SENILE INTELLECTUAL DETERIORATION AND THE ELECTROENCEPHALOGRAM: A QUANTITATIVE CORRELATION

By

W. McADAM, M.D., M.R.C.P.I., D.P.M.

and

R. A. ROBINSON, M.B., B.Ch., B.A.O., D.P.M.

From The Department of Clinical Research, Crichton Royal, Dumfries

INTRODUCTION

THE association of abnormal low frequency rhythms in the EEG with intellectual deterioration in old age has now often been described, but there has been no clear indication of a quantitative correlation between the degree of abnormality of the EEG and the severity of the deterioration. The present paper describes an attempt to explore the possibility of the existence of such a quantitative correlation.

METHOD

Case Selection

There are many disorders in old age which are accompanied by intellectual impairment, and many of these disorders affect the EEG. It was considered essential, therefore, to adhere to a rigid case selection. Only cases showing a simple deterioration affecting all accessible aspects of the personality were investigated. A typical case would be that of an individual of over 70 with a history of mental illness starting at or after the age of 65 years, subsequently showing gradually progressive disintegration of the intellect and personality of such degree that he was no longer able to deal satisfactorily with his life situation: whose physical state was deteriorating although there was no sign of focal, neurological or gross cardiac or renal failure or conspicuous disease in any system; and who showed some degree of impairment of memory, orientation, insight, intellectual ability and social adaptation and behaviour. We decided to reject, for example, cases showing presbyophrenic features, i.e. those in whom there was a striking discrepancy between a reasonably well-preserved social façade and a severe degree of intellectual impairment; hemiplegias, dysphasias and epilepsies; cases with a suspicion of psychotic illness other than that of simple senile deterioration, for example the depressions, paranoid states and the presenile dementias; and major endocrine disease such as diabetes mellitus or subthyroidism. As far as was possible we sought to restrict the group to cases in which the significant variable was the degree of deterioration in ability to adapt to the environment. It is to be noted that in preliminary studies it was not found possible to distinguish, by means of the pattern of the disability, between senile and arteriosclerotic forms of intellectual deterioration. We do not here take any sides in the question of whether or not the distinction is a valid one. If it is so our series is presumably loaded in the direction of a preponderance of the senile type, since we had resolved to exclude cases showing evidence of focal neurological disorder; otherwise our use of the

expression "senile intellectual deterioration" is not, in this paper, to be taken as implying an exclusion of the arteriosclerotic type.

Clinical Evaluation

A preliminary report on a smaller group than that here studied has been published (Robinson, 1954) and those apsects of the clinical examination to which attention is paid in reaching a numerical evaluation have been fully described. The following is a list of those items, with brief notes on some. In the first group below, for each item to which a good response was obtained, a mark was awarded. There were of course many occasions on which partial or imperfect responses were given and scoring by half marks was used.

1. *Temporal orientation* was considered in orthodox fashion by asking the date, month and year.
2. *Estimate of the patient's own age.*
3. *Duration of stay in hospital* gave indication of recent memory.
4. *Remote memory* required place and date of birth, and school.
5. *Status* involved at least an appreciation that he was in "a place for looking after folks".
6. *Appreciation of Interview Situation* gave an indication of insight, as did in a different sense
7. *Appreciation of failing faculties.*
8. *Rapport.*
9. *Attention.*
10. *Concentration.*
11. *Knowledge of current affairs.* Local sporting news was accepted.
12. *Serial subtraction of sevens from a hundred.*
13. *Pennies in a shilling.*
14. *Threepennies in a shilling.*
15. *Threepennies in three and ninepence.*
16. *Activity and productivity* had to be purposeful: not just aimless restlessness.
17. *Habits* as to feeding, toilet, sphincter control.

Each of the following four, if present, lost him a mark from the above score.

18. *Confabulation.*
19. *Emotional lability.*
20. *Confusion under stress* (e.g. of the interview).
21. *Misidentification of relatives* or of the regular ward staff.

Much of the above had to be discussed and verified with the nurses: in particular 16, 17, 18, 19 and 21.

EEG Evaluation

Standard recordings were made with an Ediswan 8-channel instrument, using an alpha band-pass filter (Morris and Dawe, 1953) in order to obtain a clear picture of the alpha rhythm. The microvoltage of the alpha was used as a standard by which to assess the relative amount of low-frequency activity in the record.

