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EEG BRAIN WAVES AND CREATIVE THINKING

by John O. Wyspianski

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CURRICULUM STUDIORUM

John O. Wyspianski was born February 15, 1929, in Grudziadz, Poland. He received the Bachelor of Arts degree from the University of Ottawa in 1958. He received the Master of Arts degree in Psychology from the University of Ottawa in 1961. The title of his thesis was Validating a French Cattell 16 P.F. with Peer Ratings of Adolescents.

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INTRODUCTION

The mystery of electrical brain waves measureable by intricate amplifying systems has for long puzzled both neurologists and psychologists alike. The neurologist sought and continued to search for the origins and the possible neurophysiological concomitants of this phenomenon, while the psychologist saw the promise of a possible answer to the neurological basis of the functioning of the intellect. The discernible variables of these strange electrical patterns were quickly isolated and used as possible comparisons to the currently available tests of intellectual functioning. The psychologist's enthusiasm did not last long. The failure of nearly two decades of sporadic, largely unsuccessful investigations brought discouragement and eventual disinterest, seen in the sparcity of publications in this area of research. In reviewing the literature on this topic, it became apparent to this investigator that two major considerations have seemingly been left unnoticed. One the one hand the possible change from unsuccessfully used electroencephalographic variables to new ones, and on the other, the use of new measures purporting to tap various functions of the intellect such as divergent forms of creative thinking.

The neurologists have not given up their search and while doing so even had time to meditate and formulate consequent hypotheses concerning electrical activity emanating from the brain and related thought processes. This study owes its existence to the tireless efforts of neurologists attempting to untangle the mystery of the brain and their psychologist colleagues seeking the answer to the problem of the functioning of the intellect.

The first chapter of this thesis presents the review of the literature. Studies relating electroencephalographic variables to intelligence are first reported. This is followed by the review of tests of creativity. The conclusion of this chapter presents the hypotheses of the investigation.

The criteria for the selection of the tools and the tools used in this study are presented in chapter two. First, the psychometric tests are dealt with, to be followed by the presentation of the neurological measures of brain activity.

The third chapter presents the description of the experimental design, the population, the use of the tools, techniques employed, and finally, the statistical methods utilized in the analysis of the data.

Chapter four contains the presentation of the results and their interpretation. Suggestions for further research are found in the conclusion of this last chapter.

CHAPTER I

REVIEW OF THE LITERATURE

Investigations related to electroencephalographic measures of cerebral functioning and creative thinking are, to this date, not reported in research literature. Since this study concerns itself with creativity and possible relationships in the amplitude states and spread of electrical potentials in the cerebral hemispheres, only those studies will be reviewed which bear a meaningful relationship to this investigation. Thus, this review will consist of three sections. The first section will deal with studies relating findings in the field of neurology and electroencephalography, to be referred to hereafter as the EEG, the second with measures of creativity, and the third section will present the summary and the hypotheses.

1. Neurology and EEG.

The initial catalyst of this investigation was Eccles'[1] speculation concerning that activity of the brain which underlies the creative process. Eccles hypothesizes that creativity in the human individual is a function of

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1 J.C. Eccles, "The Physiology of Imagination", Scientific American, Vol. 199, No. 3, September, 1958, p. 135-146.

the probabilistic spread of field fronts within the cerebral cortex. Thus, the more creative the individual the more extensive is the spread of field fronts in the cerebral cortex.

In order to test Eccles'[2] hypothesis it was necessary to determine if a stimulus could be propagated and detected beyond the normal cerebral receptor. Findings of electrical activity beyond the common receptor fields in the cerebral cortex are not new. A decade ago, Torres,[3] investigating possible existing relationships between visual and auditory stimuli, found that responses observable on the EEG record spread beyond the usual receptor centres.

Walter,[4] writing on the electrical activity of the human brain, says:

> (...) flashes appeared to be breaking down some of the physiological barriers between different regions of the brain. This meant that the stimulus of the flicker received in the visual projection area of the cortex was breaking bounds; its ripples were overflowing into other areas (...) strange patterns, new and significant emerged.

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2 Eccles, Op. Cit., p. 135-146.

3 F. Torres and C. Marshall, "Reciprocal Influence of Central Responses to Visual and Auditory Stimulation in Man", EEG and Clinical Neurophysiology, Supplement No. 3, 1953, p. 72.

4 W. Gray Walter, The Living Brain, Harmondsworth, Penguin, 1961, p. 87.

Ertl,[5] investigating means for further insight into the electro-physiological basis of intelligence, introduced and measured successfully intracortical delay and propagation supporting the feasibility of measurement of spread of potentials resultant from a single stimulus. His study covered the occipital and the motor cortex areas. Ertl's study revealed a highly significant relationship between the phenomenon of intracortical delay and intelligence as measured by the Wechsler Intelligence Scale. The Pearson r was found to be .88. The subjective measurement technique employed, however, presents serious obstacles to cross-validation.

The meaning of this observable spread remains a mystery to both the neurophysiologist and the psychologist. At best, both attempt to put forth hypotheses concerning this phenomenon and continue its exploration.

Psychophysiological research in the domain of electroneurology has been limited to two areas. Firstly, reaction time studies, and secondly, in lesser volume perhaps, the exploration of possible existing relationships between human intelligence and two measurable EEG variables.

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

The most popular variables to this date have been the alpha index and alpha frequency. The former is simply the per cent of time during which a tracing is showing the presence of the alpha rhythm.

Intelligence and creative thinking have often been linked as closely related; in fact, empirically observed creative thinking exhibits intelligent behavior. Guilford's[6] multidimensional model of the intellect includes creative abilities in several of its dimensions, therefore the present review will include the studies reporting results found in search of relationships between EEG variables and intelligence.

Walter,[7] studying EEG frequency pattern variation and intelligence, suggests possible positive relationships. He reports that his intelligent or more "brilliant" subjects exhibited a tendency toward a greater pattern variability. This is in agreement with Eccles' and Sherrington's concept that brains with more numerous and variable scanning rhythms are more versatile.

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6 J.P. Guilford and P.R. Merrifield, "The Structure of Intellect Model: Its Uses and Implications", Report from the Psychological Laboratory, The University of Southern California, No. 24, April, 1960, p. 1-27.

7 Walter, Op. Cit., p. 87.

Ellingson[8] attempted to test experimentally Walter's empirical observations by way of frequency pattern variation analysis. His sample was made up of twenty-six psychiatric aides and a high grade mentally deficient Subject. Intelligence was measured by way of a short form of the Wechsler-Bellvue Intelligence Scale. Rank order correlations between I.Q. and EEG frequency pattern variations for four areas of the brain were not statistically significant.

Relationships between mental age, alpha frequency and alpha index were investigated by Knott et. al.[9] The sample consisted of forty-eight eight-year old children and 42 twelve-year old children. The highest correlation was found to be .5 between mental age and alpha frequency in the eight-year old group. The authors claimed that the organic changes associated with adolescence in the twelve-year old group may have altered the otherwise significant relationship between mental age and alpha frequency.

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

9 J.R. Knott, H. Friedman, and R. Bardsley, "Some EEG Correlates of Intelligence in Eight-Year and Twelve-Year Old Children", Journal of Experimental Psychology, Vol. 39, 1950, p. 47-51.

A study conducted by Kreezer[10] on forty-six non-differentiated familial type mental deficients of adult age yielded a correlation of .32 between mental age and alpha frequency. No significant correlation was found between mental age and alpha index.

Shagass,[11] in an extensive study, tested 1100 air-crew candidates via the RCAF Classification Test, a group test of mental ability, and found no significant relationship using the variable of alpha frequency.

Somewhat more encouraging results were found by Mundy-Castle[12] using both the alpha index and alpha frequency as the EEG variables. Testing a group of thirty-four subjects, he found significant correlations between alpha index and verbal I.Q. (0.33), alpha frequency and verbal I.Q. (0.42), and practical I.Q. (0.40), and general I.Q. (0.50). Intelligence was measured via the South African version of the Wechsler-Bellvue. The author proposed the following

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10 G.L. Kreezer and F.W. Smith, "The Relation 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.

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

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

to account for the apparent disparity of the findings: the sample was highly selected, I.Q.'s ranged from 118 to 135, and in a homogenous group non-intellective factors tapped by the Wechsler-Bellvue will serve to reveal their underlying electrophysiological correlates, whereas in a less homogenous group such relationships would be obscured by the greater variance contributed by the non-intellective factors.

Netchine[13] and his associates correlated a combination of several EEG variables with intelligence. The EEG variables were alpha index, frequency scatter index, spacial organization and amplitude. Only two correlations were found by the author to be significant. Verbal I.Q. and frequency scatter index (0.37), and performance I.Q. and frequency scatter index (0.49). Ertl,[14] in reviewing this study, however, found some statistical errors, therefore caution should be exercised in interpreting these results as significant.

Shagass[15] recently reported promising results of initial experiments with a new psychophysiological method

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

14 Ertl, Op. Cit., p. 5.

15 C. Shagass and Marvin Schwartz, "Evoked Potentials and Sensation in Man", Journal of Neuropsychiatry, Vol. 2, No. 5, June, 1961, p. 262-270.

measuring cortical potentials evoked by sensory stimulation. Since this initial phase is only the beginning of a larger study no measures of intelligence were used. Using a photic stimulator and an electrocutaneous stimulating apparatus, Shagass established that both the photic and the electrocutaneous stimulation consists of a relatively constant initial response of brief duration and length, followed by several waves of variable amplitude which may continue for relatively long periods. These secondary amplitude waves seem to be influenced by psychological factors.

The studies reported above, with the exception of the last one, sound a discouraging note. Perhaps because of a lack of highly significant findings, the research in this area has diminished to purely neurological experimentation. It seems that the researchers have given up too quickly, forgetting that the I.Q. is but a small measurable dimension of the human personality and other areas beg to be investigated further. This neurophysiological method still holds many secrets and remains of considerable value in psychophysiological experimentation. Shagass,[16] one of the most outstanding men in the field of neurophysiology has this to say:

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16 Shagass, Op. Cit., p. 269.

> The ability to measure cortical responses in a subject who is able to report his thoughts and feelings offers exciting possibilities (...) one thinks of attempting to find behavioral correlates for individual differences in the characteristics of evoked potentials.

2. Measures of Creativity.

The scope of this section will be the review of past and present available measures of creativity used with adults.

Many different kinds of tasks have been used in attempts to obtain measures of creative thinking abilities. Two of the earliest and most recurrent types of tasks are analogies tasks and projective devices such as ink blots. Ribot[17] and Spearman[18] stated their theoretical foundations for the analogy concept. Both of these authors considered analogy an almost inexhaustible instrument of creation and the essential fundamental element of creative imagination in the intellectual sphere. Although this concept of creative thinking and this type of task has received less attention in recent years, recognition of analogies is still regarded by some students of creativity as an important form

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17 T. Ribot, Essay on the Creative Imagination, Chicago, Open Court Co., 1906, p. xix-390.

18 C. Spearman, Creative Mind, London, Nisbet and Co., 1930, xiv-153 p.

of creative thinking.[19] Bourchard[20] presented a survey of projective techniques, psychoanalytically oriented, presumed to provide indications of creativity.

Dearborn[21] was one of the earliest users of ink blots as a test of imagination or creative thinking. His technique was simple and uninvolved. A drop of ink was pressed between two pages of paper and the subjects had to create from the presented ink spot. The score was the number of items created.

Chassell[22] designed twelve tasks to measure the factor of originality. The tasks mostly measured novel approaches to familiar situations.

An interesting task was developed by Simpson[23] to measure creative imagination. The test was made up of fifty sets of four dots. To each set of four dots the subject was

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19 H.H. Anderson, (Ed.), Creativity and Its Cultivation, New York, Harpers, 1959, xiii-293 p.

20 E.M.L. Bourchard, "The Use of Projective Techniques in the Analysis of Creativity", Journal of Projective Techniques, Vol. 16, No. 4, December, 1952, p. 412-427.

21 G.V. Dearborn, "A Study of Imaginations", American Journal of Psychology, Vol. 9, No. 2, January, 1898, p. 183-190.

22 L.M. Chassell, "Tests for Originality", Journal of Educational Psychology, Vol. 7, No. 6, June, 1916, p. 317-329.

23 R.M. Simpson, "Creative Imagination", American Journal of Psychology, Vol. 33, No. 2, April, 1922, p. 234-243.

to add two dots to construct pictures. The scoring emphasis was placed on creative changes.

