

# The E.E.G. in presenile dementia

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There are numerous E.E.G. studies of patients with primary presenile dementia but general agreement on the findings is lacking, especially over (1) particular E.E.G. patterns in diagnostic subgroups and (2) the relationship between the degree of E.E.G. abnormality and the severity of dementia as manifested clinically.

This lack of uniformity is due in part to the infrequency of an exact, that is, histological diagnosis. For example, the detailed E.E.G. study by Letemendia and Pampiglione (1958) was made on 17 patients with Alzheimer's disease but in only five was cerebral biopsy performed to confirm the diagnosis. Liddell's (1958) study of E.E.G. findings in 11 presenile dements provided a histological diagnosis in only three patients and that after necropsy. Green, Stevenson, Fonseca, and Wortis (1952), who performed cerebral biopsy in 19 patients with primary presenile dementia, reported the E.E.G. findings in only seven cases of Alzheimer's disease and found that they did not differ essentially from those obtained in eight patients with non-specific encephalopathy. As all but one of their patients with Alzheimer's disease were incontinent, this would suggest that the disease was well advanced (Sim, Turner, and Smith, 1966).

As most E.E.G. studies reported concern presenile dements in relatively advanced stages of their particular disease, this has led to (1) blurring of the end-points of clinical diagnosis where there was no histological confirmation, and/or (2) confining the E.E.G. findings to only one stage of the disease, namely, the late stage. For example, Letemendia and Pampiglione (1958) state that most of their patients with Alzheimer's disease exhibited apathy, the average duration of illness being seven years, and that 'an artefact-free record was difficult to obtain as the patient's cooperation was often poor. In the frontal region the potential changes due to eye movement were often troublesome'. Again, Liddell (1958) commented that most of his patients were so demented that they were not capable of being tested psychologically.

## PRESENT STUDY

**AIMS** The first was to determine the usefulness of

the E.E.G. in the diagnosis of primary presenile dementias; and the second to explore the relationships between the E.E.G. findings in these patients and (a) the presence or absence of neurological signs, (b) the type and degree of clinical dementia, (c) the duration of the illness, and (d) the degree of cerebral atrophy as determined neuroradiologically.

**THE PATIENTS** These had all been admitted to the Department of Psychological Medicine, Queen Elizabeth Hospital, Birmingham, under one of us (M.S.) for the investigation of presenile dementia. After all other factors had been excluded a diagnosis of primary presenile dementia was made. Of a total of 80 patients investigated, the diagnosis was confirmed in 72 by cortical biopsy.

**THE E.E.G.** Eighty patients had E.E.G. studies. The E.E.G. records of 19 biopsied patients admitted before 1956 were no longer available but from the reports it was possible to ascertain whether the record had been normal or abnormal and if the latter, there was a description of the nature of the disturbance.

The E.E.G. records of the 61 patients admitted between 1956 and 1966 were studied in detail by one of us (E.B.G.). These were routine tracings made on an eight-channel Offner electroencephalogram and visual analysis was employed. Measurements were made of a 10-second epoch in one channel in each record and ratings on a four-point scale were obtained for each of the following: alpha activity, flatness, fast and slow rhythms, regularity, and symmetry. In addition, paroxysmal, focal, or other abnormal features in the whole records were noted. The degree of electroencephalographic abnormality was quantified by adding the scores on the various ratings so that a higher total 'E.E.G. score' indicated a greater degree of E.E.G. abnormality.

**CLINICAL ASSESSMENT** Clinical dementia was rated on a four-point scale, employing qualitative subdivisions or 'dementia differentials' as described by the present authors (Sim and Gordon, 1967). These ratings were based on the clinical state of the patient as determined by interviews with patient and relatives and in-patient observation in the ward and in the

occupational therapy department. Every patient had been tested with the Wechsler adult intelligence scale (or Wechsler-Bellevue scale) so that these additional guides to the degree of dementia were usually available. The presence or absence of neurological signs was noted.

**E.E.G. AND NEURORADIOLOGY** In 57 of the 61 patients whose E.E.G. records were studied in detail there was neuroradiological (ventriculogram and/or pneumoencephalogram) evidence of some degree of cortical atrophy. This was rated on a four-point scale as absent, mild, moderate, or severe, according to the comprehensive radiological reports.