The records were placed in a linear order of increasing abnormality, based on a visual assessment. It was not difficult to place records in categories of slightly, moderately and severely abnormal: and within these categories to rank them. In general the amount of low frequency activity was the principal

consideration, but various other features such as abnormal microvoltages and abnormal wave forms, slowed alpha or poly-rhythmic alpha and so on, were also considered when they were observed. An attempt was made also to obtain a numerical value for the amount of low frequency activity. The indices of theta and of delta activity (i.e. the sum of the duration of each theta or delta wave in a given space of time, recorded as a percentage) were obtained by direct visual measurement from several thirty-second epochs in each record. The average microvoltage of these waves in one thirty-second epoch was assessed, again by direct measurement. These measurements were relatively easy to make in the more abnormal records but were laborious and doubtful when there was a large amount of alpha and faster rhythms present, and especially when these were in higher microvoltage than the low frequency waves and superimposed on them. The band-pass filter made the measurement of the microvoltage of the alpha ryhthms a simple matter.

From these measurements an index of the energy output of low frequency activity was obtained thus:

$$\frac{\text{theta microvoltage}}{\text{alpha microvoltage}} \times \text{theta index} + \frac{\text{delta microvoltage}}{\text{alpha microvoltage}} \times \text{delta index}$$

In the majority of cases the abnormalities were widely distributed over the hemispheres. In three cases they were sharply localized in the temporal areas. Arbitrarily these were assessed as if they had been generalized.

General

The EEG's were studied by one of us (W.McA.) in complete ignorance of the case, the records being taken by a recordist who stored them and delivered them in batches with no other information about the patient than a name. The clinical study was made similarly by the other (R.A.R.) without knowledge of the EEG which was neither shown to him nor reported on until some months after the clinical evaluation had been recorded.

RESULTS

The table shows the measurements of alpha, theta and delta rhythms from which the index of low frequency activity is derived; the age, and the clinical score. The order in the table is that of the rank order of increasing abnormality of the EEG by visual assessment. It is divided between 15 and 16 and between 31 and 32 into slightly, moderately and severely abnormal from the point of view of the EEG.

No significant difference between these three groups was found in respect of age—81·93, 82·38 and 79·05 years respectively—using Student's t test.

Figure 1 is a scatter diagram which shows a trend of conformity between the rank order of the EEG by visual impression and the clinical score—the worse the EEG the lower the clinical score. The coefficient of ranked correlation $=0{\cdot}79$ (P 0·001) which is significant at the 0·1 per cent. level of confidence.

Figure 2 shows the relationship between the index of low frequency activity and the clinical score. Again there is conformity: the more low frequency activity there is, the lower the clinical score. Assuming a linear regression, the product-moment correlation $=0{\cdot}65$ (P 0·001) significant at the 0·1 per cent. level. In order to show this correlation on a graph, the square root of the index of low frequency activity was taken. Without taking the square root, the significance works out slightly higher.

Rank Order of EEG Abnormality	Clinical Rating	Age	Mean μV. α	Mean μV. θ	Mean μV. δ	θ Index	δ Index	Standardized Low Frequency Energy Output
Slight EEG Abnormality:								
1	16½	83	11	10	—	20	—	4·2
2	14½	71	11	20	—	16	—	5·4
3	9	79	20	17	12	12	tr.	3·3
4	16½	81	25	14	—	12	—	2·6
5	6½	80	35	25	20	8	7	3·2
6	14	88	40	17	10	20	12	3·3
7	12	82	12	20	10	20	tr.	6·1
8	9	81	27	20	20	8	16	4·2
9	11	82	55	40	40	25	20	5·7
10	3	85	50	25	—	15	—	2·7
11	9	85	25	15	—	20	—	3·5
12	13½	82	25	25	25	11	11	4·7
13	3½	89	47	45	40	16	13	5·2
14	6	83	25	25	25	25	16	6·4
15	10	78	30	20	20	50	20	7·0
Moderate EEG Abnormality:								
16	13½	85	40	25	80	10	60	11·0
17	7½	77	17	25	20	80	35	12·7
18	3½	74	20	35	30	33	18	8·6
19	4	93	20	20	15	15	10	4·1
20	2½	70	17	15	15	16	4	4·4
21	8	88	25	20	15	35	15	16·1
22	4	82	22	25	15	25	14	5·7
23	5½	87	45	30	25	16	16	7·2
24	10½	82	40	35	70	33	15	7·5
25	6½	79	45	30	30	18	40	6·4
26	8	83	25	25	25	16	16	5·7
27	9	79	50	45	45	16	13	5·2
28	2	84	30	30	35	18	30	7·3
29	5½	85	30	30	25	22	22	6·3
30	−1½	82	25	25	45	16	46	8·9
31	9½	88	40	40	40	65	50	10·7
Severe EEG Abnormality:								
32	2	78	20	20	40	20	50	11·4
33	−1	65	20	20	55	20	66	14·2
34	0	91	12	17	20	40	100	15·9
35	0	85	25	30	40	70	50	12·8
36	0	80	12	20	40	80	60	18·3
37	1	80	40	45	50	22	32	8·1
38	−1	75	15	35	50	90	35	17·8
39	−3	75	15	20	50	10	100	18·4
40	1	85	20	30	25	50	80	13·2
41	4	84	20	30	20	60	20	10·5
42	0	77	45	45	40	18	30	6·7
43	2	74	20	30	30	60	22	11·0
44	0	86	15	30	50	90	60	19·2
45	0	77	30	40	30	100	80	14·5
46	0	85	20	40	100	70	40	18·4
47	5½	75	30	25	40	80	100	14·3
48	−2	72	30	30	40	80	100	14·8
49	−2	82	tr.	30	40	80	100	22·4
50	0	76	tr.	30	40	80	100	22·4

