RETINO-CORTICAL INHIBITION AND CREATIVE THINKING

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INTRODUCTION

The neurophysiological inhibition phenomenon has intrigued many psychologists in their search for neurological factors underlying psychological functions. Various theories like neural satiation, cortical inhibition and cortical conductivity have been formulated in attempts to account for the phenomenon of inhibition. According to these theories, prolonged stimulation of a sensory surface, leads to a central inhibitory process which raises resistance in the stimulated cortical area and lowers the level of cortical conductivity and functional communication between different parts of the brain. This state is believed to bear a detrimental effect on the integrative and, consequently, on the level of cognitive functioning. As the creative brain is described by Eccles as highly integrated and seemingly low in its inhibitory effects, an interest in a possible relationship between this neurophysiological inhibition phenomenon and creative thinking ability, arose which provided the impetus for the present research study.

Experimental verification on inhibition theories has only been partially successful. This is probably due to multiple factors such as the use of inadequate instrumentation, a contamination by peripheral factors or an insufficient recognition of the underlying neurophysiological complexities involved. In this study, a relatively new apparatus which

presumes to assess the degree of retino-cortical accessibility or reluctance present and which provides a reliable measurement of figure-ground light intensity necessary to produce a sustained negative after-image, has been employed as a measuring tool of retino-cortical inhibition. The Guilford Creative Thinking tests used, were also of a perceptual-figural nature. The selection of the visual sense modality as an avenue to explore possible neurophysiological mechanisms underlying the ability to think creatively, stems from the belief that the visual apparatus is anatomically and functionally more closely related to brain functioning than nerve tracks from other sense modalities.

The thesis is divided into three chapters. In the review of the literature inhibition theories and a neurophysiological theory of the creative brain as well as contemporary research related to these theories is discussed. This is followed by a second chapter which presents a description of the measuring tools, the procedures employed and an analysis of the statistical data. The final chapter deals with the reporting and discussion of the experimental results. The findings are first viewed within the theoretical framework outlined in the review of the literature. In an attempt to arrive at a deeper understanding of the results of this dissertation, a brief discussion of contemporary neurophysiological research that deals with the origin of

the inhibition phenomenon and its influence on brain functioning, is presented. Conclusions are followed by suggestions for future research which reflect the numerous unanswered problems in this complex and interesting research field.

CHAPTER I

RETINO-CORTICAL INHIBITION AND CREATIVE THINKING

In the first section of this chapter, theories of neural satiation, cortical inhibition and cortical conductivity will be discussed. Contemporary research linked to the theoretical constructs formulated by these theories will be dealt with in a second section. A third section presents Koelea's hypothesized neurophysiological functioning of the creative brain and a discussion of creative thinking. The importance of retino-cortical inhibition as a possible explanatory construct in the field of creative thinking will become evident upon these reviews. This will lead up to the formulation of the main hypothesis of the present study.

1. Theories of Neural Satiation, Cortical Inhibition and Cortical Conductivity.

It has been known to psychologists for a long time that prolonged stimulation of a sensory surface leads to a process in the central nervous system that causes subsequent responses to be altered as reflected in resulting after-effects. Different authors attempted to explain this process in terms of a neurophysiological theory. Mainly three theories, which all deal essentially with the same phenomenon, were formulated and will be discussed.

Köhler and Wallach[1] in 1944 introduced the term neural satiation as an explanatory construct to account for the phenomenon of figural after-effects. Working in the field of perception, they found that when an inspection-figure is fixated for a prolonged period of time, a subsequently presented test figure is seen as displaced from its actual position. The amount of figure displacement that occurred, was called figural after-effect and they accounted for it in terms of a neurophysiological field theory. According to this theory, electrical currents evoked by the fixation of an inspection-figure, creates a condition of electrotonus in the stimulated cortical area which leads to an immediate polarisation of tissue surfaces. This polarization of the affected cells increases their resistance and impedes subsequent current flow to that area. Functional communication between different cortical areas, which they see as a basic attribute of cortical activity, is thus decreased. Continued localized excitation, caused by prolonged fixation, increases the electronic state and causes a localized inhibition and a lowered cortical conductivity. This

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1 W. Köhler and H. Wallach, "Figural After-Effects; An Investigation of Visual Processes", Proceedings of the American Philosophical Society, 88, 1944, p. 269-357.

condition is called neural satiation. Köhler says:

> Prolonged presence of an I-object lowers the conductivity of its cortical area and adjacent regions. Actually, the change appears to be mainly an increase in polarizability of the tissues in question... If the conductivity of the area is lowered, the intensity of currents which passes through this area is at once decreased[2].

