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REG AND WAIS INTELLIGENCE
IN
A SAMPLE OF CULTURAL-FAMILIAL DEFICIENTS

by Henry P. Edwards

Thesis presented to the Faculty of
Psychology and Education of the
University of Ottawa as partial
fulfillment of the requirements
for the degree of Master of Arts



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CURRICULUM STUDIORUM

Henry P. Edwards was born in Bogota, Colombia, on September 5th, 1939. He received the Bachelor of Arts degree from Loyola College, Montreal, in 1961.

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INTRODUCTION

Since the advent of electroencephalography, a number of researchers have attempted to find relationships between measures of the electrical activity of the brain and intelligence as measured by psychological tests. Many of these efforts have been unsuccessful, and the sum total of their results remains inconclusive.

Until recently, practically all studies in this area concentrated almost exclusively on finding correlations between intelligence and the still unexplained alpha rhythm. Taken as a whole, the results of these studies have been very disappointing. Lately, however, a few researchers have begun to study new, more complex, encephalographic variables, and have demonstrated by obtaining positive results the fruitfulness of studying variables other than the alpha rhythm.

The present study has evolved from the belief that an encephalographic variable which has once been related successfully to a measure of intellectual functioning deserves further investigation, both as originally studied and with variations, on new experimental samples, and in relation to a number of measures of intellectual functioning. It is the author's belief that conclusive findings can only be formulated in this area of research after a number of similar studies agree in their positive results.

The first chapter of this thesis presents a review of the literature. It reviews studies relating intelligence to electroencephalographic variables both in mental defectives and in normal adults. It then reviews a recent study which uses creativity as a measure of intellectual functioning, and concludes with a statement of the experimental hypotheses.

The second chapter describes the actual procedure by means of which the hypotheses stated in the first chapter are tested experimentally. It sets forth the details of the experiment, including the statistical analysis of data.

The third and last chapter presents the numerical results of this experiment, and discusses their significance.

CHAPTER I

REVIEW OF THE LITERATURE

Since the advent of electroencephalography, a relatively small number of studies have been done on the possible relationship between EEG¹ variables and test intelligence. These efforts have been unsuccessful in their majority, due in part to the nature of the EEG variables analyzed, and in part to crude instruments and the use of very small samples.

However, two theses done at the University of Ottawa have obtained significant results in the comparison of EEG and intellectual variables. These, coupled with the contradictory results of previous studies, point out the need for further research in this area. This chapter reviews all relevant studies, and ends with a statement of the hypotheses tested in the present study.

1. EEG and Test Intelligence in Mental Defectives.

It is the writer's purpose to review in this section only those studies which compare EEG variables and intelligence of subjects free from overt mental illness or brain damage.

¹ The abbreviation EEG will be used to denote the following, depending on the context: Electroencephalogram, Electroencephalograph, Electroencephalography.

Kreezer and Smith² were the first to study seriously the possible relationships between EEG and test intelligence, but their earliest publications simply hint at possible relationships, and do not provide statistical data. These early studies used such primitive apparatus that they were doomed to failure.

In 1950, Kreezer and Smith,³ using a sample of forty-six adult deficient of the undifferentiated familial type, found a correlation of 0.32 between alpha frequency and mental age. They were unable to find significant correlations between alpha index⁴ or amplitude and mental age.

More recently, Netchine et al.⁵ correlated several EEG variables with intelligence, using a sample of thirty deficient subjects without clinical signs of organic damage. The EEG variables used in this study were alpha index, frequency scatter index, spatial organization, and amplitude.

2 G.L. Kreezer and F.W. Smith, "Brain Potentials in the Hereditary Type of Mental Deficiency", The Psychological Bulletin, Vol. 34, No. 6, 1937, p. 535-536.

3 -----, "The Relation of the Alpha Rhythm of the EEG and Intelligence Level in the Undifferentiated Familial Type of Mental Deficiency", The Journal of Psychology, Vol. 29, 1950, p. 47-51.

4 Alpha index is the percentage of time a particular frequency is present over the entire course of an EEG record.

5 S. Netchine, I. Talan, G.C. Lairy and R. Zazzo, "EEG et Niveau Mental", L'Année Psychologique, Vol. 2, 1959, p. 355-372.

The authors report as significant the correlations of Verbal I.Q. and Performance I.Q. with frequency scatter index. However, Ertl⁶ reports a statistical error in his review of this study, and for this reason its results must be assessed with caution.

In 1960, Netchine and Lairy⁷ did a developmental study on children, in an attempt to relate EEG frequency and mental development. Their sample consisted of 209 children aged five to twelve, divided into four age groups at two-year intervals, and into three I.Q. groups: below 75, 76 to 100, and over 100. They found that the low intelligence group showed a relative slowness of occipital frequency at all ages, when compared to the other two intelligence groups. The authors concluded that frequency increases with age at all intelligence levels, but this increase is slower in mental defectives than in normals. Extrapolating from their findings, it seems reasonable to hypothesize that, in the adult, low I.Q. will be associated with an EEG of low frequency and high amplitude.

6 J.P. Ertl, "Intracortical Delay and Intelligence", unpublished Master's thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, 1961, viii-41 p.

7 S. Netchine and G.C. Lairy, "Ondes Cerebrales et Niveau Mental: Quelques Aspects de l'Evolution Genetique du Tracé EEG Suivant le Niveau Mental", Enfance, 1960, p. 427-439.

2. EEG and Test Intelligence in Normal Adults.

The present study assumes that mental deficient of the cultural-familial type simply represent the lower end of the intelligence distribution for normal people, since they show no evidence of brain damage. Therefore, the findings of studies considered in this section are directly relevant to the present study.

In 1946, Shagass⁸ published the results of an extensive study on 1100 young air crew cadets ranging in age from eighteen to thirty-three. In this study, their scores on the RCAF Classification Test were correlated with the EEG occipital alpha frequency. The correlation obtained was not significant.