Hargraves[24] attempted to measure imagination, fluency, and originality by way of a battery made up of twelve tests. Originally they were designed to test whether imagination, fluency, and originality could be isolated from Spearman's "G" factor. No signs of a unitary and unique imaginary power were found.

McCloy and Meyer[25] attempted to study the creative process apart from technical skill and other complicating factors. They have designed a Creative Composition Apparatus where the subject had to manipulate colors and movable accessories involving the play of colored light upon clay forms and the introduction of colored background. Significant differences were found between the mean performance scores of students and established artists.

Welch[26] sought the assessment of creativity through the seeing of new combinations. His tasks include: Block

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24 H.L. Hargraves, "The Faculty of Imagination", British Journal of Psychology, Monograph Supplement, Vol. 10, 1927, p. 74.

25 W. McCloy and N.E. Meier, "Creative Imagination in Children and Adults", Psychological Monographs, Vol. 51, No. 5, 1939, p. 88-116.

26 L. Welch, "Recombination of Ideas in Creative Thinking", Journal of Applied Psychology, Vol. 30, No. 6, 1946, p. 638-643.

Construction, where the subject is to make up household furniture out of ten blocks; Sentence Construction, where the subject is asked to make sentences out of ten words; Letter Construction, making words out of letters; and finally, Short Story Construction.

Berg[27] attempted to measure flexibility by means of a test made up of sixty cards each containing one to four identical figures of a single color, four kinds of figures and four colors. The subjects were required to make varieties of arrangements in the various categories.

The measurement of creativity in machine design was attempted by Owen[28] and his associates. The authors developed a series of manipulative mechanical tasks to assess creativity in this area.

Springbett[29] and his associates designed the Difficult Lines Test, assuming that creative thinking differs from problem solving only because it involves a greater sensitivity to unconscious processes. Significant

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27 E.A. Berg, "A Simple Objective Technique for Measuring Flexibility in Thinking", Journal of General Psychology, Vol. 39, First Half, July, 1948, p. 15-22.

28 W.A. Owen, "The Measurement of Creativity in Machine Design", Journal of Applied Psychology, Vol. 41, No. 5, 1957, p. 297-302.

29 B.M. Springbett, J.G. Dark, and J. Clarke, "An Approach to the Measurement of Creative Thinking", Canadian Journal of Psychology, Vol. 11, No. 1, 1957, p. 9-20.

correlations have been obtained with tests of reasoning and intelligence.

A test of creativity in engineering was developed by Harris.[30] The test consists of two forms of twenty items and yields scores of fluency, flexibility and originality. Investigations were conducted to establish validity, reliability, interscorer agreement, relationships with other tests and face validity.

Since Guilford[31] and his associates have developed the most comprehensive tasks for measuring the creative thinking abilities in adults, theirs will be treated at a relatively greater length.

It appears from the literature available that Guilford,[32] ever since his American Psychological Association presidential address, has continued to modify his conceptualization of the creative thinking abilities and the tasks used to assess them. In a recent monograph[33] his current intellect model and modifications are summarized. Earlier, Guilford had considered the thinking abilities

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30 D. Harris, "The Development and Validation of a Test of Creativity in Engineering", Journal of Applied Psychology, Vol. 44, No. 4, August, 1960, p. 257-260.

31 Guilford and Merrifield, Op. Cit., p. 1-27.

32 J.P. Guilford, "Creativity", American Psychologist, Vol. 5, No. 9, 1950, p. 444-454.

33 Guilford and Merrifield, Op. Cit., p. 1-27.

involved in creativity to be those which he had defined as "divergent productions and transformations". He now includes the redefinition abilities which are in the convergent production category of his structure of intellect and sensitivity to problems which fall in the evaluation category. His tasks designed by means of factor analysis to measure various dimensions of creativity are the most exhaustive of all presently found available. Their variety permits the selection of those which tap different functions of creativity, and the users may choose those which will measure the function in which they are interested. The most important asset of the tests developed by Guilford lies in their theoretically established bases and the careful studies which gave them existence. A more elaborate discussion of these tests and criteria for their selection will be presented in Chapter Two, dealing with research tools.

3. Summary and the Hypotheses.

It was stated that to this date studies have not been reported dealing with EEG variables and creativity. Intelligence has often been linked with creativity and variables in creative thinking have been included in structures of the intellect, therefore studies relating a number of EEG variables to intelligence have been reviewed. It

was noted that no significant correlations between EEG variables examined and intelligence was reported in any study dealing with a sample of adults with the exception of Ertl's[34] study in which nigh correlations were found, however through a subjective measuring technique which presents serious obstacles to cross validation. It was stressed that the large number of operations necessary in the currently used intelligence tests may have introduced too many variables for adequate differentiation. A proposal was made to reduce the variables to some of those measured in creativity.

The past and present tasks in the measurement of creativity thinking in adults have been reviewed. It was stressed that studies other than Guilford's have not used the factor analytic techniques to arrive at creativity variables and have not been as extensive.

The theoretical background is partly based on Eccles'[35] assumptions regarding the functioning of the brain in creative thinking. Creativity in the human individual is a function of probabilistic field fronts within the cerebral cortex. It is therefore assumed that in the creative individual the spread will be wider and more areas of

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34 Ertl, Op. Cit., 111-41 p.

35 Eccles, Op. Cit., p. 135-146.

the cerebrum will be involved by cellular electrical activity at rest and resultant from a stimulus.

The general hypothesis is stated in the null form. There are no significant relationships between creativity and spread of field fronts in the cerebral cortex. The following additional hypotheses were formulated for testing.

There are no significant differences in EEG amplitudes among groups of individuals classified as low, middle, and high scorers on tests of creativity, in any one of the cerebral cortex areas.

There are no significant differences in EEG amplitudes, among groups of individuals classified as low, middle, and high scorers on tests of creativity, in any one of the cerebral cortex areas that would be an effect of photic stimulation.

There are no significant differences in the mean amplitudes between the resting and photically stimulated phases, for groups of individuals classified as low, middle, and high scorers on tests of creativity.

Chapter Two will present the tools used in this investigation, both psychometric and neurophysiological.

CHAPTER II

TOOLS OF RESEARCH

This chapter will present the tools utilized in this study, both psychometric and neurophysiological. The presentation will consist of the general description of Guilford's intellect model and the positions which creative thinking abilities occupy in it. This will be followed by a brief description of the Guilford tests designed to tap creative thinking abilities and, finally, the criteria used for the tests chosen in this study. The description of the EEG instrumentation will follow and conclude this chapter.

1. Guilford's Intellect Model and Creative Abilities.

Guilford's[1] major objective since 1950 has been the exploration of all aspects of intelligence. His study led to the formulation of a theoretical model for the complete structure of intellect. Investigations in the areas of creative abilities, reasoning, evaluation, planning, and problem solving have led to the formulation of this model. In order to better understand the meaning of creative

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1 J.P. Guilford and P.R. Merrifield, "The Structure of Intellect Model: Its Uses and Implications", Report from the Psychological Laboratory, The University of Southern California, No. 24, April, 1960, p. 1-27.

abilities it will be necessary to discuss briefly the hypothesized structure of intellect.

Intellectual abilities as found by factor analysis have been grouped into three major dimensions. First, in terms of Operations required in the performance of the act. In this dimension, five fundamental kinds of operations have been isolated:

1. Cognition, the operation of discovery, rediscovery, or recognition;
2. Memory, which is the operation of retention of what has been cognized;
3. Divergent (thinking) production, the operation which generates new information from known and remembered information, i.e. thinking in different directions in search of variety;
4. Convergent (thinking) production, the operation where the information leads to one right answer, or to a recognized conventional answer; and,
5. Evaluation, the operation where decisions are reached as to the correctness, suitability or adequacy of what is known, remembered and produced.

The second dimension classifies intellectual factors according to the kind of Content involved. The factors isolated in this category number four:

1. Figural Content, concrete material with all the properties of material objects;
2. Symbolic Content, composed of conventional signs such as letters and digits;
3. Sematic Content, in the form of verbal meanings or ideas; and,
4. Behavioral Content which is non-verbal, of the kind involved in human interactions.

The third and final dimension is that of Products. This means that when a certain kind of Operation is applied to a certain kind of Content, Products are obtained. There are six general kinds of Products. The kinds of products are:

1. Units which are concrete items of information;
2. Classes, which are grouped items of information according to common properties;
3. Relations which are units of information with recognized connections;
4. Systems are structured aggregates of items of information;
5. Transformations are changes in the use of known information; and,
6. Implications are "extrapolations of information, in

the form of expectancies, predictions, antecedents, and consequences".[2]

Guilford's classifications of intellectual abilities are combined and represent a unified theory of intelligence that can be represented in a cubical model. In this model, each mode of classification described above becomes a parameter or dimension of the model. Every kind of Content can be combined with every kind of Operation and each one of these combinations can be combined with every kind of Product.

The creative abilities of fluency and flexibility come from the category of Divergent (thinking) Production. Thus, to drew an example for better illustration of the model, ideational fluency is interpreted as the ability to produce divergently a number of meaningful semantic units, i.e., ideas. Flexibility, on the other hand, is interpreted as the divergent production of classes.

Guilford and his collaborators have developed tests, many of which are still in their experimental forms, to tap each specific Operation of the intellect model, i.e., Cognition, Memory, Divergent Production, Convergent Production, and Evaluation. Tests of Operations known to be unrelated to Creative Thinking will not be dealt with in

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2 Guilford and Merrifield, Op. Cit., p. 5.

this presentation. Convergent Production, though recognized as a contributing factor to Creative thinking as a whole, will not be elaborated upon here for the major interest in this study is divergence of thought rather than spontaneous convergence. Tests of Divergent (thinking) Production will now be reviewed and their positions in the intellect model stated. Tests in experimental forms and unavailable for use will not be elaborated upon.

To this date there are nine combinations of approaches to tap Divergent Production:

1. Figural Spontaneous Flexibility is divergent thinking about figural material resulting in a classification;
2. Figural Adaptive Flexibility is divergent thinking about figural or structured material resulting in transformations;
3. Word Fluency is divergent thinking about symbolic material resulting in unification;
4. Ideational Fluency is divergent thinking about semantic material resulting in unification;
5. Semantic Spontaneous Flexibility is divergent thinking about semantic material resulting in classification;
6. Associational Fluency is divergent thinking about semantic material resulting in relationships;

7. Originality is divergent thinking about semantic materials resulting in transformations;
8. Semantic Elaboration is divergent thinking about semantic materials resulting in implications; and,
9. Expressional Fluency is divergent thinking about symbolic material resulting in systems of structured aggregates of information.

2. Tests of Creativity.

Of the tests mentioned above, five have been chosen for use in this study. The reason for their selection was, first of all, their reported quality to tap divergence of thought and, secondly, their availability. A brief description of each selected test will now be given.

The test of Word Fluency taps the individual's ability to think of words rapidly, each word satisfying the same letter requirement, such as containing a stated letter. The task is made up of two parts with a time limit of two minutes per part. The score is the total number of responses satisfying the requirements. The alternate form coefficient of reliability obtained on a sample of 219 naval air cadets and naval officer candidates is reported to be .75.[3]

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3 P.R. Christensen and J.P. Guilford, Manual for the Christensen-Guilford Fluency Tests, Beverly Hills, California, Sheridan Supply Co., 1959, p. 7.

Ideational Fluency is a test which requires the subject to list rapidly ideas to meet meaningful requirements. The test is composed of four parts with a time limit of three minutes per part. The score is the total number of acceptable responses. The alternate form coefficient of reliability obtained on a sample of 219 naval air cadets and naval officer candidates is reported to be .76.[4]

Associational Fluency is a test requiring the individual to list words that bear some relation to a given word. The score is the number of acceptable responses. Alternate form coefficient of reliability obtained on a sample of 240 naval air cadets and naval officer candidates is reported to be .63.[5]

Expressional Fluency is a test requiring the individual to make four word sentences given the same four initial letters of the words to be used in all responses. The total score is the number of four word complete sentences containing the specified initial letters. The coefficient of reliability for this test has not been reported by the authors.

Alternate Uses is a test which requires the Subject to list uncommon, or less common uses of a given object

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4 Christensen and Guilford, Op. Cit., p. 7.