#### RESULTS OF THE INVESTIGATION

**E.E.G. ABNORMALITIES** No specific E.E.G. patterns or abnormalities were associated with the nosological subgroups of primary presenile dementia, though Table I shows that approximately one third of patients diagnosed as simple presenile dementia, Pick's disease, and Jakob-Creutzfeldt's disease had normal E.E.G.s whereas all patients with Alzheimer's disease (total of 48) had an abnormal E.E.G. This abnormality depended on the stage of the disease, for in patients diagnosed early there was merely a reduction or absence of the alpha rhythm, often with a concomitant flattening of the record. Later the tracings were more strikingly abnormal with rhythmical theta and delta discharges or diffuse theta or theta-delta predominant activity, the amplitude being usually low to medium.

TABLE I

NORMAL AND ABNORMAL E.E.G. ACCORDING TO DIAGNOSIS

Diagnosis	No. with		Total
	Normal E.E.G.	Abnormal E.E.G.	
Alzheimer's disease	0	48	48
Simple presenile dementia	5	14	19
Pick's disease	2	1	3
Jakob-Creutzfeldt's disease	1	3	4
Others	1	5	6

Table II lists the alpha activity according to diagnosis and shows that only in Alzheimer's disease was this activity entirely absent. The E.E.G. abnormalities in patients with simple presenile dementia and Pick's disease did not conform to any consistent pattern and, apart from the continued presence of alpha rhythms, they were not generally distinguishable from the changes seen in the later stages of Alzheimer's disease. Three of the four patients with Jakob-Creutzfeldt's disease had abnormal E.E.G.s with diffuse theta activity, one

record showing paroxysmal activity with spiking. The patient with subacute spongiform encephalopathy demonstrated paroxysmal features with rhythmical bursts of theta activity; clinically myoclonus was present.

TABLE II  
ALPHA ACTIVITY  
*Alpha Activity*

Diagnosis	Alpha Activity			Total
	Normal	Reduced	Absent	
Alzheimer's disease	2	27	7	36
Simple presenile dementia	6	8	0	14
Pick's disease	2	1	0	3
Jakob-Creutzfeldt's disease	1	1	0	2
Others	3	3	0	6

**PAROXYSMAL FEATURES** These were unusual and were found in only three other patients, one with Jakob-Creutzfeldt's disease and two with Alzheimer's disease, one of whom was very advanced and was having fits. There was a remarkable lack of correlation between the clinical and E.E.G. findings even in those patients whose illness presented initially with fits.

**FOCAL ABNORMALITIES** These were rarely present and all except two of the E.E.G.s were symmetrical.

**DEGREE OF E.E.G. ABNORMALITY AND DIAGNOSIS** This is shown in Table III. Patients with Alzheimer's disease have the highest mean score indicating the greatest degree of E.E.G. abnormality, and this is in marked contrast to the considerably lower score of patients with Pick's and Jakob-Creutzfeldt's disease and simple primary presenile dementia.

TABLE III

DEGREE OF E.E.G. ABNORMALITY

Diagnosis	Mean E.E.G. Score
Alzheimer's disease	6.9
Pick's disease	3.0
Simple presenile dementia	3.3
Jakob-Creutzfeldt's disease	4.0
Others	5.1

**NEUROLOGICAL SIGNS AND THE E.E.G.** As a number of patients with primary presenile dementia present with neurological signs (including epilepsy) a study of mean E.E.G. scores in those with and without such signs was undertaken (Table IV). Cerebral deficits, viz., dysphasia, apraxia, agnosia, and basal ganglia features such as extrapyramidal hypertonus, which are common in the later stages of Alzheimer's disease, were excluded. Table IV shows that there is no consistent relationship between the degree of

TABLE IV  
NEUROLOGICAL SIGNS AND THE E.E.G.

Diagnosis	Mean E.E.G. Scores	
	With Neurological Signs	Without Neurological Signs
Alzheimer's disease	7.2	6.9
Simple presenile dementia	3.3	3.9
Pick's disease	3.0	—
Others	5.5	5.1

E.E.G. abnormality and the presentation of clinical neurological signs.