A study by Mundy-Castle⁹ in 1958 yielded more encouraging results. The sample consisted of thirty-four normal adult subjects of both sexes, and the intelligence measure used was the South African version of the Wechsler-Bellevue. This study reports significant correlations between alpha frequency and Verbal I.Q. (0.42), alpha frequency and

⁸ C. Shagass, "An Attempt to Correlate the Occipital Alpha Frequency of the EEG with Performance on a Test of Mental Ability", Journal of Experimental Psychology, Vol. 36, February 1946, p. 88-92.

⁹ A.C. Mundy-Castle, "Electrophysiological Correlates of Intelligence", Journal of Personality, Vol. 26, No. 2, 1958, p. 184-199.

Performance I.Q. (0.40), alpha frequency and General I.Q. (0.50), also between alpha index and Verbal I.Q. (0.33).

Walter,¹⁰ using an automatic frequency analyzer, suggests that there may be a positive relationship between EEG frequency pattern variation and intelligence. The suggestion is that the more intelligent brain is more versatile, shows greater variability in its patterns. This suggestion was tested experimentally by Ellingson, and also forms the basis for one of the hypotheses tested in this study.

Ellingson¹¹ attempted to test Walter's observations experimentally. His subjects were twenty-six psychiatric aides, of both sexes, aged between nineteen and forty. An I.Q. measure was obtained from the Comprehension, Arithmetic, Block Design and Digit Symbol subtests of the Wechsler-Bellevue. The author computed rank-order correlations between I.Q. and frequency pattern variation for four different areas of the brain. None of these correlations were significant.

10 W.G. Walter, The Living Brain, London, Duckworth, 1953, xi-216 p.

11 R.J. Ellingson, R.C. Wilcott, J.G. Sineps, and F.J. Dudek, "EEG Frequency Pattern Variation and Intelligence", EEG and Clinical Neurophysiology, Vol. 9, No. 4, 1957, p. 657-660.

In one of the most encouraging studies done to this date Ertl¹² proposed that, since only alpha waves had been extensively used by previous authors, it would be profitable to explore the relationships of other EEG variables with psychological variables. He therefore studied the relationship of intra-cortical delay and intelligence on a sample of eleven post-graduate students. The correlation obtained was 0.88. However, as pointed out by Wyspianski¹³ in his review of the literature, Ertl employed a measurement technique which presents serious obstacles to cross-validation. For this reason, Ertl's results are cautiously interpreted. Nonetheless, they point out the need for new approaches to the analysis of EEG records in psychophysiological research.

3. EEG and Creativity in Normal Adults.

In this section, a recent thesis by Wyspianski¹⁴ is considered. It is included in this review of the literature on intelligence and EEG because, in the words of its author:

Intelligence and creative thinking have often been linked as closely related, and in fact, empirically observed creative thinking exhibits intelligent behaviour.¹⁵

12 Ertl, Op. Cit., viii-41 p.

13 J.O. Wyspianski, "Brain Wave Amplitude and Creative Thinking", unpublished doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, 1963, p. 3.

14 Ibid., viii-108 p.

15 Ibid., p. 4.

In this study, Wyspianski found significant differences in the EEG wave amplitudes of thirty volunteer students divided into three groups through their scores on creativity tests. The results of this experiment furnish convincing evidence that, in normal male adults, high creativity is associated with low EEG wave amplitude, and vice versa. Extrapolating from this finding, it seems reasonable to expect that intelligence will bear the same general relationship to EEG wave amplitude.

4. Summary and Hypotheses.

This chapter has reviewed all major studies that attempt to relate EEG variables and measures of intellectual functioning. These studies report as many negative results as they do positive. If one excludes the studies by Ertl and Wyspianski, one finds that the sum total of all other results is highly contradictory and inconclusive.

However, the studies by Ertl and Wyspianski sound a most encouraging note, and provide ample reason for doing further research in this area.

The present study accepts Ertl's statement¹⁶ that too much research has been concentrated on the still unexplained alpha rhythm, at the expense of other EEG variables. For

16 Ertl, Op. Cit., p. vi.

this reason, the variability and amplitude of all EEG waves are used as the experimental variables. No attempt is made in the present study to use intra-cortical delay as the experimental variable, in spite of the promising results obtained by Ertl, because its objectivity of measurement had not been adequately demonstrated at the time the data was gathered for the present study.

Two main hypotheses are tested in this study, and from each of these will arise two sub-hypotheses. The first main hypothesis is an extrapolation of the concept proposed by Walter¹⁷ and tested by Ellingson,¹⁸ that intelligent subjects exhibit a tendency towards greater EEG pattern variability. In view of the significant findings obtained by Wyspianki¹⁹ using amplitude as experimental variable, it seemed possible that more intelligent subjects should exhibit greater variability in EEG amplitude, and thus Walter's idea of the intelligent brain showing its versatility through pattern variations could be tested using amplitude rather than frequency as experimental variable.

17 Walter, Op. Cit., p. 52-73.

18 Ellingson, et al., Op. Cit., p. 657-660.

19 Wyspianki, Op. Cit., p. 37-81.

In its null form, the first main hypothesis reads:

Two groups of deficient subjects, categorized as high and low according to their WAIS²⁰ intelligence, do not differ significantly in their EEG wave amplitude variability.

Since the WAIS was used as measure of intelligence, and this test yields three scores for each subject, it was possible to derive the following sub-hypotheses from the above:

Two groups of deficient subjects, categorized as high and low according to their WAIS Verbal scores, do not differ significantly in their EEG wave amplitude variability.

Two groups of deficient subjects, categorized as high and low according to their WAIS Performance scores, do not differ significantly in their EEG wave amplitude variability.

The second main hypothesis owes its origin to Wyspianski's²¹ study. On the assumption that there is high correlation between creativity as measured in that study and intelligence as measured by the WAIS, the second hypothesis proposes that the EEG wave amplitude of more intelligent subjects should be smaller than that of less intelligent subjects. In its null form, this hypothesis reads:

Two groups of deficient subjects, categorized as high and low according to their WAIS intelligence, do not differ significantly in their EEG wave amplitude.