https://doi.org/10.1192/bjp.102.429.819 Published online by Cambridge University Press

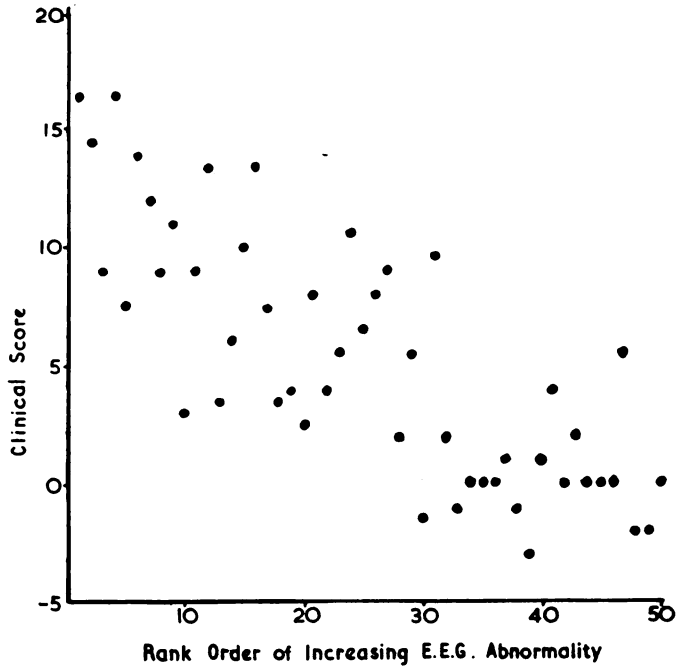

FIG. 1

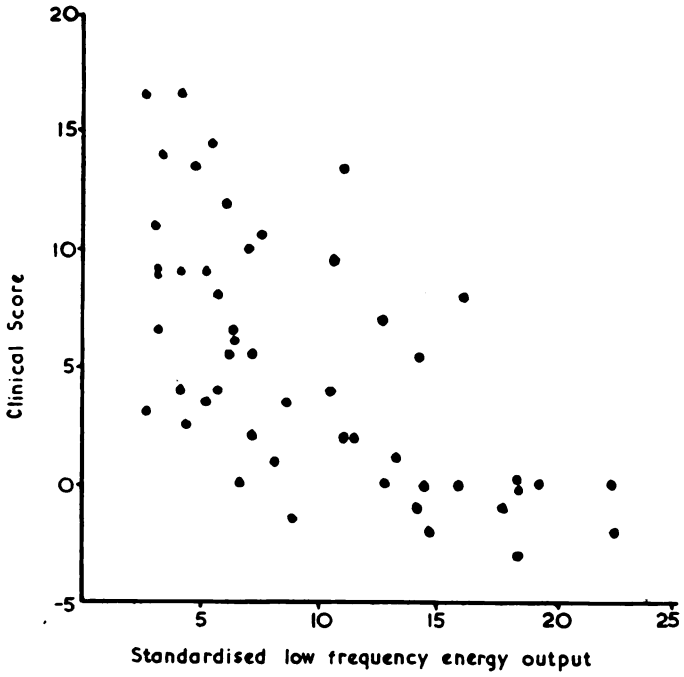

FIG. 2

https://doi.org/10.1192/bjp.102.429.819 Published online by Cambridge University Press

In view of the fact that a greater number of variables was considered in the ranking by visual impression, the higher value for this correlation is not surprising.