CLINICAL DEMENTIA AND THE E.E.G. Although all patients had been tested with the Wechsler adult intelligence scale or the Wechsler-Bellevue scale, the scores were not regarded as a reliable index of the degree of dementia. It was decided to rate each case on intellectual, emotional, and behavioural scales which we have called 'dementia differentials', and the total score, the 'global dementia' scale. A comparison was then made between those patients with 'above average' and 'below average' E.E.G. abnormalities as previously assessed (Table V).

Only in patients with Alzheimer's disease is there a definite tendency for the more severe degrees of E.E.G. abnormality to be correlated with severe degrees of dementia. Table V also indicates that the observed differences in grade of 'global dementia' are in the main due to the emotional and behavioural rather than to the intellectual components of dementia. This is mainly due to the addition of emotional and behavioural changes in the later stages of Alzheimer's disease, for in the earlier stages these features are conspicuously absent. Such relationships are not demonstrated in the other nosological groups. In patients with Pick's disease and simple presenile dementia, the degree of E.E.G. abnormality bears no relation to the degree of dementia, although the intellectual component of the dementia is much less pronounced and the emotional and behavioural aspects more prominent than in patients with Alzheimer's disease.

DURATION OF ILLNESS AND THE E.E.G. According to Table VI there is no relationship between the degree of E.E.G. abnormality and duration of illness in any of the nosological groups, though it must be realized that qualitative E.E.G. data are not manifest in the quantified results. In an earlier study of Alzheimer's disease (Sim and Sussman, 1962), of two patients seen in the first year of the illness, one had a normal E.E.G. which three months later showed loss of alpha rhythm, while the second showed only marginal changes. As most of the patients with Alzheimer's disease, including those with a history of less than three years, had had the disease for more than a year, it may be that an even earlier assessment would give some correlation between duration of illness in Alzheimer's disease and E.E.G. abnormality.

TABLE VI  
E.E.G. AND DURATION OF ILLNESS

Diagnosis	Duration of Illness	No.	Mean E.E.G. Scores
Alzheimer's disease	3 years and more	21	7.2
	Less than 3 years	15	6.5
Simple presenile dementia	3 years and more	11	3.8
	Less than 3 years	3	4.3
Pick's disease	1 year and more	1	1.0
	Less than 1 year	2	4.0
Others	2 years and more	5	5.2
	Less than 2 years	3	4.0

CEREBRAL ATROPHY AND E.E.G. The degree of cerebral atrophy as determined neuroradiologically was graded as follows in 57 cases: grade 0, no atrophy demonstrable; grade 1, mild degree of atrophy; grade 2, moderate degree of atrophy; grade 3, severe degree of atrophy.

Table VII shows the corresponding E.E.G. and clinical dementia scores, as well as duration of illness, with respect to each grade of cerebral atrophy. The results indicate the lack of correlation between the degree of cerebral atrophy and the degrees of dementia and E.E.G. abnormality. If grades 0 and 1 of cerebral atrophy are taken together and similarly grades 2 and 3, there emerges (Table

TABLE V

DEGREES OF DEMENTIA AND E.E.G. ABNORMALITY

Diagnosis	Mean E.E.G. Scores	No.	Dementia 'Differentials'			
			Intellectual	Emotional	Behavioural	Global
Alzheimer's disease	7 or more	19	2.8	1.3	1.1	5.2
	Less than 7	17	2.6	0.4	0.4	3.4
Simple presenile dementia	3 or more	8	1.7	1.5	2.1	5.3
	Less than 3	6	1.8	1.7	2.7	6.2
Pick's disease	3 or more	2	1.5	2.0	3.0	6.5
	Less than 3	1	1.0	2.0	3.0	6.0
Others	5 or more	5	2.8	1.4	1.8	6.0
	Less than 5	3	1.7	1.7	2.5	5.9