²⁰ Wechsler Adult Intelligence Scale.

²¹ Wyspianski, Op. Cit. viii-108 p.

In addition to the above, the following secondary hypotheses are tested in the present study:

Two groups of deficient subjects, categorized as high and low according to their WAIS Verbal scores, do not differ significantly in their EEG wave amplitude.

Two groups of deficient subjects, categorized as high and low according to their WAIS Performance scores, do not differ significantly in their EEG wave amplitude.

In concluding this chapter, the writer wishes to note that, although most previous studies in this research area have attempted to find a correlation between EEG and test intelligence, the present study will concern itself exclusively with differences between group means. Therefore, all hypotheses will be tested for statistical significance by means of critical ratios.

In the chapters that follow, there will be a discussion of the tools, methods and results of the present study.

CHAPTER II

EXPERIMENTAL DESIGN

This chapter describes the actual procedure by means of which the hypotheses stated in the first chapter were tested experimentally. The first two sections describe the sample and the instruments used. The last two sections set forth the experimental procedure and the statistical analysis of data.

1. The Sample.

The sample originally chosen for this study consisted of sixty subjects clinically diagnosed as cultural-familial deficientes at the Ontario Hospital School, Smiths' Falls, where they were hospitalized. The procedure was to search through the files at the Ontario Hospital School for all the adult male subjects that ranged in age from sixteen to thirty years, had intelligence no lower than high imbecile, were considered free from epilepsy, mental illness or any form of brain damage, and were clinically diagnosed as cultural-familial deficientes. EEG records were then obtained for all of these subjects.

Of the sixty subjects thus chosen, seventeen had to be dropped from the experiment, either because their EEG records showed epileptic-like paroxysmal discharges, or

because they showed definite signs of neurological involvement in their gait, general coordination or mannerisms. It was felt that the diagnosis of cultural-familial was not tenable in these subjects. Although the exclusion of these subjects severely limits the possibility of generalizing from the sample used to a greater population, it is the writer's contention that the main purpose of a pilot study such as this is not to generalize, but rather to smooth the way for a larger study from which more general conclusions can be drawn.

The experimental sample actually used, therefore, consisted of forty-three adult male cultural-familial deficient, free from observable brain pathology or mental illness, ranging in age from sixteen to twenty-seven years, and in WAIS I.Q. from less than 41 to 81. None of these subjects were under the influence of drugs at the time of the experiment.

2. The Tools.

EEG records were made by the technical staff of the Ontario Hospital School especially for this study, with their eight-channel apparatus. Except for the initial evaluation of records, only the left occipital tracing was used in the present study. The EEG instrument used was model 3D made by the Grass Instrument Company. This

instrument was purchased in 1954, but is reported to be in excellent working condition.

As measure of intelligence, the Wechsler Adult Intelligence Scale, usually known as the WAIS, was administered to all the subjects. This is perhaps the most widely used test of general intelligence on the market today, and has the obvious advantage over omnibus tests that each subject's I.Q. is divisible into sub-scores, so that verbal and non-verbal components of intelligence can be evaluated separately.

3. The Experiment.

Once the experimental sample had been chosen from the files of the Ontario Hospital School in the fashion already described, an eight-channel EEG record of each subject was obtained at a paper speed of 6 cm. per second. For this purpose, needle electrodes were placed over the frontal, central, parietal and occipital regions. The left occipital electrode, which yielded the only record analysed in this study, was placed one-sixth of the distance from the midline to the external meatus, and upwards from theinion ten per cent of the distance between inion and nasion. Plate electrodes on the ear lobes were used for reference, and the muscle filters were on to eliminate from the record as many waves as possible that were not due to the electrical

activity of the brain itself. In an effort to minimize later errors in amplitude readings, each record was obtained with the apparatus calibrated to give the largest pen deflection that was compatible with faithful recording of the peaks of all brain waves.

Since it was considered very important to obtain all EEG's under constant conditions, they were all obtained with the subjects awake but resting with their eyes closed, lying down in a semi-dark, sound-attenuating room. A preliminary record was made in order to accustom each subject to the procedure, and in order to decide how the apparatus should be calibrated to yield large waves. Following this, a ten-minute record of each subject at rest was made. This record was subsequently analyzed for amplitude and variability.

The next step in this project was to administer the WAIS individually to each subject. The writer himself administered all forty-three intelligence tests to ensure standard conditions of testing. There were no significant departures from the standard administration and scoring instructions contained in the WAIS manual.¹

¹ D. Wechsler, Manual for the Wechsler Adult Intelligence Scale, New York, Psychological Corporation, 1955, vi-110 p.

All subjects were tested in the daytime, in a private office that was well ventilated and free from loud noises or other sources of distraction. The actual test administration was preceded by a period during which rapport was established by conversing on some simple topic of interest to the patient. There was also a short break between the Verbal and Performance parts of the test.

A few of the subjects tested could not read or write, and therefore were not able to do the Digit Symbol subtest. They were given a score of zero in it. This was not considered a significant departure from standard procedure because all of these subjects belonged definitely in the lower I.Q. and lower Performance groups.

4. Analysis of Data.

In the present study, the intelligence measure is used as independent variable, and the EEG wave amplitude and variability are treated as dependent variables. It is felt, however, that whenever variables are measured rather than manipulated, the division into dependent and independent variables is somewhat arbitrary.

The amplitude and variability of each subject's brain waves were chosen as the dependent variables for reasons outlined in chapter one. The decision to consider only the occipital cortex in this pilot study is based on the finding

by Wyspianski² that the occipital cortex represented most emphatically the EEG amplitude differences among his three creativity groups. It became necessary in this study, however, to measure amplitude by a different technique from Wyspianski's³ in the hope of finding a way to measure amplitude which was sufficiently reliable yet not prohibitively laborious for future, larger-scale studies.