The current flow pattern evoked by subsequent test figures is thus altered in the form of a displacement from the affected satiated region. The amount of displacement is reflected in a figural after-effect which is the main observable and measurable indicator of the phenomenon called neural satiation.

Köhler and Wallach's empirical work on the figural after-effect has been largely confirmed and extended but their neurophysiological interpretation has been disputed. Their main critics, Osgood and Heyer[3], attempted to explain after-effects within the framework of accepted neurological principles. According to them, fixation of an inspection-figure causes a ridge of neural activity which, through summative processes, results in a peaked distribution in

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2 Wolfgang Köhler and Hans Wallach, "Figural After-Effects", Proceedings of the American Philosophical Society, 88, 1944, p. 269-357, quoted by John Kranakopf, "The Magnitude of Figural After-Effects as a Function of Duration of Test Period", American Journal of Psychology, Vol. 67, No. 4, Dec. 1954, p. 684-690.

3 Charles E. Osgood and Albert W. Heyer, "A New Interpretation of Figural After-Effects", Psychological Review, Vol. 59, No. 2, 1952, p. 98-118.

the stimulated cortical area. The contour of the subsequent test figure is skewed away from the first contour because of an area of depressed excitability caused by the inspection figure. The distance between the peaks of the two contours results in the appearance of a figural after-effect. Smith[4,5] criticized Köhler and Wallach's as well as Osgood and Heyer's theory. He pointed out that both fail to explain after-effects which occur across the vertical median of the eye and thus across the longitudinal fissure in the striate cortex; after-effects of apparent movement as well as after-effects occurring in other sense modalities.

Despite disagreement on theoretical grounds, the existence of satiation effects as inferred from measuring the effect of visual stimulation on subsequent perceptual responses is, by most authors, agreed upon as being an empirically established fact. Köhler and his followers believe in the central origin of visual after-effects. The argument for central versus peripheral origin is based on the empirical finding that shifting to a fresh retina after one retina has been stimulated does not change the satiation effect while

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4 Kendon R Smith, "The Satiational Theory of Figural After-Effects", The American Journal of Psychology, Vol. 61, No. 2, 1948, p. 252-256.

5 Kendon Smith, "The Statistical Theory of the Figural After-Effect", Psychological Review, Vol. 59, No. 5, 1952, p. 401-402.

shifting to a fresh hemisphere shows no evidence that satiation did take place. Day[6] argued that appearance of the after-image, through the nonstimulated eye, cannot be taken as sole evidence of a central origin because of the overlap of monocular visual fields in the occipital lobe of the brain. To point out clearly that peripheral and cortical components are involved in the satiation process, it will be more appropriate to talk of retino-cortical satiation than neural satiation.

Eysenck[7], in his search for neurological causative factors underlying dimensions of personality, hypothesized a construct in the field of learning similar to neural satiation which he called cortical inhibition. The neo-Pavlovian concept of excitation-inhibition balance which was assumed to be a constitutional factor predisposing an individual to develop either excitatory potentials particularly strong and inhibitory potentials weak or vice versa, forms the basis of his theory. Eysenck theorized that whenever a stimulus-response connection is made in the organism, the response at the same time leaves a condition in the physical structure

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6 S.H. Day, "On Interocular Transfer and the Central Origin of Visual After-Effects", The American Journal of Psychology, Vol. 71, No. 4, 1958, p. 784-790.