5 Ibid., p. 7.

whose common use is stated. There are three parts to the test with three items per part. The time limit is four minutes per part. The score is the total number of acceptable responses. Reliability estimates in "samples of young adults" with above average I.Q.'s range from .68 to .85. The N of the population is not stated.[6]

To facilitate communication concerning the tests described, the reader is referred to Appendices 1, 2, 3, 4, and 5, which represent samples of each test used in this investigation.

From the foregoing examination of the tests of Divergent Thinking it can be concluded, with some assurance, that they differ from the currently popular I.Q. tests. It appears that I.Q. tests are very much confined to cognitive categories and concentrate on a very few factors in the structure of the intellect. Usually they do not include items tapping divergent thinking or transformations. This is the reason why it is believed that former attempts to find relationships between I.Q. and biological measures of cerebral behavior have failed.

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6 R.C. Wilson, P.R. Christensen, P.R. Merrifield, and J.P. Guilford, Alternate Uses, Manual of Administration, Scoring, and Interpretation, Beverly Hills, California, Sheridan Supply Co., 1960, p. 2.

3. Electro-Neurological Measures.

The instrumentation employed in this study, to stimulate, monitor, and record cerebral activity will now be described.

EEG records were obtained from a Type 150, Transistorized, eight channel Offner system. Seven of the eight channels were employed to monitor cerebral activity and the eighth channel served as a marking device for the photic stimulus flashes.

The photic stimulator was a Model PS 3 Grass System, set at single exposures. The photic stimulator was connected to the eighth channel of the EEG by way of a photo cell to trigger off the marking mechanism.

Electrodes were of the Edison-Swan[7] type, made up of a short silver tube capped by a small pad which was in direct contact with the scalp.

The recording room was copper shielded in order to eliminate outside electrical interference.

The following chapter will describe the experimental design of this investigation.

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7 R.K. Hughes, Introduction to Clinical Electroencephalography, Bristol, G.B., John Wright and Sons, 1961, p. 3.

CHAPTER III

EXPERIMENTAL DESIGN

The purpose of this chapter is to present the methods followed in order to test the hypothesis as stated in the first chapter. Thus, this chapter will be divided into sections specifically dealing with the population used in this study, the experimental procedures followed, the analysis of EEG amplitude potentials, and the statistical analysis of the obtained data.

1. The Population.

The selection of Subjects for this study was based on three criteria. Firstly, the primacy of the English language; secondly, the minimum age of eighteen; and, thirdly, male subjects. The necessity for the English language was determined by the creativity tests which presuppose native facility with the English language. The minimum age requirement was necessary to preclude possible EEG pattern changes attributable to maturation level which occur up to the age of sixteen. Women were excluded from this study because of the possible electrical distortions which can be brought about by the variety of lotions used on the hair containing mineral elements which could have distorted the recording of cerebral discharges. An additional factor

for selection was the ability to relax in the recording situation, in order to minimize electromyographic activity.

Thus, with the above criteria thirty subjects were chosen. All were unpaid volunteer undergraduate and graduate students of the University of Ottawa, in apparently normal health. Their ages ranged from eighteen to forty-two years with a mean age of 26.6.

2. Experimental Procedure.

In order to obtain the data for this study, two testing sessions were necessary: the EEG recording session and the administration of the creativity tests. These sessions will now be discussed in that order.

Facilities for EEG recordings were made available by the National Defence Tri-Service Hospital in Ottawa. The apparatus was described in Chapter Two. The apparatus to record cerebral activity was operated by a licensed EEG technician.

Recording sessions were conducted on three consecutive Saturday afternoons. The Subjects were told, several days in advance of the proposed recording date, to refrain from consumption of any alcoholic beverages twenty-four hours prior to recording. Before preparation for recording the Subjects were instructed that this part of the investigation dealt with the recording of the electrical activity in the cerebral cortex and that no painful stimuli were to be expected.

electrodes. The eyes were kept closed for a partial reduction of eye blinks.

The location and the numbering of the recording sites were as follows: Channel I Prefrontal, Channel II Frontal, Channel III Parietal, Channel IV Occipital, Channel V Anterior Temporal, Channel VI Temporal, and Channel VII Posterior Temporal. The unilateral method of recording was used, the recording side being determined by the individual's handedness.

The photic stimulator was set at a distance of thirty-eight inches from the head of the Subject, adjusted to eye level. The selection of this distance and position was prompted by the experimenter's tests carried on prior to this investigation in attempting to eliminate electromyographic activity distorting EEG records resultant from common eye blinks. The stimulator was set at single exposures.

The EEG instrument was situated outside of the shielded room where the subject was seated. The instrument was set to record at a time constant of .3 seconds, master gain setting of 5/9. The filter was on to eliminate noise, and the micro volt setting was at 50 with a pen deflection of 11.5 mm. The paper speed was set at 12 cm. per second.

For the purpose of this study the monopolar or reference technique of EEG recording was chosen. The

reference electrode was of the same kind and treated in the same manner as those described above. The ear lobe was chosen to act as the constant. Tests carried out prior to this study by the same experimenter showed that the lobe of the ear was inactive with respect to responses evoked by visual stimulation and yet was sufficiently proximal to the scalp to minimize the interference of other electrical activity.

The total recording time consisted of approximately three minutes duration. The first recording was obtained of the Subject's cerebral activity during a resting state. This period lasting one and one half minutes; then reactions to forty photic stimulations exposed at random during a period of one and one half minutes were recorded. With this the EEG recording was ended.

The analysis of the EEG data obtained as described will be presented in the section of this chapter dealing specifically with the analysis of data, both EEG and creativity.

The creativity tests described in Chapter Two were administered and scored only after the analysis of the EEG data was completed.

The five tests of creativity were administered in one group session on a Saturday afternoon. The place of testing was a large classroom in the School of Psychology

and Education of the University of Ottawa. Subjects were comfortably seated sufficiently distant from each other to prevent copying. Before the testing began, the group was told that this was the second part of the study in which they had volunteered to participate. The testing session followed. Before each test, the instructions were read aloud by the writer and the subjects read silently. The testing session lasted approximately one hour. The instructions for each of the five creativity tests can be read in Appendices 1, 2, 3, 4, and 5.

3. Analysis of the EEG Amplitude Variable.

For the purpose of EEG analysis in this study the amplitude variable was chosen. The choice was made with one purpose in mind, that is, to monitor and record cerebral output at rest and subsequently in a stimulated state. Each EEG record consisted of approximately twenty-two meters of standard EEG paper occupied by eight red ink traces of which the top seven represented cerebral electrical activity and the eighth served as a marking device to indicate the instant place of the photic stimulus exposure.

A wave amplitude analysis was performed on each of the seven channels for both the resting and the stimulated phases. Attempts to use a polar decompensating metric planimeter to measure amplitude have proven that the human

error in the tracing of small areas is too great for acceptance of its results. It was thus decided to use a different technique which would yield more reliable results.

To obtain indirect measures of wave amplitude, transparent acetate sheets of constant weight of .003 inch thickness were used. The constancy of weight for this study was determined by cutting out one hundred, one square centimeter pieces of acetate from the sheets to be used in this study and weighing each individual piece separately on a Mettler Grammatic Balance. Deviations in weight were found to be in the fourth decimal. The constancy of acetate weight was accepted.

For each Subject, twenty amplitude samples were obtained of one second duration for each channel during resting and stimulated phases. Thus each sample represented one second of cerebral activity recorded from a given area of the scalp.

A one second sample consisted of a twelve centimeter EEG paper length occupied by an electrical wave trace. The wave trace to be measured was marked off by two parallel vertical lines with a twelve centimeter displacement. The peaks of this wave trace were joined by straight lines thus forming an enclosed delineated area. Geometrically the shape resembled a rhomboid of twelve centimeter length. In the measurement of amplitude in the stimulated phase the

first vertical line was drawn at the point of stimulus as indicated by the stimulus marking spike of Channel VIII.

The delineated area on the EEG paper was then covered with an acetate sheet and the delineating line was traced with a Bard-Parker number 11 surgical scalpel applying slight pressure. The result of this operation was a separated piece of acetate having the same area as the delineated area on the EEG paper. The weight of this one piece of acetate as weighed on a Nettler Grammatic Balance represented an indirect measure of amplitude of a wave trace of one second duration.

This operation was repeated 280 times for each individual record, that is 20 samples of resting, and 20 samples of stimulated cerebral output, for seven channels were obtained.

The final amplitude score for a given channel at a resting or stimulated phase was the sum weight of the twenty samples for that phase by the above described method. Thus, each Subject had a total of fourteen scores for EEG amplitude. Each one of the seven channels bore two scores: one for the resting phase and the other for the stimulated phase. The weighings were made to one ten thousandth of a gram, thus the scores were represented by four digit

numbers. In order to facilitate calculations the scores were rounded out to the third digit.

4. Statistical Analysis of Data.

The hypotheses as presented in the third section of Chapter One indicated several variables which might be related to creativity and EEG amplitude potentials. These are: individuals, creativity, EEG channels, and resting and stimulated phases of amplitude potentials. Creativity consisted of five independent test scores, and a sixth classification was obtained by using the sum of the five scores obtained by each Subject. The seven EEG channels represented seven areas of the cerebral cortex in two phases: resting amplitude and stimulated amplitude. The sums of amplitude for the seven channels in a resting phase and the stimulated phase, and finally the total amplitude for each channel were obtained by adding the two phases. With so many interacting factors, it was decided to use analysis of variance as the first step in the data analysis. A pseudo-four dimensional model for analysis of variance was chosen.[1]

The plan for analysis of variance divided the thirty Subjects of this study into three equal groups of ten, thus

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1 Quinn McNemar, Psychological Statistics, Third Edition, New York, John Wiley and Sons, 1962, p. 335.

establishing three levels of creativity: High (H), Middle (M), and Low (L). The classification of individuals into three equal groups was arrived at through a distribution of creativity scores, using an interval of two. The top ten scores constituted the High level, the Middle ten the Middle level, and the lowest ten the Low level. These three levels constituted the three Blocks in the design. The Rows of the design referred to the Individuals, the Columns to the seven Channels and the other dimension to the Phases.

This design permitted the analysis of the following main effects: Individuals (I), Creativity (CR), Channel (CH), and Phase (P). The three double interactions and the one triple interaction computable in this model were: CRxCH, CRxP, CHxP, and CRxCHxP. The residual combined the quadruple interaction and uncomputable double and triple interactions. To obtain the sums of squares for the individual main effect, the following formula was adapted, using the code letters described above:

$$SS_I = \frac{\Sigma(ICR)^2}{14} - \frac{\Sigma CR^2}{140}$$

This entire procedure was repeated six times for each measure of creativity utilized in this study.

Since the F value of the main effect of Creativity did not yield significance in the overall analysis it was

decided to perform F tests independently at each level for each channel. The error term in this supplementary analysis remained the same as the one used in the overall analysis of variance.[2]

To consider the mean differences between resting and stimulated amplitudes for each channel, t tests were used. The standard error of the difference for the calculation of the t value required the use of the correlation between resting and stimulated amplitude phases for each one of the seven channels for the whole sample. For the Pearson r the following formula was used:[3]

$$r_{12} = \frac{N\Sigma XY - \Sigma X \Sigma Y}{\sqrt{\left[N\Sigma X^2 - (\Sigma X)^2\right]\left[N\Sigma Y^2 - (\Sigma Y)^2\right]}}$$

Thus the formula for the standard error of the difference was:

$$\sigma_D = \sqrt{2/N \text{ "ERROR"}(1 - r_{12})}$$

The "Error" term was constant for each test of Creativity but the r differed with each channel

The following chapter will present the findings and interpretations of this investigation.

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2 E.F. Lindquist, Statistical Analysis in Educational Research, New York, Houghton Mifflin Co., 1940, p. 170-171.

3 L.T. Dayhaw, Manuel de statistique, Ottawa, Editions de l'Universite, 1958, p. 126.

CHAPTER IV

PRESENTATION OF RESULTS

This final chapter will present the results stemming from this investigation. The summary of the overall analyses of variance will be shown and commented upon. This will be followed by the results of individual F and t tests conducted on each channel for the six creativity measures. The presentation of differences measured between resting and stimulated amplitude phases will conclude the presentation of results. The final portion of this chapter will consist of the interpretation of the results presented with possible suggestions concerning further research.