In the present study, it was decided to measure amplitude in terms of area, using a Keuffel & Esser Compensating Polar Planimeter. The exact procedure for amplitude measurements is described in the paragraphs that follow.

The first step was to select from each record thirty segments of EEG tracing, each of them 6 cm. long, in such a way that they would be a representative sample of the entire record. It was felt that this could be achieved by taking any 6 cm. segment within the first two pages⁴ of the record, and subsequent to this choosing a segment every two pages that corresponded exactly in location within its page to the first segment chosen, until thirty segments had been thus

2 J.O. Wyspianski, "Brain Wave Amplitude and Creative Thinking", unpublished doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, 1963, p. 77.

3 Ibid., p. 31-34.

4 Each EEG record was continuous, but made on paper which folds into pages, each page being 30 cm. long.

selected. The boundaries of each segment were marked by two vertical lines spaced six centimeters apart.

The next step was to join the peaks of each six-centimeter wave trace by straight lines, thus forming an enclosed delineated area. The dimensions of the thirty areas obtained in this way for each record were calculated in square centimeters to one decimal, and constituted the thirty amplitude estimates for that record. The calculations, as already stated, were made by means of a compensating polar planimeter.

In view of Wyspianski's⁵ objection that the compensating polar planimeter is not sufficiently accurate for use in small areas, an attempt was made to increase its accuracy by using the planimeter under a five-inch Dazomagnifier. This procedure enables the observer to see the area being traced more clearly than he could with the naked eye. Two reliability estimates were made using the planimeter this way, on two typical 6 cm. areas, by calculating the dimensions of each ten times. The means obtained were 3.1 cm² and 7.3 cm², and the standard deviations were 0.18 and 0.13 respectively. It was felt that the small standard deviations justified the use of the compensating polar planimeter when placed under a powerful magnifying lens.

⁵ Wyspianski, Op. Cit., p. 31-32.

Table I.-

Amplitude Estimates Made on Two Six-Centimeter Lengths of EEG Tracing, Using a Compensating Polar Planimeter.

	<u>EEG</u>	
	1	2
Estimates	3.3 3.0 3.1 3.1 2.8 3.3 3.0 2.9 3.4 3.2	7.3 7.2 7.3 7.3 7.4 7.1 7.5 7.2 7.4 7.1
Mean Estimate	3.1	7.3
Standard Deviation	0.13	0.13

Since errors in the use of this instrument are due partly to lack of steadiness in the user's pulse, the writer attempted to keep these constant by taking all the readings himself, and repeating any readings in which he felt he had deviated from the perimeter of the tracing.

It has been mentioned that thirty amplitude estimates were made for each EEG record, and this figure can be justified now that the procedure for making each estimate has been described. Based on Wyspianski's⁶ study, in which he estimated mean amplitude for any channel from twenty one-second estimates, it was decided to check whether twenty six-centimeter (one second) estimates would also yield a stable mean amplitude in the present study.

In order to check this, the EEG records of three subjects were picked out by chance, and a mean amplitude was estimated for each subject both after twenty 6 cm. estimates and after thirty 6 cm. estimates. The two means obtained for each subject were then compared, and it was found that their differences were less than 0.1 c.m.² in all three cases. Therefore, it was concluded that twenty six-centimeter estimates of amplitude per subject were sufficient to yield a stable mean amplitude. However, since an estimate of amplitude variability was also desired, it was decided to take thirty amplitude estimates per subject.

⁶ Wyspianski, Op. Cit., p. 32.

Table II.-

Comparison of Mean Amplitude Estimates Made on the EEG's of Three Cultural-Familial Mental Deficients, after the Reading of Twenty and Thirty Six-Centimeter Lengths of Tracing with a Compensating Polar Planimeter.

Subject ^a	Mean 1 ^b	Mean 2 ^c	Difference
1551	6.38 cm. ²	6.43 cm. ²	0.05 cm. ²
3117	5.40	5.46	0.06
3481	6.20	6.24	0.04

a File number at the Ontario Hospital School, Smiths' Falls, Ontario.

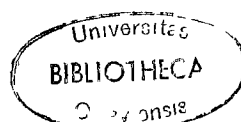
b Mean amplitude estimated from twenty readings of 6 cm. lengths of EEG tracing throughout the record.

c Mean amplitude estimated from thirty readings of 6 cm. lengths of EEG tracing throughout the record.

In preparation for the tests of significance demanded by the experimental hypotheses, it was necessary to obtain the mean amplitude and amplitude variability of each subject. The mean amplitude of each record was directly obtained as the quotient of the sum of amplitude readings divided by the number of readings, in other words, as the arithmetic average of amplitude readings.

As has been stated earlier in this chapter, however, the EEG was calibrated separately for each subject. On account of this, the mean amplitudes as obtained above are not directly comparable for all subjects, unless transformed into what they would be at a common amplification.

The transformation of each mean amplitude into a converted mean that could be compared to those of all other subjects was accomplished as follows. First, the number of EEG's that were calibrated at each amplification was counted. It was found that four different amplifications had been used. The settings on the EEG apparatus corresponding to the four amplifications were labelled 6, 7, 8 and 9. Three records had been calibrated at setting 6, sixteen records at setting 7, twenty-one records at setting 8, and three records at setting 9. Since the largest number of records had been calibrated at setting 8, it was decided to make this the amplification into which all others would be converted.



The conversion was effected by obtaining the ratio of a twenty-microvolt calibration stimulus at a setting of 8 to a twenty-microvolt calibration stimulus at the setting of the record being converted, and multiplying this by the mean amplitude being converted. The product was then equivalent to a mean amplitude in square centimeters at setting 8. This conversion was carried out for all records calibrated at a setting other than 8, before they were compared in the tests of significance.