7 H.J. Eysenck, "Cortical Inhibition, Figural After-effect, and Theory of Personality", The Journal of Abnormal and Social Psychology, Vol. 51, No. 1, 1955, p. 94-106.

of the brain which inhibits the activity in question. Individuals differ with regard to the speed with which reactive inhibition is produced, the strength of it and the speed of dissipation. He verified his theory in the field of personality. Eysenck has used the kinesthetic after-effect as a measuring tool of reactive cortical inhibition, inferring the latter process by measuring the effect of stimulation on subsequent motor responses. He sees neural satiation as essentially similar to reactive cortical inhibition, calling the former cortical inhibition in the visual sense modality. He writes:

> The general law of inhibition enunciated by Pavlov and more explicitly by Hull, appears to be formally identical with that advanced by Köhler in terms of perceptual satiation[8].

The foregoing theories have been enlarged upon by Klein and Krech[9] who chose to talk in terms operationally the inverse of cortical inhibition, i.e. cortical conductivity. They claim that any neuronal activity increases resistance to conductivity and hypothesize in addition individual differences in basal levels of cortical conductivity. Cortical conductivity, according to them, is

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8 Eysenck, Op. Cit. p. 99.

9 George S. Klein and David Krech, "Cortical Conductivity in the Brain-Injured", Journal of Personality, Vol. 21, No. 1, 1952, p. 118-148.

a basic parameter which reflects the status of the total neurophysiological economy. It determines the degree of functional communication between the basic units of the brain and is a crucial parameter of individual differences in cortical integration and cognitive functioning. Their main contribution lies in their implication of individual differences in the basal level of cortical conductivity. This basic level is mainly determined by the overall status of the cortex and its level, degree and persistence of satiation-ability are reflected in reactive cortical conductivity which can be measured through visual or kinesthetic after-effects.

Becker[10] objected to Eysenck's interchangeable use of the terms inhibition, reactive inhibition, satiation and cortical conductivity. He contributed significantly to the field by his clarification and identification of these terms in historical and functional perspective and by listing different psychological and physiological measures pertaining to the specific type of inhibition. In an experimental study using these different measuring tools, he found no empirical evidence to support Eysenck's assumption that satiation and reactive inhibition form a unitary trait. They showed some common variance with basal inhibition measures, but not with

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10 Wesley C. Becker, "Cortical Inhibition and Extraversion-Introversion", The Journal of Abnormal and Social Psychology, Vol. 61, No. 1, 1960, p. 52-66.

each other. His study is important and calls for caution but its validity can be questioned in the light of his small sample. Fenton[11] also objected to Eysenck's "theoretical looseness" in his conceptualization of inhibition. She correlated scores on a basal and temporal inhibition measure in an experimental study but found no significant relationship between them. The unreliability of her temporal inhibition measure, however, weakens her results. Rechtschaffen[12] who estimated low but insignificant correlations between visual and kinesthetic after-effect measures, questioned their reliability but remarked that lack of correlation of response measures does not rule out similarities in underlying processes. Despite the unfortunate lack of neurophysiological or psychological experimental evidence regarding the identity of different types of inhibition, their underlying similarities have been recognized and pointed out by Duncan[13],

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11 Marilyn Fenton, Reactive Inhibition and Evoked Cortical Responses, Unpublished Master's thesis, University of Ottawa, 1964, 63 p.

12 Allan Rechtschaffen, "Neural Satiation, Reactive Inhibition, and Introversion-Extraversion", The Journal of Abnormal and Social Psychology, Vol. 57, No. 3, 1958, p. 283-291.

13 Carl P. Duncan, "On the Similarity Between Reactive Inhibition and Neural Satiation", The American Journal of Psychology, Vol. 69, No. 2, 1956, p. 227-235.

Meier[14] and several other authors. Although existing theories of neural satiation, cortical inhibition and cortical conductivity are all far too simple and too speculative at the neurophysiological level to explain any causality, they all, as Meier said, imply that a continuous excitation of a sensory surface leads to a process in the central nervous system which causes subsequent responses to be altered.

