity and the primitive character of the emotional reactions of epileptics, for it implies a disintegration of the higher, more complex mental functions and a consequent slackening of control over the lower, more purely instinctive reactions. Even normal people are inattentive to the things they do not understand; they fail to see and hear them. Quickness of reaction, especially of 'choice' reactions, is partly affected by the same condition; W. G. Smith¹¹ found that while epileptics did not differ appreciably from normals in what would nowadays be called the rate of tapping, they were distinctly slower in 'choice' reactions, such as sorting a pack of cards; this is just what one would expect if their deterioration were intellectual, for the more complex functions would be affected first. Similarly, as the more primitive mental functions, the purely instinctive reactions, would be the last to be affected, we have here a possible explanation of the ego-centricity, the hypersensitivity, the obstinacy, irritability, and general variability of mood of the epileptic.

It is possible, therefore, that, instead of deterioration being the result of heightened egoism, as MacCurdy suggests, the latter may be the result of a general intellectual deterioration; but our methods of estimating this, especially in adults, are so crude, and our ignorance of our emotional and instinctive equipment so profound that this suggestion is offered with the utmost diffidence.

CONCLUSIONS.

1. The average intelligence of epileptic children is appreciably below the normal.
2. There is definite evidence of deterioration that is due directly to epilepsy.
3. All epileptic children do not deteriorate equally; some appear to show no deterioration; some lapse into a state of complete imbecility.

4. The variability in intelligence of the epileptic group examined is slightly, but not significantly, higher than that of the other patients.

5. Our observations do not permit the assertion of a significant correlation between the degree of deterioration and the length of time the patient has been subject to convulsions.

6. There appears to be no significant correlation between either the severity or the frequency of the convulsions at the time of admission to hospital and either subsequent improvement in general condition or subsequent mental progress.

7. There is a significant correlation between improvement in general condition and mental progress.

8. Epileptics come from a stock which appears to be normal as far as intelligence is concerned.

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