Before the above-mentioned conversion ratio could be calculated for each record, it was necessary to obtain area values for twenty-microvolt calibration stimuli at settings of 6, 7, 8 and 9. Since the areas of the waves formed by these stimuli on each EEG calibration page were too small to calculate with a compensating polar planimeter, they were calculated as described in the next paragraph.

The procedure was to join the upper and lower peaks of a subject's occipital calibration tracing by two parallel straight lines. A third line was then drawn between the other two, equidistant to them. Two of the peaks produced by twenty-microvolt calibration stimuli were each joined by two straight lines to the points at which the EEG tracing crossed the middle horizontal line immediately before and after the peak. Thus, a triangle was formed, the area of which could be used as an estimate of a twenty-microvolt

discharge, and computed as the product of its height by one-half its base. The area of each triangle was estimated using a fine ruler, in square centimeters. It was discovered that the bases of the triangles as formed in this procedure were of constant length regardless of the calibration setting used, and that only the height of the triangles varied from one setting to another.

In the fashion described above, calibration areas were computed for three subjects at setting 6, five subjects at setting 7, five subjects at setting 8, and three subjects at setting 9. An average value for the area corresponding to a twenty-microvolt discharge was calculated for each setting. These values were then used in the ratio for the conversion of each subject's amplitude to its value at a setting of 8. In square centimeters, the values were 0.21 for setting 6, 0.32 for setting 7, 0.48 for setting 8, and 0.77 for setting 9.

The preceding paragraphs have explained that the tests of significance to be carried out in this study required the conversion of each subject's mean amplitude into a form that made it comparable to those of all other subjects. They have also explained how this conversion was carried out. As mentioned earlier, the statistical analysis in this study will require, in addition to each subject's mean amplitude, a measure of the amplitude variability of

Table III.-

Values in Square Centimeters for a Stimulus of Twenty Microvolts, Computed at Four Different Amplifications from the Calibration Pages of EEG Records Used in the Present Study.

Record ^a	Stimulus Value ^b in cm ²	Amplification ^c	Average Value for each Amplification
2465	0.24	6	0.21
3294	0.20	6	
4087	0.20	6	
808	0.32	7	0.32
1976	0.32	7	
2523	0.34	7	
3481	0.32	7	
3625	0.32	7	
145	0.48	8	0.48
609	0.48	8	
1815	0.48	8	
3024	0.48	8	
3384	0.48	8	
858	0.76	9	0.77
867	0.76	9	
3895	0.80	9	

a Each record is identified by the file number of the corresponding subject at the Ontario Hospital School, Smiths' Falls, Ontario.

b The value shown for each record is the average value obtained for that record from two readings.

c The number used corresponds to the number on the amplification dial of the EEG apparatus used.

his EEG. The measures of amplitude variability, like those of amplitude, must be comparable for all subjects.

The amplitude variability of each subject was calculated as a coefficient of variation (V) rather than as a standard deviation (σ) because the writer wanted an estimate of variability which would be independent of the size of the mean. The coefficient of variation for each subject was obtained by the following formula:⁷

$$V = \frac{100\sigma}{M}$$

The coefficient of variation is not affected by the size of the mean, and has the added advantage of being an absolute number. In consequence, the coefficients of all subjects can be compared directly, without further transformation.

5. Statistical Analysis.

This section will discuss the statistics employed in the present study. The results achieved by the application of these statistics, however, are presented in chapter three.

All the null hypotheses presented at the end of chapter one are identical in their basic form, and can be

⁷ J.P. Guilford, Fundamental Statistics in Psychology and Education, Toronto, McGraw-Hill, 1956, p. 101.

accepted or rejected by a repetition of the same statistical test. In outline, the hypotheses state that, when a sample of mentally deficient subjects are divided into high and low groups according to their scores on an intellectual variable, the two groups thus formed do not differ significantly on an EEG variable.

In the present study, the hypotheses consider three intellectual variables and two EEG variables. The intellectual variables used as criteria for grouping of subjects are WAIS I.Q., WAIS Verbal scores and WAIS Performance scores. The EEG variables are wave amplitude and amplitude variability.

It was decided that the critical ratio for the significance of a difference between two means obtained from the scores of independent groups could be used as test of significance for all the null hypotheses stated in chapter one.

In preparation for using the critical ratio as test of significance, the first step was to obtain comparable EEG amplitudes and amplitude variabilities for all forty-three subjects. The subjects were then divided three times into high and low intelligence groups, according to WAIS I.Q., WAIS Verbal score and WAIS Performance score respectively. After each of these divisions into high and low groups, using the median of the intelligence scores as dividing line, first the amplitude and then the amplitude variability of each subject were considered as scores, and a group mean for

these measurements was obtained. The critical ratio was then used as test of significance for the difference between these means, as required by each null hypothesis, using the following formula:

$$CR = \frac{M_1 - M_2}{\sqrt{\sigma_{M_1}^2 + \sigma_{M_2}^2}}$$

In this formula, M_1 , M_2 , σ_{M_1} and σ_{M_2} are the means and standard errors of the EEG variables.

It has been the aim of this chapter to describe the sample and tools used in the present study, and to discuss in detail the experimental procedures. The results of the tests of significance are presented and discussed in the next chapter.

CHAPTER III

PRESENTATION AND DISCUSSION OF RESULTS

It is the object of this final chapter to present and discuss the statistical results of this experiment. Discussion will stress the possible implications of this pilot study in terms of further research in the same general area.

1. Results of the Tests of Significance.

For the sake of clarity, the null hypotheses stated in chapter one will be repeated here, and the statistical results will be presented after each null hypothesis.

The first main hypothesis states that two groups of deficient subjects, categorized as high and low according to their WAIS intelligence (I.Q.) do not differ significantly in their ERG wave amplitude variability.

The amplitude variability of subjects in each group was calculated as a coefficient of variation, and group means were calculated for the variation coefficients. These group means were 18.4 for the high I.Q. group and 16.2 for the low I.Q. group. The difference between them is 2.2, and the critical ratio is 1.29. This is not significant.