1. The Statistical Findings.

This section will be the presentation and a commentary on the results of the analyses of variance for the six measures of creativity employed in this study. To facilitate communication the reader will be presented with a brief description of each creativity measure prior to the presentation of the summary of the analysis of variance. This description will include the definition of each test and its place in Guilford's model of the intellect.

The preparation of each Subject for recording was approximately of four minutes duration. The Subject was asked to sit on a chair while the EEG technician measured his head and prepared the selected sites of the skull for recording. The electrodes consisted of short silver tubes capped by small pads which were in contact with the scalp. These electrodes were steadied by a small polythene support. The pads were chlorided at frequent intervals and soaked, between recordings, in saline solution. A soft rubber harness served to hold the electrodes in position. Before applying the electrode to the scalp a small area of the scalp was cleansed by rubbing vigorously with methylated spirits. Following this, a little Cambridge jelly was applied to the cleansed area. The harness was then put on and the electrodes slipped under the straps of the harness so that the pads rested on the treated areas of the skin. With this preparation completed the Subject was asked to sit in a comfortable armchair in the recording room. The room in which the Subject was seated was shielded with copper wiring in order to eliminate any outside electrical interference, and was sound attenuating. The usual sounds emanating from the outside could not be heard. When the Subject was seated he was asked to assume a relaxed position and to close his eyes. Maintaining a sitting, rather than a reclining position, minimized changes in orientation of scalp

Table I summerizes the analysis of variance for the test of Alternate Uses, a creativity test, requiring the ability to list uncommon, or less common uses of a given object whose common use is stated. In terms of Guilford's[1] structure of the intellect this test involves the operation of divergent thinking about semantic material, resulting in a classification, that is, a grouping of aggregate items of information because of their common properties.

The analysis reveals that the main effect of this Creativity test was not statistically significant. The main effects of Channel and Phase, however, demonstrated high significance beyond the .001 level of confidence. The double interactions of CRxCH and CHxP were both significant beyond the .01 level of confidence. The double interaction of CRxP, as well as the triple interaction of CRxCHxP were not significant.

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1 J.P. Guilford and P.R. Merrifield, "The Structure of Intellect Model: Its Uses and Implications", Report from the Psychological Laboratory, The University of Southern California, No. 24, April, 1960, p. 1-27.

Table I.-

Table of Variance for Four Dimensions with Creativity Defined as Alternate Uses.

Source	Sums of Squares	df	Variance Estimate	F	P.05	P.01
Individual	3583071.86	27	132706.36			
Creativity	599646.00	2	299823.00	2.26	3.35	5.49
Channels	1079077.29	6	179846.21	39.85	2.09	2.80
Phase	113784.69	1	113784.69	25.21	3.84	6.64
CRxCH	127712.47	12	10642.70	2.36	1.75	2.18
CRxP	14913.20	2	7456.60	1.65	2.99	4.60
CHxP	101236.16	6	16872.69	3.74	2.09	2.80
CRxCHxP	27940.20	12	2328.35	--	1.75	2.18
Residual	1584129.64	351	4513.19			

Table II on the following page presents the summary of the analysis of variance for the test of Expressional Fluency, a test of creative ability to make four word sentences given the same four initial letters of the words to be used in all responses. According to Guilford's[2] model of the intellect this is an operation involving divergent thinking about symbolic material resulting in a system, that is, organized or structured aggregates of items of information. The reader will notice that this product is rather similar to the product of classification present in the test of Alternate Uses.

Here the main effect of this type of Creativity was found to be significant at the .05 level of confidence, lacking merely .07 points to meet the .01 probability requirement. The main effects of both Channel and Phase were again found to be significant beyond the .001 level of probability. The double interaction of CRxCH was short of merely .14 points to reach the .05 level of significance. The double interactions of CRxP and CHxP, and the triple interaction of CRxCHxP were not found to be significant in this overall analysis.

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2 Guilford and Merrifield, Op. Cit., p. 1-27.

Table II.-

Table of Variance for Four Dimensions with Creativity Defined as Expressional Fluency.

Source	Sums of Squares	df	Variance Estimate	F	P.05	P.01
Individual	2270214.12	27	84082.00			
Creativity	912503.74	2	456251.87	5.43	3.35	5.49
Channels	1079077.29	6	179846.21	18.32	2.09	2.80
Phase	113784.69	1	113784.69	11.59	3.84	6.64
CRxCH	190010.03	12	15834.17	1.61	1.75	2.18
CRxP	45574.35	2	22787.17	2.32	2.99	4.60
CHxP	101236.16	6	16872.69	1.72	2.09	2.80
CRxCHxP	74042.95	12	6170.25	--	1.75	2.18
Residual	3445068.18	351	9815.01			

The results of the overall analysis of variance for the test of Associational Fluency are presented in Table III, on the following page. This creativity test requires the ability to list words that bear some relationship to a given word. The thought process involved in this task, according to Guilford's[3] model of the intellect, is an operation in divergent thinking about semantic material resulting in relationships, that is, recognized connections between units of information based upon variables that apply to them.

The main effect of this type of Creativity did not yield a significant relationship to amplitude as measured by the EEG. The main effects of Channels and Phase, on the other hand, were again significant beyond the .001 level of probability. Of the three double effects, CHxP was alone found to be significant at the .05 level of confidence. The triple effect CRxCHxP again did not show statistical significance.

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3 Guilford and Merrifield, Op. Cit., p. 1-27.

Table III.-

Table of Variance for Four Dimensions With Creativity Defined as Associational Fluency.

Source	Sums of Squares	df	Variance Estimate	F	P.05	P.01
Individual	2996108.83	27	110966.99			
Creativity	186609.03	2	93304.51	--	3.35	5.49
Channels	1079077.29	6	179846.21	24.12	2.09	2.80
Phase	113784.69	1	113784.69	15.26	3.84	6.64
CRxCH	110375.94	12	9197.95	1.23	1.75	2.18
CRxP	9516.29	2	4758.14	--	2.99	4.60
CHxP	101236.16	6	16872.69	2.26	2.09	2.80
CRxCHxP	17757.81	12	1478.15	--	1.75	2.18
Residual	2617065.47	351	7456.03			

Table IV on the following page presents the summary of the analysis of variance for the test of Ideational Fluency. This creativity test requires the ability to list rapidly ideas to meet meaningful requirements. The thought process involved here, according to Guilford's[4] model of the intellect is a divergent operation involving semantic content resulting in units, that is, segregated or circumscribed items of information.

Of the three measurable main effects, Channels and Phase remained significant beyond the .001 level of probability but the effect of this type of Creativity was found not to be significantly related to the EEG measures of amplitude. The double effect of CHxP was significant at the .05 level of confidence. The remaining two double effects CRxCH, CRxP, and the triple effect CRxCHxP did not show significance.

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4 Guilford and Merrifield, Op. Cit., p. 1-27.

Table IV.-

Table of Variance for Four Dimensions With Creativity Defined as Ideational Fluency.

Source	Sums of Squares	df	Variance Estimate	F	P.05	P.01
Individual	3089094.30	27	114410.90			
Creativity	93623.66	2	46811.83	--	3.35	5.49
Channels	1079077.29	6	179846.21	23.79	2.09	2.80
Phase	113784.69	1	113784.69	15.05	3.84	6.64
CRxCH	89303.11	12	7441.93	--	1.75	2.18
CRxP	9175.37	2	4587.68	--	2.99	4.60
CHxP	101236.16	6	16872.69	2.32	2.09	2.80
CRxCHxP	21185.53	12	1765.46	--	1.75	2.18
Residual	2635088.40	351	7508.66			

The summary of the analysis of variance for the test Word Fluency appears in Table V on the following page. This test of creativity requires the ability to think of words rapidly, each word satisfying the same letter requirement. In terms of Guilford's[5] model of the intellect, this test involves divergent thinking about symbolic content resulting in units, that is, segregated or circumscribed items of information.

The main effect of this type of Creativity was not found to be significant. The Channels and Phase effects continued to remain at the .001 level of significance. The double effect of CRxCH was significant at the .01 level, and CHxP at the .05 level of probability. The remaining double effect CRxP and the triple effect CRxCHxP did not show significance.

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5 Guilford and Merrifield, Op. Cit., p. 1-27.

Table V.-

Table of Variance for Four Dimensions With Creativity Defined as Word Fluency.

Source	Sums of Squares	df	Variance Estimate	F	P.05	P.01
Individual	2933798.29	27	108659.19			
Creativity	248920.57	2	124460.28	1.14	3.35	5.49
Channels	1079077.29	6	179846.21	25.43	2.09	2.80
Phase	113784.69	1	113784.69	16.09	3.94	6.64
CRxCH	190494.10	12	15874.51	2.24	1.75	2.18
CRxP	31320.39	2	15660.19	2.21	2.99	4.60
CHxP	100236.16	6	16706.03	2.36	2.09	2.80
CRxCHxP	50440.21	12	4203.35	--	1.75	2.18
Residual	2482439.91	351	7072.47			

A final dimension of creativity was arrived at by combining the test totals of the five creativity tests used, thus arriving at an additional measure. Here individuals were classified into the three blocks, low, middle, and high by taking their total score on all five tests of creativity. The following Table VI presents a summary of this analysis of variance.

The significant main effects were Channels and Phase, both beyond the .001 level of probability. Creativity was not significant. The double effects CRxCH and CRxP were not significant while CHxP was significant at the .05 level of probability. The triple effect CRxCHxP remained not significant.

Considering the analysis of this final dimension of creativity, it must be remembered that the heterogeniety of functions, added together from the five tests of creativity, likely cancelled out most of the existing relationships between the specific measures of creativity and EEG amplitude.

The section to follow will present the results of F and t tests performed independently of the analysis of variance for each test of creativity for all seven channels.

Table VI.-

Table of Variance for the Dimensions of Creativity Defined as the Combined Test Table of all Five Tests of Creativity.

Source	Sums of Squares	df	Variance Estimate	F	P.05	P.01
Individual	2853137.85	27	105671.77			
Creativity	329580.02	2	164790.02	1.56	3.35	5.49
Channels	1079077.29	6	179856.21	24.54	2.09	2.80
Phase	113784.69	1	113784.69	15.53	3.84	6.64
CRxCH	124032.75	12	10336.06	1.41	1.75	2.18
CRxP	10605.71	2	5030.28	--	2.99	4.60
CHxP	101236.16	6	16872.69	2.30	2.09	2.80
CRxCHxP	47919.59	12	3993.29	--	1.75	2.18
Residual	2572147.45	351	7328.05			

The search for relationships between levels of creativity and EEG amplitudes was continued by considering each EEG channel separately to discover possible existing trends.

Table VII on page 52 presents such findings for each channel on the test of creativity defined as Alternate Uses.

In viewing this table, an interesting trend should be noticed in the total scores of the three levels of creativity, low, middle, and high. It becomes immediately evident that in channels I and V there exists a descending effect from high numbers in the Low creativity group, to low numbers in the High creativity group. In channels II, III, IV, VI, and VII, on the other hand, there is a curve effect with the Middle level of creativity bearing the highest amplitude of the three. The High creativity group, nevertheless, bears the smallest amplitude of the three, in all seven channels, without exception.

The next phenomenon to be considered is the decrease in the total scores from the Resting phase to the Stimulated phase. This trend is present in all channels except Channel I.

The F and t tests will now be considered. It must be noted that when applying the F formula to any three scores, the significant difference shown is always between

the highest and the lowest number of the three scores. For this reason it was decided to use an additional t test for each channel and phase of it to determine the significance of the difference between Low scorer amplitude and High scorer amplitude on each creativity test.

The F tests revealed significant differences beyond the .01 level of probability in both Resting and Stimulated phases in channels I, II, and IV. Channels III, and VII showed significant differences in the Resting phase with the Stimulated phase decreasing below the level of significance.

The t tests showed similar results. Channels I, II, and IV, showed significant differences in amplitude beyond the .01 level between Low and High scorers for both phases. For channels III, V, and VII only Resting phases showed significant differences at the .05 level of probability. Channel VI showed no significant difference for either phase.

Finally, the totals of all seven channels for each phase were considered. In this operation only F tests were used showing highly significant differences. The Resting phase and Stimulated phase showed significances well above the .001 level of confidence.

The tests of significance conducted on the test of Expressional Fluency will be considered next.