2. Recent Research on Neural Satiation, Cortical Inhibition and Cortical Conductivity

Although the different theories discussed in the previous section all deal essentially with the same neurophysiological inhibition phenomenon, each one stimulated different fields of research. The fact that multiple response measures were used, often unrelated and inadequate, led to a great deal of confusion, fluctuation and even contradiction of evidence and opinion among research workers. Unfortunately, no direct evidence is available in the literature on possible relationships between retino-cortical inhibition and creative thinking as measured through the use of perceptual-figural test material. Other research studies where the inhibition phenomenon is demonstrated and which are

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14 V. Meier, "Psychological Effects of Brain Damage", Handbook of Abnormal Psychology, New York, Basic Books, 1961, p. 529-565.

of indirect importance to the investigation proposed by the present study, will therefore be reviewed. The writer is especially interested in the inhibition phenomenon as tapped through the visual sense modality as it is believed that the visual apparatus is anatomically and functionally closer related to brain functioning than nerve tracks from other sense modalities. It will thus probably yield the best index of cortical inhibition apart from direct neurological measures of the cortex itself. Examples of inhibition measures related to intracranial pathology, prototype of the inhibited brain, to personality variables and to perceptual-cognitive functioning will be discussed.

Intra-cranial pathology has, by different authors, been found related to neural satiation and cortical inhibition. Price and Deabler[15] used the Spiral After-Effect, interpreted as a measure of neural satiation, to compare the performance of 120 intra-cranial pathology cases with a control group and found that seventy-two percent of the former could not see any after-effect at all. Page and Rakita[16] also found differences in Spiral After-Effect test

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15 A. Cooper Price and H.L. Deabler, "Diagnoses of Organicity by Means of Spiral Aftereffect", Journal of Consulting Psychology, Vol. 19, No. 4, 1955, p. 299-302.

16 H.A. Page, G. Rakita et al., "Another Application of the Spiral Aftereffect in the Determination of Brain Damage", Journal of Consulting Psychology, Vol. 21, No. 1, 1957, p. 89-91.

performance between brain-damaged subjects and normals statistically significant. Kovatch[17] tested the hypothesis that intra-cranial pathology cases show more cortical reactive inhibition according to the theoretical positions of Pavlov and Eysenck. He used the Negative After-Image Threshold, interpreted as a measure of retino-cortical inhibition, as measuring tool and found the duration of the after-image significantly shorter in the brain-damaged cases. His findings support the theory that the after-image is cortically influenced and that pathology of one area of the brain, can affect the functioning of the visual cortex. Jaffe[18] tested unilateral brain-damaged cases with the kinesthetic after-effect but found no significant difference between them and normals. Klein and Krech[19] commented on this study by saying that Jaffe's unilateral cases may not have shown enough organismic involvement to introduce a general physiological change which, if present, would have been reflected in the level of cortical conductivity. Klein and Krech interpret the relation between cortical inhibition and

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17 Joseph D. Kovatch, Intra-Cranial Pathology and the Negative After-Image Threshold, Unpublished Masters Thesis, University of Ottawa, 1961, 42 p.

18 Robert Jaffe, "Kinesthetic After-Effects Following Cerebral Lesions", The American Journal of Psychology, Vol. 67, No. 4, 1954, p. 668-676.

19 Klein and Krech, Op. Cit., p. 145.

intra-cranial pathology as evidence of a lowered state of cortical conductivity in the brain injured and consequently as a greater amount of functional isolation between the different cortical areas. They see a narrowing of interest and rigidity as behavioral correlates of lowered cortical conductivity. Hamilton[20] stated that inhibition as a result of brain-damage is a function of the whole cortex and in turn learning is inhibited or enhanced by a generalised cortical functioning.

High performance scores on the Necker Cube and Reversible Figures tests illustrating perceptual flexibility and interpreted by Köhler in terms of neural satiation, were found by several authors to be inversely correlated to intra-cranial pathology. These studies, according to Spitz[21], give the impression of a positive correlation between brain-damage and a low state of satiation but he concludes righteously that satiation theory fails to explain the Necker Cube phenomenon satisfactorily.

After-effects, as measuring tools, have been brought to the field of personality mainly through the experimental

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20 Max Hamilton, "On the Nature of Inhibition in the Cerebral Cortex", Psychological Review, Vol. 59, No. 1, 1952, p. 49-53.