The two sub-hypotheses arising from the first main hypothesis state that two groups of deficient subjects,

categorized as high and low, in one case according to their WAIS Verbal scores, and in the other according to their WAIS Performance scores, do not differ significantly in their EEG wave amplitude variability.

When the subjects were divided according to their WAIS Verbal scores, the group means for the variation coefficients were 18.1 for the high group, and 16.5 for the low group. The difference between the means was 1.6 and the critical ratio was 0.94. This is not significant.

When the subjects were divided according to their WAIS Performance scores, the group means for the variation coefficients were 18.5 for the high group and 15.6 for the low group. The difference between the means was 2.9 and the critical ratio was 1.71. This is not significant.

The statistical results arising from the first main hypothesis and its sub-hypotheses are presented in Table IV. It should be noted that, although no statistically significant differences were found, the high intelligence group in all three cases yielded, as a group, the higher amplitude variability. Hence, the difference found, though not statistically significant, was in the direction expected. Due to lack of significance, however, the first main hypothesis and its sub-hypotheses have not been rejected. It seems worthwhile, in future research, to look for differences in wave amplitude variability on groups that are larger and

Table IV.-

Comparison of High and Low Intelligence Groups of Mentally Deficient Subjects^a in Terms of the Group Means for the Subjects' EEG Wave Amplitude Variability^b, Using the Critical Ratio as Test of Significance for the Difference between Two Group Means.

Criterion for Grouping	High Group		Low Group		Diff. of Means	C.R.	Signif.
	N	M	N	M			
WAIS I.Q.	21	18.4	22	16.2	2.2	1.29	No
Verbal I.Q.	21	18.1	22	16.5	1.6	0.94	No
Perf. I.Q.	22	18.5	21	15.6	2.9	1.71	No

a The subjects are forty-three cultural-familial patients from the Ontario Hospital School, Smiths' Falls, Ontario, divided into high and low intelligence groups according to their WAIS scores.

b EEG wave amplitude variability is measured in absolute numbers, as a coefficient of variation.

differ more widely in intelligence than the one used in the present study. Using these, it should be possible to accept or reject this hypothesis and its sub-hypotheses with greater certainty.

The second main hypothesis states that two groups of deficient subjects, categorized as high and low according to their WAIS intelligence (I.Q.) do not differ significantly in their EEG wave amplitude.

The amplitude of subjects in both groups was calculated in square centimeters and corrected for differences in amplification during recording of the EEG's. Then, a mean was computed for each group as the arithmetic average of the mean amplitudes of all the subjects in the group.

On testing the above hypothesis, the writer obtained means of 6.4 cm^2 and 7.9 cm^2 for the high and low I.Q. groups respectively. The difference between the two means was 1.5 cm^2 , and the critical ratio obtained was 1.44. This is not significant.

From the second main hypothesis arose two secondary hypotheses. These state that two groups of deficient subjects, categorized as high and low, in one case according to their WAIS Verbal scores and in the other according to their WAIS Performance scores, do not differ significantly in their EEG wave amplitude.

When the groups were divided according to their WAIS Verbal scores, group amplitude means of 7.1 cm^2 and 7.3 cm^2 were obtained for the high and low group respectively. The difference between the means was 0.2 cm^2 , and this data yielded a critical ratio of 0.17. This is negligible.

When the groups were divided according to their WAIS Performance scores, group amplitude means of 6.5 cm^2 and 7.9 cm^2 were obtained for the high and low group respectively. The difference between the means was 1.4 cm^2 , and a critical ratio of 1.29 was derived from this data. This is not significant.

Table V presents the data arising from this second group of hypotheses. It should be noted here, as in the first group of hypotheses, that the results of the second main hypothesis and its sub-hypotheses are directionally as expected, agreeing in this respect with Wyspianski's¹ results, although they are not statistically significant.

2. Discussion of Results.

None of the critical ratios worked out in this study showed significant differences to exist, and therefore it

¹ J.O. Wyspianski, "Brain Wave Amplitude and Creative Thinking", unpublished doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, viii-106 p.

Table V.-

Comparison of Two Groups of Mentally Deficient Subjects^a,
Divided into High and Low According to Their Test
Intelligence, in Terms of the Group Means^b for
EEG Wave Amplitude, Using the Critical Ratio
as Test of Significance for the Difference
Between Two Group Means.

Criterion for Grouping	High Group		Low Group		Diff.of Means	C.R.	Signif.
	N	M	N	M			
<u>WAIS</u> I.Q.	21	6.4	22	7.9	1.5	1.44	No
Verbal I.Q.	21	7.1	22	7.3	0.2	0.17	No.
Perf. I.Q.	22	6.5	21	7.9	1.4	1.29	No

a The subjects are forty-three cultural-familial patients from the Ontario Hospital School, Smiths' Falls, Ontario.

b EEG wave amplitude is measured in square centimeters.

becomes necessary to accept the six null hypotheses tested in the present study. This is done with caution, because statistically failure to find a significant difference does not prove that difference to be non-existent. Furthermore, in all cases the group that was higher on the intellectual variable had a lower wave amplitude but higher amplitude variability, which is the directional expectation stated in chapter one.

It is possible that failure to find significant differences in the present study may be partly due to the fact the subjects used in this study, having spent a considerable part of their lives in the common environment of a hospital, are not sensitive to the rather culturally loaded Verbal part of the WAIS. As a result of this, it is possible that intelligence differences among at least some of the subjects was obscured, and this may have lowered the results of the tests of significance. Unfortunately, the writer is not aware of any intelligence tests that have been validated on a population of deficient subjects similar to that found in Canadian institutions.

In consequence, the validity of any standard intelligence test on a sample of mentally deficient subjects remains doubtful. One possible solution to this problem which may be attempted in future research is to compare groups which differ very widely in intelligence, each group being relatively

homogeneous on this variable. In this way, even though the validity of the intelligence test be low, differences between the groups will be large enough that very little contamination of the EEG variable will occur.