Table VII.-

Table of F Tests and t Tests Obtained by Comparing the EEG Amplitudes, for Seven Channels, Both Resting and Stimulating Phases, of Low, Middle, and High Scoring Groups on the Test of Creativity Defined as Alternate Uses.

Channel	Phase	Creativity Low	Mid.	High	S.S.	df	s^2	F[a]	M_L	M_H	t[b]
I	R	3470	3099	2501	47806.87	2	23903.43	5.30	347.0	250.1	3.22
	S	3571	3218	2355	69267.80	2	34633.90	7.67	357.1	235.5	4.05
II	R	3257	3518	2468	59771.40	2	29885.70	6.62	325.7	246.8	2.63
	S	3076	3290	2329	50910.90	2	25455.45	5.64	307.6	232.9	2.49
III	R	3574	3955	2921	54690.87	2	27345.43	6.06	357.4	292.1	2.17
	S	3035	3397	2612	24531.27	2	12265.63	2.72	303.5	261.2	1.41
IV	R	4692	5050	3030	232360.27	2	116180.13	25.74	469.2	303.0	5.53
	S	3595	3753	2697	64883.47	2	32441.73	7.19	359.5	375.3	2.99
V	R	2655	2417	1978	23589.80	2	11794.90	2.61	265.5	197.8	2.25
	S	2417	2225	1915	12832.17	2	6416.08	1.42	241.7	191.7	1.67
VI	R	2379	2566	1926	21659.27	2	10829.63	2.40	237.9	192.6	1.51
	S	2457	2394	1931	16500.47	2	8250.23	1.83	245.7	193.1	1.75
VII	R	2967	3498	2343	66845.40	2	33422.70	7.40	296.7	234.3	2.08
	S	2438	2644	2092	15561.87	2	7780.93	1.72	243.8	209.2	1.15
All	R	22994	24103	17167	396628.13	2	198314.06	43.94			
	S	20589	20831	15931	217931.00	2	108965.50	24.14			

a F value P.05 = 2.99, P.01 = 4.60, P.001 = 6.91.
b t value P.05 = 1.96, P.01 = 2.58, P.001 = 3.29.

Table VIII presents the results of *F* tests performed on the EEG amplitude totals of the three creativity groups, and *t* tests of EEG amplitude means between the Low and High groups of creativity, for the test defined as Expressional Fluency.

The observation of this table reveals trends which were present in the analysis of Table VII. The trend of descending amplitudes is again seen, with the highest amplitude present in the Low creativity group and the lowest in the High creativity group. This descending effect is present in channels I, II, IV, VI, and VII for both resting and stimulated phases. In channel III the resting phase follows the descending pattern but in the stimulated phase a curve effect occurs with the Middle group amplitude being somewhat higher than that of the Low group. In channel V this curve effect was present in both phases.

The next trend to be observed was the decrease in amplitude from the resting phase to the stimulated phase. This trend is present in all channels and creativity groups except the Low creativity group on channel I.

The *F* tests will now be considered. Significant differences beyond the .05 level of probability were obtained on channel I both resting and stimulated phases. The resting phase of channel II also yielded significance

at the .05 level of probability, while the stimulated phase did not reach significance. In channel III the resting phase was significant beyond the .01 level of probability and again the stimulated phase remained not significant. Channel IV showed significance far beyond the .001 level of probability for the resting phase and the stimulated phase was significant at the .01 level of probability. Channels V and VI did not reveal significant differences between the three groups' amplitudes, while channel VII in the resting phase yielded a significance at the .01 level with the stimulated phase remaining not significant.

The combined channels for the resting phase showed significant differences far beyond the .001 level of probability. The same .001 significance was found to be present in the stimulated phase.

The *t* tests conducted between the amplitude scores of the Low group and the High group demonstrate the following results. On channel I the resting phase significance was found at the .05 level of confidence and .01 in the stimulated phase. Channel II demonstrated significant differences for the resting phase at the .01 and the stimulated phase .05, levels of confidence. In channels III and VII only the resting phases showed significant differences at the .01 level. In channel IV both phases were significant at the .01 level. Channels V and VI did not demonstrate significant differences.

Table VIII.-

Table of F Tests and t Tests Obtained by Comparing the REG Amplitudes, for Seven Channels, Both Resting and Stimulating Phases, of Low, Middle, and High Scoring Groups on the Test of Creativity Defined as Expressional Fluency.

Channel	Phase	Creativity Low	Mid.	High	S.S.	df	s^2	F[a]	M_L	M_H	t[b]
I	R	3416	3275	2379	63268.87	2	31634.43	3.22	341.6	237.9	2.34
	S	3585	3227	2332	83306.80	2	41653.40	4.24	358.5	233.2	2.82
II	R	3547	3337	2359	80397.60	2	40198.80	4.09	354.7	235.9	2.66
	S	3262	3138	2295	55370.47	2	27685.23	2.82	326.2	229.5	2.18
III	R	4298	3407	2745	121464.47	2	60732.23	6.19	429.8	274.5	3.50
	S	3188	3286	2480	38683.47	2	19341.74	1.97	318.8	248.0	1.60
IV	R	5803	4089	2880	431446.87	2	215723.44	21.98	580.3	288.0	6.60
	S	3941	3598	2506	112311.27	2	56155.64	5.72	394.1	250.6	3.24
V	R	2506	2541	2003	18122.60	2	9061.30	--	250.6	200.3	1.13
	S	2312	2310	1935	9425.27	2	4712.63	--	231.2	193.5	--
VI	R	2569	2459	1843	30621.07	2	15310.54	1.56	256.9	184.3	1.64
	S	2538	2453	1791	33449.27	2	16724.64	1.70	253.8	179.1	1.68
VII	R	3757	2805	2246	116730.20	2	58365.10	5.95	375.7	224.6	3.41
	S	2710	2480	1984	27533.07	2	13766.85	1.40	271.0	198.4	1.64
All	R	25896	21913	16455	641840.66	2	320920.33	32.70			
	S	21536	20492	15323	316237.46	2	158118.73	16.11			

a F Value P.05 = 2.99, P.01 = 4.60, P.001 = 6.91.
b t Value P.05 = 1.96, P.01 = 2.58, P.001 = 3.29.

Table IX presents the results of F tests performed on the EEG amplitude totals of the three creativity groups, and t tests of EEG amplitude means between the Low and the High groups of creativity, for the test defined as Associational Fluency.

The examination of this table reveals trends found in Tables VII and VIII. The trend of descending amplitudes was found again in channels III, Iv, V, and VII. The curve effect was observed in channels I, II, and VI.

The next trend reoccuring again was the decrease in amplitude from the resting phase to the stimulated phase. This phenomenon is present in all seven channels and phases with the exception of the Low creativity group on channel I where a reversal occurred.

It was found that in this measure of creativity, only channel IV in the resting phase showed significant differences between the groups. The significance in this channel and phase was beyond the .001 level of confidence.

The combined resting phase was again significant at .001 level of confidence and the stimulated phase at .05.

On the t tests only two channels demonstrated significant differences. Channel IV in the resting phase showed .001 level of confidence, and at the stimulated phase the probability of .05. The .05 level of significance was also demonstrated by the resting phase of channel VII.

Table IX.-

Table of F Tests and t Tests Obtained by Comparing the EEG Amplitudes, for Seven Channels, Both Resting and Stimulating Phases, of Low, Middle, and High Scoring Groups on the Test of Creativity Defined as Associational Fluency.

Channel	Phase	Creativity Low	Mid.	High	S.S.	df	s^2	F[a]	M_L	M_H	t[b]
I	R	3132	3219	2719	14271.27	2	7135.63	--	313.2	271.0	1.07
	S	3109	3373	2662	25834.20	2	12917.10	1.73	310.9	266.2	1.16
II	R	3072	3269	2902	6746.60	2	3373.30	--	307.2	290.2	--
	S	2888	3004	2803	2036.07	2	1018.03	--	288.8	280.3	--
III	R	3695	3509	3246	10178.87	2	5089.43	--	369.5	324.6	1.16
	S	3177	2926	2851	5830.07	2	2915.03	--	317.7	285.1	--
IV	R	5111	4220	3441	139654.07	2	69827.03	9.36	511.1	344.1	4.32
	S	3778	3322	2945	34798.47	2	17399.23	2.33	377.8	294.5	2.16
V	R	2646	2258	2144	13970.40	2	6985.20	--	264.6	214.4	1.30
	S	2378	2140	2039	6058.87	2	3029.43	--	237.8	203.9	--
VI	R	2353	2367	2131	3865.87	2	1932.93	--	235.3	213.1	--
	S	2245	2479	2058	8898.87	2	4449.43	--	224.5	205.8	--
VII	R	3301	3079	2428	41173.80	2	20586.90	2.76	330.1	242.8	2.26
	S	2588	2453	2133	10921.67	2	5460.83	--	258.8	213.3	1.18
All	R	23312	21941	19011	137919.73	2	68959.86	9.25			
	S	20163	19697	17491	58205.60	2	29102.80	3.90			

a F Value P.05 = 2.99, P.01 = 4.60, P.001 = 6.91.
b t Value P.05 = 1.96, P.01 = 2.58, P.001 = 3.29.

Table X presents the results of *F* tests performed on the EEG amplitude totals of the three creativity groups, and *t* tests of EEG amplitude means between the Low and the High groups of creativity, for the test defined as Ideational Fluency.

The trend of descending amplitudes in this analysis is only found to be present in channels V and VI. The remaining channels demonstrated a curve effect with the amplitude of the Middle creativity group being the higest.

The decrease in amplitude from the resting to the stimulated phase was found to be present in all three creativity groups for channels II, III, IV, V, and VII. In channel I there was found to be a reversal in the Low and Middle groups of creativity, and in channel VI the Middle group showed the same reversal.

Significant differences between creativity groups were found to exist in channels I and IV. The former was in the stimulated phase at the .05 level of confidence and the latter in the resting phase also at .05 level of confidence.

The combined amplitudes of channels in the resting phase yielded significant differences at the .01 level of probability. The combined stimulated phase showed no significant differences.

The *t* tests yielded no significant differences.

Table I.-

Table of F Tests and t Tests Obtained by Comparing the EEG Amplitudes, for Seven Channels, Both Resting and Stimulating Phases, of Low, Middle, and High Scoring Groups on the Test of Creativity Defined as Ideational Fluency.

Channel	Phase	Creativity Low	Mid.	High	S.S.	df	s^2	F[a]	M_L	M_H	t[b]
I	R	2938	3420	2712	26155.47	2	13077.73	1.73	293.8	271.2	--
	S	2946	3580	2618	47832.80	2	23916.40	3.16	294.6	261.8	--
II	R	2907	3211	3125	4911.20	2	2455.60	--	290.7	312.5	--
	S	2756	2940	2999	3213.87	2	1606.43	--	275.6	299.9	--
III	R	3599	3873	2978	52058.07	2	21029.03	2.78	359.9	297.8	1.60
	S	3102	3021	2831	3870.07	2	1935.03	--	310.2	283.1	--
IV	R	4245	4794	3733	56308.87	2	28154.43	3.72	424.5	373.3	1.32
	S	3344	3574	3127	9993.27	2	4996.63	--	334.4	312.7	--
V	R	2495	2302	2253	3275.80	2	1636.90	--	249.5	225.3	--
	S	2260	2149	2148	828.87	2	414.43	--	226.0	214.8	--
VI	R	2328	2323	2220	743.27	2	371.63	--	232.8	222.0	--
	S	2184	2405	2193	3128.87	2	1564.43	--	218.4	219.3	--
VII	R	3004	3124	2680	10550.40	2	5275.20	--	300.4	268.0	--
	S	2439	2378	2357	363.07	2	181.53	--	243.9	235.7	--
All	R	21516	23047	19701	80161.43	2	40080.71	5.40			
	S	19031	20047	18273	22637.20	2	11318.60	1.50			

a F Value P.05 = 2.99, P.01 = 4.60, P.001 = 6.91.

b t Value P.05 = 1.96, P.01 = 2.58, P.001 = 3.29

Table XI presents the results of F tests performed on the EEG amplitude totals of the three creativity groups, and t tests of EEG amplitude means between the Low and the High groups of creativity, for the test defined as Word Fluency.

The trends of descending amplitudes or curve effect were not found in this test of creativity. The lowest EEG amplitude in the three groups of creativity was found to be had by the Middle group, thus effecting an inverted curve effect.