21 Herman H. Spitz, "The Present Status of the Köhler-Wallach Theory of Satiation", Psychological Bulletin, Vol. 55, No. 1, 1958, p. 1-28.

work of Eysenck and his associates[22]. Eysenck believesthat the fundamental difference between introversion and extraversion is inherited in the form of a cortical predisposition called cortical inhibition which hampers early learning, conditioning, and hence socialization, predisposing the individual to the extravert pole of the personality dimension. He verified his position by supplying evidence that extreme extraverts showed significantly more inhibition than extreme introverts as measured through a kinesthetic after-effect. Lynn[23] found a correlation of -.43 between extraversion and the duration of the Archimedes Spiral, thus supporting Eysenck. Holland[24] also found significant correlations between spiral duration times and introversion-extraversion in the hypothesized direction. Noroross, Lipman and Spitz[25], however, in working out twenty correlations between the variables introversion, extraversion, visual and kinesthetic after-effects, found only one significant correlation (.29)

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22 Eysenck, Op. Cit., p. 94-106.

23 R. Lynn, "Extraversion, Reminiscence, and Satiation Effects", The British Journal of Psychology, Vol. 51, Part 4, 1960, p. 319-324.

24 H.C. Holland, The Spiral After-Effect and Extraversion, Unpublished Doctoral Thesis, University of London, 1959.

25 Kathryn J. Noroross, Ronald S. Lipman et al., "The Relationship of Extraversion-Introversion to Visual and Kinesthetic Aftereffects", The Journal of Abnormal and Social Psychology, Vol. 63, No. 1, 1961, p. 210-211.

namely between extraversion and visual after-effects. Their results were essentially confirmed by Rechtschaffen[26] who criticised Eysenck's work and concluded that evidence for his theory remained meager.

McDougall[27] also explained differences between introverts and extraverts in neurophysiological terms. He saw extraversion as a result of a chemical disposition of the nervous system which produces a relative condition of general dissociation and heightens resistance at synapses while introversion was explained in terms of low synapse resistance. He used the Necker Cube as a test of introversion-extraversion hypothesizing that increased synaptic resistance would decrease the rate of fluctuation. His theory has been contested but received also empirical support. In a recent extensive experiment, Franks and Lindall[28] tested 46 introverts and 46 extraverts with the Necker Cube. The rate of fluctuation of the introverts was higher than from the extraverts as expected from McDougall's theory but the

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26 Rechtschaffen, Op. Cit., p. 283-291.

27 William McDougall, "The Chemical Theory of Temperament applied to Introversion and Extroversion", The Journal of Abnormal and Social Psychology, Vol. 24, No. 3, 1929, p. 293-309.

28 Cyril M. Franks and L.E.H. Lindahl, "Extraversion and Rate of Fluctuation of the Necker Cube", Perceptual and Motor Skills, Vol. 16, No. 1, 1963, p. 131-137.

difference was statistically significant only in one of the three mass trials.

Conditioning studies, based on Eysenck's inhibition model, were in general successful as reported by Franks[29] in his review of the literature. According to this model, conditioning is facilitated by excitatory potentials. Introverts are thus expected to condition quicker and stronger than extraverts. That conditioning is facilitated by an excitatory neuronal state and hampered by inhibition, received empirical support from the work of Zakusov[30]. He concluded, after an analysis of the effects of various pharmacological agents on higher divisions of the central nervous system, that substances having a depressant type of action, inhibit the formation of conditioned connections while those with stimulating effects, facilitate these connections. This should, according to him, explain the effect of processes of inhibition and irradiation on nervous activity.

Eysenck and McDougall also used drugs to verify their theories. According to Eysenck's drug hypostulate, depressant

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29 Cyril M. Franks, "Personality and Eyeblink Conditioning Seven Years Later", Acta Psychologica, Vol. 21, No. 4, 1963, p. 295-312.