TABLE VII

Degree of Cerebral Atrophy	No.	DEGREE OF ATROPHY (1)				Mean E.E.G. Score	Mean Duration of Illness (yr.)
		Intellectual	Emotional	Behavioural	Global		
Grade 0	3	2.0	0.7	1.3	4.0	4.6	1.4
Grade 1	5	2.0	1.2	1.6	4.8	4.6	2.6
Grade 2	32	2.4	1.2	1.4	5.0	6.0	3.4
Grade 3	17	2.5	1.1	1.2	4.8	6.3	3.3

TABLE VIII

Degree of Cerebral Atrophy	No.	DEGREE OF ATROPHY (2)		
		Mean Global Dementia Score	Mean E.E.G. Score	Mean Duration of Illness (yr.)
Grades 0 and 1	8	4.5	4.6	2.1
Grades 2 and 3	49	4.9	6.1	3.4

VIII) some tendency for the more marked degrees of cerebral atrophy to be associated with (1) greater E.E.G. abnormality; (2) longer duration of illness, and (3) minimally more severe clinical dementia. It is noteworthy that three patients with abnormal E.E.G.s and unequivocal clinical dementia demonstrated no cerebral atrophy on neuroradiological examination.

No consistent relationship was found between the type or degree of E.E.G. abnormality and dilatation of the third ventricle. Further, there was no agreement between asymmetry and focal abnormality as seen on neuroradiology or in the E.E.G. Neither were lateralizing neurological signs related to lateralized E.E.G. abnormalities nor to asymmetrical neuroradiological appearances.

## DISCUSSION

The present study shows that in primary presenile dementias abnormal E.E.G.s are invariably exhibited in patients with Alzheimer's disease whereas in the other nosological groups there is frequently a normal E.E.G. This finding is both at variance and in accord-

ance with earlier studies, but as in these the number of patients as well as the comprehensiveness of the investigations were considerably less than in the present series (Table IX) it would not be helpful to give detailed comparisons. Reference to only specific points in these papers and in others will therefore be made.

We have already mentioned the work of Green *et al.* (1952) who found the E.E.G. unhelpful in distinguishing their patients with Alzheimer's disease from those with unspecified primary presenile dementia. Schergna and Turinese (1960) found that in their demented patients (including 11 with primary presenile dementia all of whom had an abnormal E.E.G.) there was no relationship between E.E.G. changes and the aetiology of the dementia, and claimed that this confirmed the earlier work of Dell, Seggiaro, and van Reeth (1952). Also, Mundy-Castle, Hurst, Beerstecher, and Prinsloo (1954) found normal E.E.G.s in nine out of 10 cases of presenile dementia.

On the other hand, Letemendia and Pampiglione (1958) found no normal E.E.G. in 17 patients with Alzheimer's disease and Swain (1959) confirmed this in his 10 patients. Passouant, Cadilhac, Walter, and Moretti (1957) reported an abnormal E.E.G. in every one of 15 patients with either Pick's disease or Alzheimer's disease.

It is obvious that there can be wide variations in the E.E.G. findings in presenile dementia and that these become meaningful only when (a) an accurate diagnosis is made and this should be supported with histological examination of the brain; (b) a full clinical history is available from patient or relatives; (c) a full clinical and laboratory examination has been done to exclude systemic and local cause of dementia; (d) the duration of the illness is defined; (e) neuroradiology is available; (f) a detailed study, including a quantitative assessment of the E.E.G. abnormalities, is made; (g) a full intellectual, behavioural, and emotional assessment of the patient is made in order to define the degree and nature of

TABLE IX

## E.E.G. STUDIES IN PRESENILE DEMENTIA IN THE LITERATURE

Author	No. of Patients	Duration of Illness	Diagnosis		Dementia (Graded)	E.E.G. (Graded)	Neuro-radiology
			Histology	Clinical			
Green <i>et al.</i> (1952)	19	+	+	+	+	-	+
Mundy-Castle <i>et al.</i> (1954)	10	-	-	+	+	+	-
Weiner and Schuster (1956)	6	+	-	+	+	+	-
Passouant <i>et al.</i> (1957)	15	-	-	+	-	+	+
Letemendia and Pampiglione (1958)	17	?	+	+	?	+	-
Liddell (1958)	11	-	3	-	-	+	-
Swain (1959)	14	-	+	?	-	?	-
Schergna and Turinese (1960)	11	-	-	+	+	+	+
Turton and Warren (1960)	4	-	-	+	+	+	-
Haug (1962)	12	-	-	+	-	-	+
Present authors	80	+	72	+	+	+	57

the 'global dementia'; (h) a sufficiently large series of the nosological groups comprising the primary presenile dementias is studied, for there are individual variations according to the stage of the illness, particularly in Alzheimer's disease.