The decrease in amplitude from the resting to the stimulated phase was found to be present in all groups of creativity for channels II, III, IV, V, and VII. In channels I, and VI the Low and the Middle creativity groups were inverted with the stimulated phase being of higher amplitude than the resting phase.

The F tests revealed significant differences at the .05 level of confidence in the stimulated phases of channels I and IV, and the resting phase of channel III. A significant difference beyond the .001 level of probability was found in the resting phase of channel IV. The remaining channels yielded no significant differences.

The combined resting phases demonstrated significant difference beyond the .001 level of probability, and the stimulated phase .05 level of confidence.

Table XI

Table of F Tests and t Tests Obtained by Comparing the EEG Amplitudes, for Seven Channels, Both Resting and Stimulating Phases, of Low, Middle, and High Scoring Groups on the Test of Creativity Defined as Word Fluency.

Channel	Phase	Creativity Low	Mid.	High	S.S.	df	s^2	F[a]	M_L	M_H	t[b]
I	R	3199	2753	3118	11290.07	2	5605.04	--	319.9	311.8	--
	S	3591	2902	2651	47377.10	2	23688.55	3.35	359.1	265.1	2.50
II	R	2965	2698	3580	40914.60	2	20457.30	2.89	296.5	358.0	1.63
	S	2853	2655	3187	14459.47	2	7229.73	1.02	285.3	318.7	--
III	R	3605	2928	3917	51126.47	2	25563.23	3.61	360.5	391.7	--
	S	2789	2861	3304	15555.27	2	7777.63	1.10	278.9	300.4	1.37
IV	R	5120	3122	4530	210752.27	2	105376.13	14.90	512.0	453.0	1.57
	S	3613	2747	3685	54499.47	2	27249.73	3.85	361.3	368.5	--
V	R	2489	2088	2473	10309.40	2	5154.70	--	248.9	247.3	--
	S	2343	2066	2148	4049.27	2	2024.63	--	234.3	214.8	--
VI	R	2208	2169	2494	6298.07	2	3149.03	--	220.8	249.4	--
	S	2283	2193	2306	56.41	2	28.20	--	228.3	230.6	--
VII	R	3217	2413	3178	41105.40	2	20552.70	2.91	321.7	317.8	--
	S	2404	2133	2637	12724.87	2	6362.43	--	240.4	263.7	--
All	R	22803	18171	23290	228079.73	2	114039.86	16.12			
	S	19876	17557	19918	52161.10	2	26080.55	3.69			

a F Value P.05 = 2.99, P.01 = 4.60, P.001 = 6.91.

b t Value P.05 = 1.96, P.01 = 2.58, P.001 = 3.29.

Table XII presents the results of F tests performed on the EEG amplitude totals of the three creativity groups, and t tests of EEG amplitude means between the Low and the High groups of creativity, final measure of creativity defined as Combined Creativity.

The trend of descending amplitudes was present in channels IV and VII. The rest of the channels demonstrated the curve effect with the middle group amplitude being the highest of the three.

The F tests revealed significant differences between the creativity groups in channel I stimulated phase at the .05 level of confidence; in channel III resting phase at the .05 level of confidence, and in channel IV at the .001 level of confidence.

The combined resting phases and the combined stimulated phases were both found to demonstrate significant differences beyond the .001 level of probability.

The t tests estimating differences between the amplitude means of the Low and the High creativity groups demonstrated significant differences in the stimulated phase of channel I at the .01 level of confidence, and in the resting phase of channel IV a difference at the .001 level. The resting phase of channel IV was significant at the .05 level. In channel VII the resting phase was found to be significant at the .05 level of confidence.

Table XII.-

Table of F Tests and t Tests Obtained by Comparing the EFG Amplitudes, for Seven Channels, Both Resting and Stimulating Phases, of Low, Middle, and High Scoring Groups on the Test of Creativity Defined as Combined Creativity.

Channel	Phase	Creativity Low	Mid.	High	S.S.	df	s^2	F[a]	M_L	M_H	t[b]
I	R	3199	3287	2584	29339.27	2	14669.63	2.00	319.9	258.4	1.61
	S	3591	3034	2519	57486.60	2	28744.30	3.92	359.1	251.9	2.80
II	R	2965	3576	2702	40212.20	2	20106.10	2.74	296.5	270.2	--
	S	2853	3222	2620	18428.47	2	9214.23	1.26	285.3	262.00	--
III	R	3605	3937	2908	55162.47	2	27581.23	3.76	360.5	290.8	1.82
	S	2789	3513	2652	42808.87	2	21404.43	2.92	278.9	265.2	--
IV	R	5120	4231	3421	144434.07	2	72217.03	9.85	512.0	342.1	4.44
	S	3615	3570	2862	15093.63	2	7546.81	1.02	361.5	286.2	1.96
V	R	2489	2522	2039	14562.60	2	7281.30	--	248.9	203.9	1.17
	S	2343	2221	1993	6312.27	2	3156.13	--	234.3	199.3	--
VI	R	2208	2589	2074	14278.07	2	7139.03	--	220.8	207.4	--
	S	2283	2466	2033	9449.27	2	4724.63	--	228.3	203.3	--
VII	R	3217	3140	2451	35580.20	2	17790.1	2.43	321.7	245.1	2.00
	S	2404	2591	2179	8511.27	2	4255	--	240.4	217.9	--
All	R	22803	23282	18179	226911.53		78	15.48			
	S	19876	20617	16858	119008.80		64.40				

a F Value P.05 = 3.35, P.01 = 5.49, P.001 = 9.61.

b t Value P.05 = 1.96, P.01 = 2.58, P.001 = 3.3[illegible]

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The observation of the data stemming from the overall analysis of variance prompted the investigator to consider one additional dimension of this study; namely, the differential amplitude changes occurring between the resting and stimulated phases in the three creativity groups.

Table XIII presents the results of this analysis conducted on the creativity test defined as Alternate Uses.

The data revealed no significant differences between phases in channels I, II, and VI. In channel III, the difference between the resting and the stimulated amplitude means for the Low and the Middle groups was found to exceed the .001 level of confidence while the mean difference in the High group was only significant at the .05 level of confidence. This is a phenomenon that occurred frequently. In channel IV the differences between means were significant at the .001 level in all creativity groups, with the Low group again having relatively the smallest t value of the three. In channel V the means of the Low group demonstrated a difference at the .01 level; the Middle group at the .05 level of significance, while the High group means show no significant difference. In channel VII the means of the Low and the Middle group showed differences beyond the .001 level, while the High group only demonstrated a .05 level of significance.

Table XIII.-

Means of Resting and Stimulated EEG Amplitude Phases, [b] Differences Between Means and t's and Their Significances On Seven Channels for Low, Middle and High Scoring Groups on the Test of Creativity Defined As Alternate Uses.

CH.	CR.	M_R	M_S	D	σ_D [a]	t
I	L	347.0	357.1	-10.1	11.41	-
	M	309.9	321.8	-11.9	11.41	1.04
	H	250.1	235.5	14.6	11.41	1.28
II	L	325.7	307.6	18.1	12.61	1.43
	M	351.8	329.0	22.8	12.61	1.81
	H	246.8	232.9	13.9	21.61	1.10
III	L	357.4	303.5	53.9	12.92	4.17
	M	395.5	330.7	64.8	12.92	5.01
	H	292.1	261.2	30.9	12.92	2.39
IV	L	469.2	359.5	109.7	9.01	12.17
	M	505.0	375.3	129.7	9.01	14.39
	H	305.0	269.7	35.3	9.01	3.69
V	L	265.5	241.7	23.8	7.81	3.05
	M	241.7	222.5	19.2	7.81	2.46
	H	197.8	191.5	6.3	7.81	-
VI	L	237.9	245.7	-7.8	12.61	-
	M	256.6	239.4	17.2	12.61	1.36
	H	192.6	193.1	- .5	12.61	-
VII	L	296.7	243.8	52.9	10.81	4.89
	M	349.8	264.4	85.4	10.81	7.90
	H	234.3	209.2	25.1	10.81	2.32

a $\sigma_D = \sqrt{\frac{2 \text{ "Error"}}{N}} (1-r_{12})$

b Significant F's are: 1.96 at P.05; 2.58 at P.01; 3.24 at P.001.

Table XIV presents the analysis of differential amplitude changes occurring between the resting and stimulated phases in the three creativity groups for the test defined as Expressional Fluency.

In this analysis channels I and VI did not yield significant differences in any one of their three creativity groups. In channel II the difference between the means of the Middle creativity group was significant at the .01 level of confidence with the High group mean difference remaining below statistical significance. In channel III the only significant difference present was between the means of the Low group, at the .001 level of confidence, with the Middle and the High remaining not significantly different. Channel IV demonstrated differences in the Low and Middle creativity groups at the .001 level of confidence, while the High group of this channel showed a difference of.01 level of confidence. In channel V the means of the Middle group were significant at the .01 level of confidence with the High group remaining not significant. In channel VII the Low group means differed at the .001 level, and the Middle group at the .05 level of confidence, while the High group means remained not significantly different.

Table XIV.-

Means of Resting and Stimulated EEG Amplitude Phases,[b] Differences Between Means and t's and Their Significances On Seven Channels for Low, Middle and High Scoring Groups on the Test of Creativity Defined As Expressional Fluency.

CH.	CR.	M	M	D	σ_D[a]	t
I	L	341.6	358.5	-16.9	16.84	1.00
	M	327.5	322.5	4.8	16.84	-
	H	237.9	233.2	4.7	16.84	-
II	L	354.7	326.2	28.5	18.61	1.53
	M	333.7	313.8	48.4	18.61	2.60
	H	235.9	229.5	6.4	18.61	-
III	L	429.8	318.8	111.0	19.05	5.83
	M	340.7	328.6	13.9	19.05	-
	H	274.5	248.0	26.5	19.05	1.39
IV	L	580.3	394.1	186.2	13.29	14.09
	M	408.9	359.8	49.1	13.29	3.69
	H	288.0	250.6	37.4	13.29	2.81
V	L	250.6	231.2	19.4	11.52	1.68
	M	254.1	231.0	23.1	11.52	2.01
	H	200.3	193.5	6.8	11.52	-
VI	L	256.9	253.8	3.1	18.61	-
	M	245.9	245.3	.6	18.61	-
	H	184.3	179.1	5.2	18.61	-
VII	L	375.7	271.0	104.7	15.95	6.56
	M	280.5	248.0	32.5	15.95	2.04
	H	224.6	198.4	26.2	15.95	1.64

a $\sigma_D = \sqrt{2\,\frac{\text{Error}}{n}(1-r_{12})}$

b Significant F's: 1.96 at P.05; 3.58 at P.01; 3.24 at P.001.

Table XV presents the analysis of differential amplitude changes occurring between the resting and stimulated phases in three creativity groups for the test defined as Ideational Fluency.

Channels I, II, and VI presented no significant differences between the resting and the stimulated means of the three creativity groups. In channel III, the Low group's means differed at the .01 level and the Middle group's means at the .001 level of confidence, while the High group differences remained not significant. In channel IV the means of the three groups were significantly different at the .001 level of confidence, but the t value of the High group was the lowest of the three. In channel V the only significant difference between the means was found in the Low group at the .05 level of confidence. Both Middle and High groups did not reach statistically significant differences. In channel VII both the Low and the Middle groups had means significantly different at the .001 level while the High group had a difference significant at only the .05 level of confidence.

Table XV.-

Means of Resting and Stimulated EEG Amplitude Phases, Differences Between Means and t's and Their Significances[b] On Seven Channels for Low, Middle and High Scoring Groups on the Test of Creativity Defined as Ideational Fluency.

CH.	CR.	M_R	M_S	D	σ_D[a]	t
I	L	293.8	294.6	-.8	14.77	-
	M	342.0	358.8	-16.0	14.77	1.08
	H	271.2	261.8	9.4	14.77	-
II	L	290.7	275.6	15.1	16.33	-
	M	321.1	294.0	27.1	16.33	1.66
	H	312.5	299.9	12.6	16.33	-
III	L	359.9	310.2	49.7	16.72	2.97
	M	387.3	302.1	85.2	16.72	5.09
	H	297.8	263.1	14.7	16.72	-
IV	L	424.5	334.4	90.1	11.66	7.73
	M	479.4	357.4	122.0	11.66	10.46
	H	373.3	312.7	60.6	11.66	5.20
V	L	249.5	226.0	23.5	10.11	2.32
	M	230.2	214.9	15.3	10.11	1.51
	H	225.3	214.8	10.5	10.11	1.04
VI	L	232.8	218.4	14.4	16.33	-
	M	232.3	240.5	-8.2	16.33	-
	H	222.0	219.3	2.7	16.33	-
VII	L	300.4	243.9	56.5	14.00	4.04
	M	312.4	237.8	74.6	14.00	5.33
	H	268.0	235.7	32.3	14.00	2.31

a $\sigma_D = \sqrt{2 \frac{\text{Error}}{N} (1-r_{12})}$

b Significant F's are: 1.96 at P.05; 2.58 at P.01; 3.24 at P.001.