30 V.V. Zakusov, "The Effects of Pharmacological Agents on Conditioned and Unconditioned Reflexes", Annals of the New York Academy of Sciences, Pavlovian Conference on Higher Nervous Activity, Vol. 92, Academy of Sciences, 1961, p. 984-989.

drugs increase inhibitory and decrease excitatory potentials, while stimulant drugs have the opposite effect. He expected that the effect of depressant drugs would resemble extravertic behaviour patterns and that extraverts would be more susceptible to these drugs than introverts. Using Doriden and Meprobate as depressant drugs, he obtained significant results although his correlations were low[31]. In hypothesising that stimulant drugs will increase the duration of visual afterimages and depressant drugs will decrease it, Eysenck, Holland and Trouton[32] investigated the effect of Sodium Amythal and Dexedrine on the duration of the Archimedes Spiral. The results with the depressant drugs were highly significant while the results using the excitant drug just missed statistical significance.

Some corroborative evidence to neural satiation and inhibition theories has been provided by electroencephalographic studies. Santibanez-H[33], for example, proved experimentally that repeated stimulation creates an

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31 H.J. Eysenck, Experiments in Personality, Vol. 1, London, Routledge and Kegan Paul, 1960, vii-262 p.

32 H.J. Eysenck, H. Holland et al., "Drugs and Personality III, Effects of Stimulant and Depressant Drugs on Visual Aftereffects", Journal of Mental Science, Vol. 103, 1957, p. 119-131.

33 Guy Santibanez-H, "Behavioral and Electrophysiological Effects of Repetitive Transient Stimulation", Symposium X, Acta Psychologica, Vol. 23, 1964, p. 139-140.

inhibitory feedback which is exhibited in the form of decreased evoked potentials. Shagass and Schwartz[34] in correlating age, introversion-extraversion and evoked potentials, found that amplitudes differed significantly with respect to extraversion and age interactions below twenty and above forty years of age. In the interpretation of the results, he attributed the difference in early years to late maturation and that in later years to an earlier neurological degeneration in the extraverts.

Klein and Krech[35] through their theory of cortical conductivity, provided the main impetus for research on the inhibition phenomenon in the perceptual-cognitive sphere. According to their theory, cortical conductivity is a crucial parameter for individual differences in cortical functioning and cortical integration. Following the rationale of this theory, Krech and Calvin[36] used the after-image of tachistoscopically presented nonsense figures, which consisted out of stimulus patterns arranged in different degrees of complexity, and found the level of perceptual organisation

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34 C. Shagass and M. Schwartz, "Age, Personality and Somatosensory Cerebral Responses", Science, Vol. 148, No. 3675, 1965, p. 1359-1361.

35 Klein and Krech, Op. Cit., p. 118-148.

36 David Krech and Allen Calvin, "Levels of Perceptual Organization and Cognition", The Journal of Abnormal and Social Psychology, Vol. 48, No. 3, 1953, p. 394-400.

highly related to intelligence. In discussing this finding, they write that the rate and degree of perceptual development may be determined by the level of cortical conductivity. Mundy-Castle[37] used the same after-image and found it significantly related to alpha rhythm frequency of the E.E.G., visual imagery and intelligence. He continued to say that alpha rhythm seems closely related to cortical conductivity, if not a measure of it, and cortical conductivity seems to be a determinant of speed of perception and speed of central processes. These remarks of Mundy-Castle are challenging and worth investigating. They receive some empirical support from Ertl's[38] important finding of a high inverse correlation (.88) between intelligence and intra-cortical delay as measured through evoked potentials elicited by a single visual stimulus. These studies highlight the importance of the theory of cortical conductivity as well as of tachistoscopically presented nonsense figures as measuring tools. However, this after-image has not been shown related to other after-images usually employed as measures of satiation or retino-cortical inhibition and caution should be exercized in

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

38 J. Ertl, Intra-Cortical Delay and Intelligence, Unpublished Masters Thesis presented to the School of Psychology and Education, University of Ottawa, 1961, 41 p.

drawing conclusions in terms of these constructs.

Following a hypothesis directly deducted from Klein and Krech's theory, Lipman and Spitz[39] correlated scores on vocabulary with scores on visual and kinesthetic after-effects but did not arrive at significant results. Meier[40] however, found a low but significant relationship of -.26 between vocabulary and the magnitude of kinesthetic after-effect.