**E.E.G. ABNORMALITIES** With regard to specific abnormalities, reduction of alpha activity was much more characteristic of the E.E.G.s of patients with Alzheimer's disease than of the other patients' records and complete absence of the alpha rhythm was seen only in the Alzheimer group. These findings are of importance in differential diagnosis since they were obtained even in early cases where minimal dementia was clinically manifest.

Slow electroencephalographic activity was observed to be the most prominent feature in most of the abnormal records irrespective of clinical diagnosis. Theta and delta activity is of course non-specific diagnostically, and records with bursts of theta or delta activity on a background of diffuse theta activity were of no diagnostic significance since such phenomena were observed in the later stages of Alzheimer's disease as well as in varying stages of the other forms of primary presenile dementia. These 'slow' E.E.G.s were far less common in patients with simple presenile dementia and Pick's disease and when evident were quite unrelated to the stage of these illnesses. Kiloh and Osselton (1966) emphasize that such E.E.G. changes as do occur in Alzheimer's disease differ only in degree from those seen in senile dementia. The results of the present investigation would add to that statement 'and in certain other types of primary presenile dementia'.

Although focal abnormalities have frequently been reported in primary presenile dementia, in our series such features, slowing in type, were seen in only two of the records. Both were patients with Alzheimer's disease who had been ill for more than three years, and the degree of E.E.G. abnormality was above the mean, both for that particular subgroup and for the total series.

Paroxysmal features were seen in the E.E.G.s of only four patients, two with Alzheimer's disease (one of long standing with grand mal seizures), one with Jakob-Creutzfeldt's disease, and one with subacute spongiform encephalopathy with clinical myoclonus. This poor correlation between paroxysmal features and epilepsy in the primary presenile dementias has already been stressed by Frey and Sjögren (1956) and Passouant *et al.* (1957).

Our findings do not support the statement by Kiloh and Osselton (1966) that 'the E.E.G. abnormalities in Pick's disease are similar, but as a rule less marked than in Alzheimer's disease'. Two of our three patients with Pick's disease had a normal

E.E.G. and none of the three records showed an absence of alpha rhythm. Gibbs and Gibbs (1964) in four patients with Pick's disease reported one normal record and that the three abnormal records were only mildly so, with focal slowing in one temporal lobe. Similarly Swain (1959) could detect little abnormality in the E.E.G.s of his four patients with Pick's disease. We would support his contention that 'the E.E.G. may be helpful in the early diagnosis of Alzheimer's disease but may miss Pick's disease'. The patient with Pick's disease in our series with an abnormal E.E.G. showed a mild degree of diffuse theta activity and only minimal reduction in alpha activity.

Five of our 19 patients with simple presenile dementia had normal E.E.G.s and the 14 abnormal E.E.G.s were non-specific and similar to, but less severe, than the slow changes in the late Alzheimer records, excepting that in no case was alpha activity completely absent. This could account for reports, like those of Green *et al.* (1952), of patients with 'undetermined encephalopathy' with lack of differentiation clinically and electrographically from their patients with Alzheimer's disease. The mean degree of E.E.G. abnormality observed in our patients with simple presenile dementia was much reduced compared with that for Alzheimer's disease and was in fact very close to that obtained for the patients with Pick's disease.

Three of our four patients with Jakob-Creutzfeldt's disease had abnormal E.E.G.s with diffuse 2-5 c/s activity of mild to moderate degree with spiking in one. The latter phenomenon and/or sharp waves has been recorded in this disease by Lesse, Hofer, and Austin (1958) in one patient and by Abbott (1959) in two patients. Gonatas *et al.* (1964) showed inconsistent diffuse changes in two patients, which is more in keeping with our findings.