Table XVI presents the analysis of differential amplitude changes occurring between the resting and stimulated phases in three creativity groups for the test defined as Associational Fluency.

The data revealed no significant differences between phases for any one of the three creativity groups in channels I, II, and VI. In channel III the difference between the resting and stimulated phases for the Low creativity group was found to be significant at the .01 level, and the Middle group at the .001 level of confidence, while the High group was only significant at the .05 level of confidence. In channel IV the differences between means were significant at the .001 level in all creativity groups, with the Low group again having relatively the smallest t value of the three. In channel V the means of the Low group demonstrated a difference at the .05 level of significance, while the Middle and the High group means showed no significant difference. The lowest t value was again seen in the High creativity group. In channel VII the Low and the Middle group means showed differences beyond the .001 level, while the High group only demonstrated a .05 level of significance. The reoccurring phenomenon of the lowest t value in the High creativity group seemed to be present in all channels except channel I.

Table XVI.-

Means of Resting and Stimulated EEG Amplitude Phases, Differences Between Means and t's and Their Significances[b] On Seven Channels for Low, Middle and High Scoring Groups on the Test of Creativity Defined as Associational Fluency.

CH.	CR.	M_R	M_S	D	σ_D[a]	t
I	L	313.2	310.9	2.3	14.67	-
	M	321.9	337.3	-15.4	14.67	1.05
	H	271.9	266.2	5.7	14.67	-
II	L	307.2	288.8	18.4	16.22	1.13
	M	326.9	300.4	26.5	16.22	1.63
	H	290.2	280.3	9.9	16.22	-
III	L	369.5	317.7	51.8	16.61	3.12
	M	350.9	292.6	58.3	16.61	3.51
	H	324.6	285.1	39.5	16.61	2.37
IV	L	511.1	377.8	133.3	11.59	11.50
	M	422.0	332.2	89.8	11.59	7.75
	H	344.1	294.5	49.6	11.59	4.28
V	L	264.8	237.8	27.0	10.04	2.69
	M	225.8	214.0	11.8	10.04	1.17
	H	214.4	203.9	10.5	10.04	1.04
VI	L	235.3	224.5	10.8	16.22	-
	M	238.7	247.9	-9.2	16.22	-
	H	213.1	205.8	7.3	16.22	-
VII	L	330.1	258.8	71.3	13.90	5.13
	M	307.9	245.3	62.6	13.90	4.50
	H	242.8	213.3	29.5	13.90	2.12

a $\sigma_D = \sqrt{2 \frac{\text{Error}}{n}(1-r_{12})}$

b Significant F's are: 1.96 at P.05; 2.58 at P.01; 3.24 at P.001.

Table XVII presents the analysis of differential amplitude changes occurring between the resting and the stimulated phases in three creativity groups for the test defined as Word Fluency.

An interesting departure from the trends seen in the previous tests was observed in this test of creativity. The differences between the means of the Middle group were the smallest of the three. In this analysis the only channel showing no significant differences was channel VI. In channel I the mean differences in the Low and High groups were significant at the .01 level of confidence, while the High group showed no significance. In channel II the only significance shown was in the High group at the .05 level of confidence. Channel III showed significances at the .001 level in the Low and High creativity groups, while the Middle group was not significant. In channel IV the differences between means were significant at the .001 level in all creativity groups with the Middle group having relatively the smallest *t* value. In channel V both Low and Middle groups showed no significance while the High group showed a mean difference significance at the .001 level of confidence. In channel VII the Low and High groups were significant at the .001 level, and the Middle group at only the .05 level of confidence.

Table XVII.-

Means of Resting and Stimulated EEG Amplitude Phases, Differences Between Means and t's and Their Significances[b] On Seven Channels for Low, Middle and High Scoring Groups on the Test of Creativity Defined as Word Fluency.

CH.	CR.	M_R	M_S	D	σ_D[a]	t
I	L	319.9	359.1	-39.2	14.29	2.74
	M	275.5	290.2	-14.9	14.29	1.04
	H	311.8	265.1	46.7	14.29	3.27
II	L	296.5	285.3	11.2	15.80	-
	M	269.8	265.5	4.3	15.80	-
	H	358.0	318.7	39.3	15.80	2.49
III	L	360.5	278.9	81.6	16.17	5.05
	M	292.8	286.1	6.7	16.17	-
	H	391.7	330.4	61.3	16.17	3.79
IV	L	512.0	361.3	150.7	11.28	13.36
	M	312.2	274.7	37.5	11.28	3.32
	H	453.0	368.5	84.5	11.28	7.49
V	L	248.9	234.3	14.6	9.78	1.49
	M	208.8	206.6	2.2	9.78	-
	H	247.3	214.8	32.5	9.78	3.32
VI	L	220.8	228.3	-7.5	15.80	-
	M	216.9	219.3	-2.4	15.80	-
	H	249.4	230.6	18.8	15.80	1.19
VII	L	321.7	240.4	81.3	13.54	6.00
	M	241.3	213.3	28.0	13.54	2.07
	H	317.8	263.7	54.1	13.54	3.99

a $\sigma_D = \sqrt{2\frac{\text{Error}}{n}(1-r_{12})}$

b Significant F's are: 1.96 at P.05; 2.58 at P.01; 3.24 at P.001.

Table XVIII presents the analysis of differential amplitude changes occurring between the resting and stimulated phases in three creativity groups for the combined test of creativity.

In this analysis no significant differences were found for any of the three groups in channel VI. In channel I the Low group difference showed significance at the .01 level of confidence while the Middle and High groups did not demonstrate significant differences. In channel II both the Low and High groups were below significance and the Middle group was significant at the .05 level of confidence. In channel III there was a descending effect in mean differences. The Low group was significant at .001, the Middle at .05 level, and the High group did not show to be significant. In channel IV all three creativity groups were significant at the .001 level of confidence, and the *t* values demonstrated the descending effect from high values in the Low group to low values in the High group. In channel V the only significance was shown in the Middle group at the .01 level of confidence. In channel VII the descending effect was again seen with a .001 significance in the Low and the Middle groups, and a .05 significance in the High group.

Table XVIII.-

Means of Resting and Stimulated EEG Amplitude Phases, Differences Between Means and t's and Their Significances[b] On Seven Channels for Low, Middle and High Scoring Groups on the Combined Measure of Creativity

CH.	CR.	M_R	M_S	D	σ_D[a]	t
I	L	319.9	359.1	-39.2	14.54	2.70
	M	328.7	303.4	25.3	14.54	1.74
	H	258.4	251.9	6.5	14.54	-
II	L	296.5	285.3	11.2	16.07	-
	M	357.6	322.2	35.4	16.07	2.20
	H	270.2	262.0	8.2	16.07	-
III	L	360.5	278.9	81.6	16.46	4.96
	M	393.7	351.3	42.4	16.46	2.56
	H	290.8	265.2	25.6	16.46	1.55
IV	L	512.0	361.3	150.7	11.48	13.13
	M	423.1	357.0	66.1	11.48	5.76
	H	342.1	286.2	55.9	11.48	4.87
V	L	248.9	234.3	14.6	9.95	1.47
	M	252.2	222.1	30.1	9.95	3.02
	H	203.9	199.3	4.6	9.95	-
VI	L	220.8	228.3	-7.5	16.07	-
	M	258.9	246.6	12.3	16.07	-
	H	207.4	203.3	4.1	16.07	-
VII	L	321.7	240.4	81.3	13.78	5.90
	M	314.0	259.1	54.9	13.78	3.98
	H	245.1	217.9	27.2	13.78	1.97

a $\sigma_D = \sqrt{2\frac{Error}{n}(1-r_{12})}$

b Significant F's are: 1.96 at P.05; 2.58 at P.01; 3.24 at P.001.

2. Interpretation of Results.

The final section of this chapter will attempt to interpret the data stemming from this investigation. The findings will be considered in the light of the hypotheses presented in conclusion of Chapter One. To facilitate the reading of the manuscript, the hypotheses will be presented preceding each interpretation.

The main hypothesis was stated in the null form: There are no significant relationships between creativity and spread of field fronts in the cerebral cortex. This first hypothesis could not be rejected on the basis of the findings of this study due to insufficient information available from the EEG records. Changes upon stimulation occurred in all EEG channels, that is, each cortical area monitored and recorded. After the conclusion of the total analysis it was realized that more sensitive electronic instrumentation would be necessary for the measurement of spread of field fronts from the point of view of reception. Thus, Eccles'[6] hypothesis remained to be further investigated.

The first sub-hypothesis of this investigation was formulated in the following manner: There are no significant differences in EEG amplitudes among groups of

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6 J.C. Eccles, "The Physiology of Imagination", Scientific American, Vol. 199, No. 3, September, 1958, p. 135-146.

individuals classified as Low, Middle, and High scorers on tests of creativity, in any one of the cerebral cortex areas investigated. This hypothesis had to be rejected. Findings have demonstrated that amplitude output significanlty differs in groups of individuals classified as Low, Middle, and High scorers on tests of creativity. Significant differences were obtained at different levels of probability on the six measures of creativity from the channel IV recordings. This cortical area representing the occipital cortex demonstrated most emphatically the amplitude differences existent among the groups. Significant differences, while at different levels of probability, were obtained from other channels but with less consistency.

The second sub-hypothesis dealt with the stimulated phase of cerebral output. There are no significant differences in EEG amplitudes, among groups of individuals classified as Low, Middle, and High scorers on tests of creativity, in any one of the cerebral cortex areas that would be an effect of photic stimulation. This hypothesis was also rejected. The findings in this EEG phase were less significant, however differentiation between groups was still obtained even though at less significant levels of probability and fewer channels. It must be noted that in a stimulated state, differences are more difficult to obtain because amplitude decreases in all cases upon photic

stimulation. In spite of this phenomenon, differences were obtained on all measures of creativity.

The third and final sub-hypothesis was formulated in the following form: There are no significant differences in the mean amplitudes between the resting and photically stimulated phases, for groups of individuals classified as Low, Middle and High scorers on tests of creativity. This hypothesis also had to be rejected. This final sub-hypothesis was intended to investigate information stemming from the first and second sub-hypotheses. It became evident in the early stages of this investigation that some individuals had low and other high EEG amplitudes. Upon classification of these individuals into creativity groups according to their scores on the creativity measures, a speculation that creative individuals have a low amplitude cerebral output became affirmed. The differential reduction in amplitude potentials upon photic stimulation became a related point of interest. The reason for this interest was this investigator's extension on Walter's[7] alpha rhythms scanning hypothesis wherein he implies that the alpha wave rhythm best observed in the occipital cortex can be thought of as a scanning mechanism. His thinking can be extended to say that the smaller the amplitude the higher

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7 W. Gray Walter, The Living Brain, Harmondsworth, Penguin Books, 1961, p. 101.

the frequency; consequently, the greater the brain activity. Finally, the greater the initial, or resting brain activity, the lesser the change will be upon stimulation. To put it less formally, the more alert the brain the less effort will it require upon stimulation to respond adequately. For this reason, the creative individual, the person falling into the high creativity group in this study, will draw answers to problems with greater facility, since the material is more readily available to him, while his non-creative, or low scoring colleague on the creativity tests will have to put forth more effort to respond with creative answers. The amount of change of amplitude between the resting and the stimulated phases was interpreted as the amount of the cerebral energy expended. With the exception of the creativity test defined as Word Fluency, the high creativity group demonstrated the smallest differences of the three creativity groups in the change of amplitude upon stimulation. These findings seem to substantiate strongly the extended speculation of Walter.[8]

Considering these findings, it becomes evident that the study of brain functioning from the psychoneurological point of view should be investigated in less global dimensions. The neurological complexity of the physical

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8 Walter, Op. Cit., p. 101.

organ of intellect is such that much could be gained for the understanding of the whole by careful study of its parts. Guilford's factor analytic attempt at considering the intellect in structures of different operations has opened an important avenue which psychoneurology can follow in its search for answers to the functioning of the brain and the behavioral concomitants of these functions.