Several perceptual-cognitive styles like leveling-sharpening and field dependence - field independence have been found to be of importance to theories of neural satiation, cortical inhibition and cortical conductivity. Klein, Witkin and their associates[41] believe that perception varies according to preferred styles of organizing, controlling and selecting stimuli. They call these styles cognitive attitudes and assume that a person shows the same basic cognitive attitude in different perceptual situations including basic perceptual experiences like after-images as well as complex

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39 Ronald S. Lipman and Herman H. Spitz, "Cortical Conductivity and Vocabulary", The Journal of Abnormal and Social Psychology, Vol. 63, No. 2, 1961, p. 459-560.

40 Manfred J. Meier, "Interrelationships among Personality Variables, Kinesthetic Figural Aftereffect, and Reminiscence in Motor Learning", The Journal of Abnormal and Social Psychology, Vol. 63, No. 1, 1961, p. 87-94.

41 H.A. Witkin, H.B. Lewis, et al., Personality Through Perception, New York, Harper, 1954, xxvi-571 p.

stimulus patterns. Klein[42] feels that their research in the perceptual-cognitive attitude of leveling-(minimizing stimulus differences) sharpening (maintaining the discreteness and independence of stimuli) touches common ground with research in time-errors and in satiation-effects and may thus fruitfully be used as a conceptual starting-point for the study of individual differences in these events. Holzman[43] believes that the attitude of leveling-sharpening is the basic cause for individual differences in time-errors and proved in an experimental study that a group of levelers showed significantly more time-errors than sharpeners. Individual differences in time-errors are in turn explained by Claridge[44] in terms of Eysenck's theory of cortical inhibition. He provided evidence of significant differences in time-errors between introverts and extraverts in the expected direction supporting a previous similar finding of Eysenck.

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42 George S. Klein, "The Personal World through Perception", Perception: An Approach to Personality, New York, Ronald Press, 1951, p. 328-355.

43 Philip S. Holzman, "The Relation of Assimilation Tendencies in Visual, Auditory and Kinesthetic Time-Error to Cognitive Attitudes of Leveling and Sharpening", Journal of Personality, Vol. 22, No. 3, 1954, p. 375-394.

44 G.S. Claridge, "The Excitation-Inhibition Balance in Neurotics", in H.J. Eysenck, Experiments in Personality, London, Routledge & Kegan Paul, 1960, p. 107-156.

Berkowitz[45] also feels that cortical inhibition may be a significant parameter to account for individual differences in cortical functioning. He tested the hypothesis that subjects preferring simple phenomenal experiences, tend to achieve perceptual-cognitive simplicity through excessive leveling. He found a significant relationship between leveling tendencies and simplicity scores as measured by Barron's Complexity-Simplicity Scale. In an attempt to account for this phenomenon, he correlated complexity scores with intelligence and initial learning ability but found no significant results and concluded: "Individual differences may be a function of differences in certain aspects of cortical functioning such as cortical inhibition or cortical conductivity."[46]

The perceptual-cognitive style, field dependence - field independence which reflects according to Witkin "the progress towards the development of differentiated psychological structure"[47], has been found related to introversion-extraversion by Taft and Coventry[48]. They found extraverts

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45 Leonard Berkowitz, "Leveling Tendencies and the Complexity-Simplicity Dimension", Journal of Personality, Vol. 25, No. 6, 1957, p. 743-751.

46 Berkowitz, Op. Cit., p. 750.

47 Witkin, Op. Cit., p. 248.

48 Ronald Taft and James Coventry, "Neuroticism, Extraversion, and the Perception of the Vertical", The Journal of Abnormal and Social Psychology, Vol. 56, No. 1, 1958, p. 139-141.

significantly more field dependent. Gardner[49] provided the meaningful evidence that field articulation, a cognitive control principle which finds expression in field dependence - field independence tests, is related to a person's satiation proneness. He proved that those who were less satiation prone, saw a smaller amount of visual illusion and scored higher on field articulation tests. In another study, he showed that subjects scoring high in field articulation, were fluent in ideas related to stimulus words while those who scored low, manifested few associations and frequent blocking.[50]

The theories and the studies discussed so far, demonstrated that the theoretical constructs of neural satiation, cortical inhibition and cortical conductivity have been experimentally verified and can be measured for individual differences. They were found to be significantly related to the chronic inhibited brain of the brain-injured and, according to Eysenck, to the constitutional inhibited brain of the extravert where conditioning, learning and socialization is hampered. Also shown, was their importance

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49 Riley W. Gardner, "Cognitive Controls of Attention Deployment as Determinants of Visual Illusions", The Journal of Abnormal and Social Psychology, Vol. 62, No. 1, 1961, p. 120-127.