In support for the idea that the WAIS Verbal items do not discriminate well among long-hospitalized mental deficient, it may be noted that the lowest critical ratios obtained in the present study were yielded by the division of subjects into high and low groups according to WAIS Verbal scores.

Another possible explanation for the failure to find significant differences in the present study may be that subjects classified as cultural-familial mental deficient, though they are considered as constituting simply the low end of the normal intelligence distribution, may in fact differ qualitatively from normal adults, so that the relationships between EEG variables and test intelligence which exist in normal adults may in fact not be present in a given sample of mental deficient.

In concluding this chapter, it seems fitting to make a few remarks on the directions which future research may profitably take in this general area. A very recent publication by Ertl² shows that he has now developed an

² J.P. Ertl, "Detection of Evoked Potentials by Zero Crossing Analysis", EEG and Clinical Neurophysiology, Vol. 18, 1965, p. 630-631.

objective technique for measuring evoked potentials. Using this technique, he has done a pilot study on the relationship between evoked potentials and intelligence, the results of which show that high psychometric intelligence may be associated with short delays in the later components of the evoked potentials. Due to the present success of Krtl's studies, and due to the fact that his technique can now be cross-validated, this seems a most promising field for future study of the relationship between EEG and intellectual functioning of mentally deficient subjects. It is probable that with sophisticated instrumentation, significant relationships will be found in spite of the need to use measures of intelligence which are not completely adequate.

As for the technique used in the present study for the analysis of EEG amplitude and amplitude variability, it is not without its possibilities, especially for studies which must rely on the study of records already in files, if the subjects are not directly available.

The writer wishes to conclude the present chapter with the following quotation which, he feels, is an accurate statement of future possibilities in this general area of research:

The hypothesis deserves further scrutiny that the EEG may be related to a physiological process underlying human intelligence.³

Research attempting to link intelligence and EEG has met with many failures. The present study illustrates some of the difficulties encountered in attempts to link together these two sets of variables when dealing with a restricted group of subjects. Yet, a sufficient number of experiments have obtained significant relationships between the two to warrant further investigation, especially as new, more sophisticated techniques are developed for the measurement of both EEG and intellectual variables.

³ W. Voguel and D.M. Broverman, "Relationship Between EEG and Test Intelligence: A Critical Review", Psychological Bulletin, Vol. 62, No. 2, 1964, p. 133.

SUMMARY AND CONCLUSIONS

The present study was an attempt to differentiate high and low intelligence groups of deficient subjects on the basis of their EEG wave amplitude and amplitude variability.

Two main hypotheses were tested experimentally. The first of these stated that when the experimental sample was divided into high and low intelligence groups, these would not differ significantly in their EEG wave amplitude. The second stated that when the experimental sample was divided as above, the resulting groups would not differ significantly in their EEG wave amplitude variability.

The critical ratio was used as statistical test of significance for the experimental hypotheses. The results were not statistically significant, and hence the experimental hypotheses were not rejected. It was noted, however, that the more intelligent subjects, as a group, had somewhat lower EEG mean amplitude and somewhat higher EEG wave amplitude variability.

BIBLIOGRAPHY

Ellingson, R.J., R.C. Wilcott, J.G. Sineps, and F.J. Dudek, "EEG Frequency Pattern Variation and Intelligence", EEG and Clinical Neurophysiology, Vol. 9, No. 4, 1957, p. 657-660.

This study, in correlating EEG frequency pattern variation with intelligence, demonstrates the need for linking EEG variables other than alpha waves to intelligence. The results were negative.

Ertl, J.P., "Intracortical Delay and Intelligence", unpublished Master's thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, 1961, viii-41 p.

A study relating the EEG variable of intracortical delay and intelligence, it obtained highly significant correlations, thereby showing the profits that can be derived from the investigation of previously unexplored EEG variables.

Knott, J.R., H. Friedman and R. Bardsley, "Some Electroencephalographic Correlates of Intelligence in Eight Year and Twelve Year Old Children", Journal of Experimental Psychology, Vol. 30, 1942, p. 380-391.

This study correlates the EEG variables alpha index and alpha frequency to standard measures of intelligence.

Kreaser, G.L., and F.W. Smith, "Brain Potentials in the Hereditary Type of Mental Deficiency", The Psychological Bulletin, Vol. 34, No. 6, 1937, p. 535-536.

This is the earliest study on the possible relationships of EEG and test intelligence on a sample of hereditary mental deficient. These early studies used very primitive apparatus, and studied only alpha waves.

-----, "The Relation of the Alpha Rhythm of the EEG and Intelligence Level in the Non-Differentiated Familial Type of Mental Deficiency", The Journal of Psychology, Vol. 29, 1950, p. 47-51.

This is an early attempt at correlating alpha index and alpha frequency with test intelligence.

Lindsley, D.B., "Psychological Phenomena and the EEG", EEG and Clinical Neurophysiology, Vol. 4, No. 4, 1952, p. 443-456

This paper attempts to show how neurophysiological and psychological phenomena may be related through time relationships. It also proposes reasons for the inadequacy of previous research efforts in this area.

Mundy-Castle, A.C., "Electrophysiological Correlates of Intelligence", Journal of Personality, Vol. 26, No. 2, 1958, p. 184-199.

This study, investigating as EEG variables alpha index and alpha frequency, found a small positive correlation between these and test intelligence.

Ketchine, S., I. Talan, G.C. Lairy, and R. Zazzo, "EEG et Niveau Mental", L'Annee Psychologique, Vol. 2, 1959, p. 355-372.

This study correlated several EEG variables with intelligence on a sample of thirty deficient subjects. Positive correlations of frequency scatter index with intelligence were found.

Shagass, C., "An Attempt to Correlate the Occipital Alpha Frequency of the EEG with Performance on a Test of Mental Ability", Journal of Experimental Psychology, Vol. 36, 1946, p. 88-92.