It is assumed that the past attempts to find relationships between intelligence and EEG variables have largely failed due to the oversight of the multidimensional variables present in the intelligence tests used today.

In view of the volume of material stemming from this research, a global interpretation of the tables was followed. The interested reader could gain knowledge from the scrutiny of differences in individual channels, phases, and aspects of creativity. A large number of observations can be made from the data in the tables. Many of these will result in working hypotheses for further research.

Suggestions for future research appear limitless and the following evasion of specifity in this regard may be viewed as the level of present creativity at the disposal of this investigator. Because of the divergence entailed in such speculation, it may be more appropriate to suggest two broad categories of investigation. One the one

hand, it may prove profitable to search for correlations between the employed encephalographic variable and test productions or performances purported to measure aspects of creativity, imagination and high level of cognitive functioning. And on the other hand, correlations with living behavior patterns and styles, that is, the extended quantity and quality of human behavioral produce.

SUMMARY AND CONCLUSIONS

This investigation attempted to compare divergent creative thinking abilities to EEG measured brain activity via the amplitude variable. The first purpose was to explore a theory of spread of cerebral field fronts as a factor in creativity. The second aim was to investigate possible amplitude differences in resting and photically stimulated states among groups of individuals classified as Low, Middle, and High scorers on tests of creativity. Finally, an attempt was made to investigate mean amplitude differences between the resting and photically stimulated phases for the three creativity groups.

The main hypothesis considering a possible relationship between the spread of field fronts in the cerebrum and creativity could not be conclusively tested due to the insufficient sensitivity of the EEG instrumentation.

The first sub-hypothesis that there are no significant differences in EEG amplitudes, among groups of individuals classified as Low, Middle, and High scorers on tests of creativity, in any one of the cerebral cortex areas investigated, was rejected. It was found that amplitude output significantly differed in groups of individuals classified as Low, Middle, and High scorers on tests of creativity utilized in this study.

The second sub-hypothesis stated that there are no significant differences in EEG amplitudes, among individuals classified as Low, Middle, and High scorers on tests of creativity, in any one of the cerebral cortex areas that would be an effect of photic stimulation. This hypothesis was also rejected. Differences were obtained indicating different levels of effected amplitude for the three creativity groups.

The third and final sub-hypothesis that there are no significant differences in the mean amplitudes between the resting and photically stimulated phases, for groups of individuals classified as Low, Middle, and High scorers on tests of creativity also had to be rejected. Significant differences were found on all measures of creativity used in this investigation.

The interesting phenomenon of the lowest amplitude in the high creativity group was present in all tests with the exception of one, where the exact reversal occurred.

These findings suggest an apparently limitless scope for further research. Correlations could be sought between the EEG variable employed in this investigation and test performances which purport to measure aspects of creativity, imagination and other levels of cognitive functioning.

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A summary report of information concerning known factors in the area of intellectual aptitudes. Tests of creativity of the divergent type of thinking are presented among others and their places in the intellect model are indicated.

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APPENDIX 1

TEST OF CREATIVITY DEFINED AS ASSOCIATIONAL FLUENCY

APPENDIX 1

TEST OF CREATIVITY DEFINED AS ASSOCIATIONAL FLUENCY

Form "A"

by Paul R. Christensen and J. P. Guilford

NAME _____ SEX: M ____ F ____ SCORES: I ____ II ____

GROUP _____ DATE _____ Total ____

In this test you are to write words similar in meaning to the given word.

SAMPLE ITEM:

Write words similar in meaning to the word HARD.

HARD:

difficult _____ severe _____

solid _____ unfeeling _____

tough _____ _____

stiff _____ _____

Notice that the words written above are all somewhat like the word HARD in meaning. In the test you are to write as many words as you can that are similar in meaning to the given word.

WAIT FOR THE SIGNAL BEFORE TURNING OVER PAGE.

Write as rapidly as you can. Avoid using a word more than once. Your score will be the total number of words you write (similar in meaning to the given word).

There are two parts to this test. You will have 2 minutes for each part.

Are there any questions?

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART I

a. CALM:

b. FOUL:

STOP HERE. WAIT FOR [illegible] INSTRUCTIONS.

PART II

a. POSITIVE:

b. FAIR:

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

APPENDIX E

TEST OF CREATIVITY DEFINED AS WORD FLUENCY

APPENDIX B

TEST OF CREATIVITY DEFINED AS WORD FLUENCY

Form "A"

By Paul R. Christensen and J.P. Guilford

NAME _____ SEX: M ____ F ____ SCORES: I ____ II ____

GROUP _____ DATE _____ Total ____

In this test you are to write words that contain a certain letter of the alphabet. This will be a different letter in each item of the test.

SAMPLE ITEM:

Write words containing the letter O.

load	provide	
pot	fought	
over	loss	
too		

All the words written above contain the letter "O" at least once.

WAIT FOR THE SIGNAL BEFORE TURNING THIS PAGE.

Avoid using a word more than once; avoid even different forms of the same word, such as "bond" and "bonded." Your score will be the number of words that you write containing the given letter during limited time, so work rapidly.

There are two parts to this test. You will have 2 minutes for each part.

Are there any questions?

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART I

WRITE WORDS CONTAINING THE LETTER B.

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART II

WRITE WORDS CONTAINING THE LETTER T.

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

APPENDIX B

TEST OF CREATIVITY DEFINED AS ALTERNATE USES

APPENDIX 3

ALTERNATE USES

Form "A"

TEST OF CREATIVITY DEFINED AS ALTERNATE USES

Paul R. Christensen, J.P. Guilford, Philip R. Merrifield and Robert C. Watson

NAME _____ SEX: M ____ F ____ SCORES: I ____ II ____ III ____

GROUP _____ DATE _____ Total ____

In this test, you will be asked to consider some common objects. Each object has a common use, which will be stated. You are to list as many as six other uses for which the object or parts of the object could serve.

EXAMPLE:

Given: A NEWSPAPER (used for reading). You might think of the following other uses for a newspaper.

a. start a fire

b. wrap garbage

c. swat flies

d. stuffing to pack boxes

e. line drawers or shelves

f. make up a kidnap note

Notice that all of the uses listed are different from each other and different from the primary use of a newspaper. Each acceptable use must be different from others and from the common use.

Do not spend too much time on any one item. Write down those uses that occur to you and go on to the others in the same Part. You may return to the incomplete items in a Part if time for that Part permits.

There are three parts to this test, with three items per part. You will have 4 minutes for each part.

If you have any questions, ask them now.

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART I

List as many as six possible uses for each of the following objects:

1. SHOE (used as footwear)

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

2. BUTTON (used to fasten things)

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

3. KEY (used to open a lock)

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART II

List as many as six possible uses for each of the following objects:

4. CHAIR (used for sitting)

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

5. WATCH (used for telling time)

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

6. SAFETY PIN (used for fastening)

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

List as many as six possible uses for each of the following objects:

7. WOODEN PENCIL (used for writing)

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

8. AUTOMOBILE TIRE (used on the wheel of an automobile)

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

9. EYEGLASS (used to improve vision)

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

APPENDIX 4

TEST OF CREATIVITY DEFINED AS IDEATIONAL FLUENCY

IDEATIONAL FLUENCY I

TEST OF CREATIVITY DEFINED AS IDEATIONAL FLUENCY

Form "A"

By Paul R. Christensen and J.P. Guilford

NAME _____ SEX: M ____ F ____

SCORES: I ____ II ____ III ____ IV ____ Total ____

GROUP _____ DATE _____

In this test you are to name things that belong in certain classes.

SAMPLE ITEM:

Name FLUIDS that will BURN.

gasoline
kerosene
hydrogen
Alcohol

In this sample item, the task is to make a list of fluids that will burn. Four such fluids have been listed by way of example. Of course, there are many other answers that could be listed.

For this test, a fluid is any non-living thing that is liquid of gas. A solid is any non-living thing that is not liquid or gas.

The items in this test will be soewhat like the sample item above. Your task will be to write as many things as you can that belong to certain classes. If you are not certain whether a thing fits the class, write it down anyway and try to think of another suitable thing.

WAIT FOR THE SIGNAL BEFORE TURNING THIS PAGE.

There will be four parts to this test. You will have 3 minutes per part. Are there any questions?

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART I

Name FLUIDS that are suitable for DRINKING.

Acceptable - milk
Not acceptable - ether

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART II

Name SOLIDS that
FLOAT on water.

Acceptable - a cork
Not acceptable - oil

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART III

Name ARTICLES of CLOTHING

Acceptable - coat
Not acceptable - spectacles

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

APPENDIX 4

PART IV

Name SOLIDS that are generally used as FOOD and that are SWEET TASTING.

Acceptable - sugar
Not acceptable - flour

6

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

APPENDIX 5

TEST OF CREATIVITY DEFINED AS EXPRESSIONAL FLUENCY

APPENDIX B
TEST OF CREATIVITY DEFINED AS EXPRESSIONAL FLUENCY

EXPRESSIONAL FLUENCY

Form A

By Paul R. Christensen and J.P. Guilford

NAME _____ SEX M ___ F ___ SCORE I ___ II ___ III ___ IV ___
(Print) Last First Middle

GROUP _____ DATE _____ Total ___

In this test you are to write sentences each made up of four words. Each word must begin with the letter indicated.

SAMPLE ITEM:

K eep u p y our i nterest

K ill u seless y ellow i nsects

K idnapping u psets y oung i nfants

K u y i

The task in this item is to write sentences using words that begin with the given letters: K, u, y, and i, in that order. The test contains items similar to this one. You will be required to write as many four-word sentences as you can, using words that begin with the given letters.

WAIT FOR THE SIGNAL BEFORE TURNING THIS PAGE.

All sentences should make sense and be complete. Avoid using the same word twice. Your score will be the number of acceptable sentences you write in the time allowed.

There are four parts to this test. You will have 2 minutes for each part. Are there any questions?

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART I

L c e n

L c e n

L c e n

L c e n

L c e n

L c e n

L c e n

L c e n

L c e n

L c e n

L c e n

L c e n

L c e n

L c e n

L c e n

L c e n

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART II

F o s p

F o s p

F o s p

F o s p

F o s p

F o s p

F o s p

F o s p

F o s p

F o s p

F o s p

F o s p

F o s p

F o s p

F o s p

F o s p

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART III

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

B t h d

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

PART IV

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

M a r g

STOP HERE. WAIT FOR FURTHER INSTRUCTIONS.

APPENDIX 6

ABSTRACT OF

EEG Brain Waves and Creative Thinking

APPENDIX 6

ABSTRACT OF

EEG Brain Waves and Creative Thinking[1]

This study set out to investigate the possible relationship between measurements of EEG amplitude and creative thinking as measured by five tests of creativity in the dimension of divergent thinking

The first stage of the investigation involved an attempt to evaluate Eccles' electrophysiological theory of creative thinking. The second phase of the study included an investigation of possible amplitude differences in both the resting and visually stimulated phases of brain activity among subjects categorized as High, Middle, and Low scorers on selected tests of creative thinking. The final stage of the investigation included an analysis of mean amplitude differences for the resting and stimulated phases of the three creativity groups.

Amplitude in this study was indirectly measured by the weighing in grams of transparent acetate film tracings obtained from one second samples of delinated EEG wave forms.

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1 John O. Wyspianski, doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, May 1965, viii-108 p.

Due to the complexity of the differential cortical activation to photic stimulation in all creativity groups and with all tests of creativity, a testing of the main hypothesis had to be postponed for future research when analytic instrumentation becomes available.

The second and third stages of this investigation have yielded positive results. Positive findings were obtained in that significant differences were found between levels of creativity as measured by five tests of creative thinking and EEG measurements of amplitude. The final dimension of this study showed significant differences in the decrements of amplitude for the three creativity groups upon visual photic stimulation.

Suggestions for future research, consequent to these findings might profitably include an investigation of possible relationship between the dimension studied in this dissertationwith purported psychometric assessments of high level personality qualifications, as well as correlations with situational behavior categorized as intelligent, imaginative, and creative.