One patient with subacute spongiform encephalopathy had an E.E.G. with paroxysmal features consisting of spikes followed by waves of varying breadth. This patient with myoclonus resembled both clinically and in E.E.G. those described by Jones and Nevin (1954) and Small *et al.* (1964).

**E.E.G. AND NEUROLOGICAL SIGNS** No relationship was observed between the degree of E.E.G. abnormality and the presence or absence of neurological signs. The latter phenomena were more closely related to the type of presenile dementia than to the E.E.G. findings. The clinical significance of this is being incorporated by the authors in a separate communication.

**DURATION OF ILLNESS AND E.E.G.** Though the present study indicates the absence of any relationship

between the degree of E.E.G. abnormality and the duration of illness, this finding must be qualified, for a global grading of the severity of E.E.G. abnormality submerges any qualitative differences. Furthermore, a prospective study of serial E.E.G. changes in the group of diseases under consideration would be more helpful in elucidating any chronological variations and this is now being done.

**DEGREE OF DEMENTIA AND E.E.G.** There are conflicting reports with regard to the relationship between degree of dementia and E.E.G. disturbances. We do not think it helpful to list these reports and shall discuss our own findings. In only one subgroup of the primary presenile dementias, *viz.*, Alzheimer's disease, is there reliable evidence for the more severe degrees of E.E.G. abnormality to be associated with the more severe degrees of clinical dementia. As was pointed out in our Results, the apparent differences in severity of the dementia in this disease in relation to the degree of E.E.G. abnormality are attributable to its emotional and behavioural components in the later stages.

It is probable that the lack of agreement on the E.E.G.-dementia relationship is partly due to the practice of allocating patients to broad and apparently qualitative categories of dementia. Dementia varies in its clinical manifestations and we consider that to attempt a more precise relationship between clinical dementia and concomitant phenomena, a finer and more qualitative assessment may be more valid. We have therefore elaborated 'dementia differentials', the clinical significance of which is being reported elsewhere.

The results of the present enquiry show the lack of a general association between the degree of E.E.G. abnormality and the purely 'intellectual' components of clinical dementia, yet the other components of the 'dementia differentials' do show some relationship, as does the degree of 'global' dementia in the patients with Alzheimer's disease. The fact that the other nosological categories do not show this trend could be of differential diagnostic value.

**AIR STUDIES** Our findings confirm previous investigations with regard to the tenuous relationship between the E.E.G. and the pneumoencephalogram. In particular, no association was observed between focal cerebral atrophy and focal E.E.G. changes. Levin and Greenblatt (1948) and Sisson and Ellingson (1956) came to a similar conclusion while the earlier report by Delay, Neveu, Lérique, and Desclaux (1944), indicating a positive association, has not been confirmed by subsequent work.

**CEREBRAL ATROPHY AND DEMENTIA** Gosling (1955)

demonstrated the absence of a positive relationship between cerebral atrophy and clinical dementia in 24 patients in the 45-65 years age group. Sjaastad and Lönnum (1966), quoting the work of Lennarz and Seifert (1960), also refer to this poor association, so our finding of no consistent relationship is also confirmatory.

**CEREBRAL ATROPHY AND E.E.G. ABNORMALITY** The incidence of E.E.G. abnormalities in our patients with cerebral atrophy was 92% which is higher than figures previously reported, *e.g.*, 53% (Trowbridge and Finley, 1942), 54% (Levin and Greenblatt, 1948), and 72% (Sisson and Ellingson, 1956). In these studies, the starting point of the investigations was the presence of demonstrable atrophy, and not a dementing process as in our study. When the investigation is primarily concerned with the clinical picture the concomitance of atrophy and abnormal E.E.G. is frequent (Haug, 1962).

#### SUMMARY

The E.E.G.s of 80 patients with primary presenile dementia (diagnosis confirmed in 72 by cerebral biopsy) are reviewed.

The E.E.G.s are evaluated with regard to clinical diagnosis, degree of dementia, presence of neurological signs, duration of illness, and the degree of cerebral atrophy.

Differential components of dementia are used in the assessment of clinico-E.E.G. relationships.

The importance of taking into account the stage of the dementing process in interpreting E.E.G.s is stressed.

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