This study attempted to find a correlation between occipital alpha frequency and test intelligence on a sample of 1100 young adults. It shows the futility of continuing to study only the alpha rhythm by its failure to find significant results on so large a sample.

Voguel, W., and D.M. Broverman, "Relationship Between EEG and Test Intelligence: A Critical Review", Psychological Bulletin, Vol. 62, No. 2, 1964, p. 132-144.

This is the latest comprehensive review of studies attempting to link EEG variables and test intelligence. The authors conclude that further research in this area is still profitable. The article includes many references which are only of indirect interest to the present study.

Walter, W.G., The Living Brain, London, Duckworth, 1953, xi-216 p.

A popular text on the electronics of brain functioning. The author proposes, although giving little evidence, that the intelligent brain should show its versatility through greater frequency pattern variation. One of the hypotheses in the present study originates from this observation.

BIBLIOGRAPHY

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Wyspianski, J.O., "Brain Wave Amplitude and Creative Thinking", unpublished doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, 1963, viii-108 p.

This study found significant differences in the EEG wave amplitude of high, middle and low creativity groups, the differences being most pronounced in the occipital tracings. The present study chose amplitude as experimental variable based on this study, and one of its hypotheses is an extrapolation from this study.

APPENDIX 1

INTELLIGENCE DATA

APPENDIX 1

INTELLIGENCE DATA

<u>Subject</u> ¹	<u>Age</u>	<u>Verbal I.Q.</u>	<u>Performance I.Q.</u>	<u>WAIS I.Q.</u>
231	26	43	38	41
609	24	52	35	41
650	21	45	43	41
1842	16	49	39	43
2465	17	47	39	45
1537	22	51	42	44
1334	27	48	52	47
867	20	51	48	47
1815	19	46	55	47
1551	22	54	50	49
145	25	50	55	49
3589	16	53	49	49
580	18	50	56	50
2592	17	60	45	51
1319	16	58	49	52
1944	16	58	54	54
3295	16	68	44	55
3895	16	66	51	57
3294	16	65	52	57
808	20	55	65	57
831	16	62	63	60
2092	17	58	70	61
3791	16	60	68	61
3986	17	58	70	61
3685	17	66	61	62
2120	16	62	68	62
1674	22	66	61	62
3993	16	64	70	65
1944	16	67	70	66
1976	18	64	77	69
4087	16	67	77	69
3153	20	70	77	71
1239	16	69	77	71
3117	17	59	91	71
2523	17	71	78	72

¹ File number at the Ontario Hospital School, Smiths' Falls, Ontario.

APPENDIX 1

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<u>Subject</u>	<u>Age</u>	<u>Verbal I.Q.</u>	<u>Performance I.Q.</u>	<u>WAIS I.Q.</u>
1544	16	65	86	72
858	21	63	87	72
3165	17	75	78	75
3305	17	71	69	77
1291	18	74	85	78
3481	19	71	92	79
1791	16	72	92	80
3384	16	78	89	81

APPENDIX 2

EEG DATA

APPENDIX 2

EEG DATA

<u>Subject</u> ¹	<u>Mean Amplitude</u> ²	<u>Amplitude Variability</u> ³
231	6.1	20
609	3.9	13
650	6.2	11
1842	7.4	10
2465	17.2	18
1537	9.6	10
1334	12.7	16
867	3.1	13
1815	7.0	17
1551	9.6	14
145	6.3	18
3589	6.5	19
580	5.0	16
2592	8.2	27
1319	7.4	16
1944	5.5	12
3295	8.3	17
3895	3.4	16
3294	19.4	19
808	9.4	19
831	4.0	16
2092	6.5	15
3791	8.1	20
3986	5.5	26
3685	8.3	16
2120	8.6	21
1674	4.7	19
3993	3.3	11
1944	5.8	18
1976	5.0	37

1 File Number at the Ontario Hospital School, Smiths' Falls, Ontario. Subjects in same order as in Appendix 1.

2 Mean amplitude measured in square centimeters.

3 Variability measured as a coefficient of variation.

<u>Subject</u>	<u>Mean Amplitude</u>	<u>Amplitude Variability</u>
4087	14.4	17
3153	4.4	11
1239	11.5	26
3117	5.5	17
2523	5.9	30
1544	5.4	14
858	2.6	14
3165	4.2	12
3305	5.5	22
1291	5.3	6
3481	9.4	18
1791	7.2	22
3384	5.6	13

APPENDIX 3

ABSTRACT OF

EEG and WAIS Intelligence in a Sample of
Cultural-Familial Mental Deficients

APPENDIX 3

ABSTRACT OF

EEG And WAIS Intelligence in a Sample of Cultural-Familial Mental Deficients¹

This is an investigation based on recent findings that groups which differ on creativity test scores can be differentiated in terms of their EEG wave amplitude. On the assumption that tests of creativity and tests of intelligence yield highly correlated measures of intellectual functioning, it was the purpose of the present study to see whether the main finding of the above-mentioned study would also be found on a group of mentally deficient subjects, subdivided according to intelligence scores. In addition, the present study introduced a measure of EEG wave amplitude variability.

Thus, it was the purpose of the present study to look for differences in EEG wave amplitude and amplitude variability on high and low groups of cultural-familial mental deficients, grouped according to their scores on the Wechsler Adult Intelligence Scale. Wave amplitude was measured as area with a compensating polar planimeter. Amplitude variability was calculated as a coefficient of variation.

¹ H.P. Edwards, Master's thesis presented to the Faculty of Psychology and Education of the University of Ottawa, Ontario, 1965, vii-47 p.

Two groups of hypotheses were tested using the critical ratio as statistical test of significance. The first group stated that if the subjects were divided into high and low intelligence groups, these groups would not differ significantly in their EEG wave amplitude. The second group stated that if the subjects were similarly divided, the subject groups thus formed would not differ significantly in their EEG wave amplitude variability. The data obtained in the present investigation was not statistically significant, and therefore the experimental hypotheses were not rejected.