Discussion

In an earlier paper from this department (McAdam and McClatchey, 1952) there was reported a high incidence of abnormal low frequency activity in the EEG's of cases of senile and arteriosclerotic dementia but no correlation was observed between the amount of abnormality and the depth of intellectual deterioration. In papers published subsequently, observations have been made which suggest more or less strongly that there is such a correlation. Luce and Rothschild (1953) divided a large group of psychiatric patients over 65 into four categories according to the degree of disability, and found that the proportion of abnormal to normal records was higher, the more severe the disability. Mundy-Castle *et al.* (1954) confirmed that diffuse theta or theta and delta rhythms were characteristic of the senile psychoses; found little clear relationship between type of abnormality and degree of dementia; but noted like Luce and Rothschild that diffuse theta and delta rhythms were found most often in the most severe grade of dementia; Silverman *et al.* (1955) observed that elderly subjects who continued to work and appeared to have higher intellectual capacity and fewer signs of deterioration had EEG's which indicated that their brains were functioning in a manner more closely "physiologically resembling records of younger people".

McAdam and McClatchey, commenting on the lack of correlation between amount of abnormality and severity of dementia, suggested that poor case selection might have been a factor. In the study described in the present paper, very great importance was attached to achieving as nearly as possible a uniformity of type among our cases. In McAdam and McClatchey's series there were many cases of advanced chronic schizophrenia: in that of Mundy-Castle and his associates, more than half the cases were of other than simple senile deterioration and included presbyophrenic forms, presenile deterioration, delirious states, depressions, and others. Silverman and his colleagues included cases of "functional" psychiatric illness and neurological illness such as stroke and tumour. Luce and Rothschild included psychosis with organic disease of the nervous system, alcoholic, "functional" and other conditions. We do not consider therefore that the much less direct, and lower correlations found in the extensive surveys of these authors in any way invalidate our own findings.

We have not in this paper considered the significance of different types of abnormality, e.g. the significance of slowed alpha as compared with an intrusion of theta.

The method of assessing the degree of deterioration may be worthy of comment. Luce and Rothschild considered that stream of talk, lack of memory, and disorientation were the most consistent indicators of mental impairment. We were unable to devise any numerical rating on these points that could be duplicated consistently in order to be capable of being criticized statistically. And we were unable to use orthodox methods of assessing organic deterioration, as by comparing scores on eductive tests with vocabulary scales (Raven, 1947, 1948) mainly because our worst cases were beyond the reach of such testing; also because even the simpler tests in the Progressive Matrices, for example, often cause agitation which vitiates further study: and because there is serious doubt as to the validity of vocabulary assessments of pre-deterioration capacity (Orme, 1955). The scoring that was used in the present paper is substantially a

rationalization of a clinical impression, so defined and formulated as to be capable of being submitted to criticism. We believe that clinical experience formulated *ad hoc* for studies of this kind is capable of giving valid information which is beyond the reach of the precision tools of standardized academic psychological tests.

Summary

Fifty cases of senile intellectual deterioration were studied.

Rating scales were devised for recording the amount of abnormality in the EEG and the degree of deterioration observed clinically.

A trend of conformity was demonstrated between the clinical and the EEG assessments.

Acknowledgments

We are grateful to Dr. P. K. McCowan, Physician Superintendent, and to Dr. A. C. Tait, Director of Clinical Research, for criticism, comment, and facilitation of access to case material: to Miss B. Corrie, for scrupulous recording and clerking: and to Dr. R. Hetherington, Senior Clinical Psychologist, for the statistical work.

Bibliography

Luce, R. A., Jr., and Rothschild, D., *J. Geront.*, 1953, **8**, 167.

McAdam, W., and McClatchey, W. T., *J. Ment. Sci.*, 1952, **98**, 711.

Morris, G. W., and Dawe, P. G. M., *Electronic Engineering*, 1953, **25**, 365.

Mundy-Castle, A. C., Hurst, L. A., Beerstecher, D. M., and Prinsloo, T., *E.E.G. Clin. Neurophysiol.*, 1954, **6**, 245.

Orme, J. E., *J. Ment. Sci.*, 1955, **101**, 863.

Raven, J. C., *Progressive Matrices (1947) Sets A, Ab, B.* London: H. K. Lewis and Co. Ltd.

Idem, The Mill Hill Vocabulary Scale (1948). London: H. K. Lewis and Co. Ltd.

Robinson, R. A., *Old Age in the Modern World.* (Report of the Third Congress of the International Association of Gerontology, London, 1954.) 1955. p. 433. Edinburgh and London: Livingstone.

Silverman, A. J., Busse, E. W., and Barnes, R. H., *E.E.G. Clin. Neurophysiol.*, 1955, **7**, 67.