50 R.W. Gardner, P.S. Holzman, et al., "Cognitive Control: A Study of Individual Consistencies in Cognitive Behaviour", Psychological Issues, Vol. 1, No. 4, 1959, p. 1-186.

to individual differences in some forms of perceptual-cognitive behaviour, i.e. of a possible inverse relationship between the inhibition phenomenon and an optimum level of perceptual-cognitive functioning.

3. Retino-Cortical Inhibition and Creative Thinking.

Of immediate interest to the theories of neural satiation and cortical inhibition and the research studies linked to them, is Eccles' hypothesized conception of the neurophysiological condition underlying the creative brain[51]. He sees the creative brain as very complex and versatile; as having accumulated an enormous amount of memory engrams and as having the potency for unresting activity. He believes that the wealth of highly developed complex engrams could only have been established through a decrease in inhibition and a consequent increase in synaptic efficiency. He assumes inhibition in the creative brain is very low, enabling the brain to maintain its memory engrams and to enduringly activate its patterns into novel and interacting forms.

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51 John C. Eccles, "The Physiology of Imagination", Scientific American, Vol. 199, No. 3, Sept. 1958, p. 135-146.

Following this theory directly, Wyspianski[52] tested a hypothesis of Eccles i.e. that the more creative individuals will show a more extensive spread of field fronts in the cerebral cortex because more areas of the cortex are involved in cellular electrical activity. This hypothesis was not confirmed due to insufficient information from the E.E.G. records as more sensitive electronic stimulation would be necessary to measure the spread of field fronts. Analysis of subhypotheses, however, revealed significant amplitude differences during stimulation and resting phases among groups of individuals classified as low, middle and high scorers on tests of creative thinking with the high creative subjects showing the lowest amplitude in cerebral output. According to Wyspianski's interpretation, the smaller the amplitude, the higher the frequency and the greater the brain activity. Also, the greater the initial or resting brain activity, the lesser the change upon stimulation. Short[53] lended further support to Eccles' theory by his finding that alpha rhythm of people using a high degree of visual imagery, were complex and variable in comparison with

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52 John O. Wyspianski, E.E.G. and Creative Thinking, Unpublished Doctoral Thesis presented to the School of Psychology and Education, University of Ottawa, 1963, 108 p.

53 P.L. Short, "The Objective Study of Mental Imagery", British Journal of Psychology, Vol. 44, Part 1, 1953, p. 38-51.

the almost identical rhythms of the unimaginative group. These studies are thus in agreement with Eccles' conception of the creative brain being complex, versatile and seemingly low in its inhibitory effects. Cortical conductivity, in Klein and Krech's terms, seems to be high and drops little upon stimulation enabling the brain to continue its functioning at a high level of efficiency.

The psychological study of creative thinking, has been neglected for a long time. Hutchinson[54], after having reviewed the publications on creative thinking up to 1931, concluded that hardly any important work had been done in this field. Springbett[55] hypothesized that creative thinking differs from conventional problem-solving because it involves a greater sensitivity to unconscious processes. He devised an ingenious little test with which he substantiated his hypothesis. The most extensive factor-analytic study of creative thinking, has been conducted by Guilford and his associates[56]. For the past fifteen years, he has continued

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54 Eliot Dole Hutchinson, "Materials for the Study of Creative Thinking", Psychological Bulletin, Vol. 28, No. 5, 1931, p. 392-410.

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

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

to modify and to elaborate his three-dimensional theoretical model of the structure of the intellect. The process of creative thinking forms part of this model and is called an invention which is a form of production. It includes the factors of fluency, flexibility, originality, elaboration and sensitivity to problems. In relating creative thinking aptitudes to non-aptitude traits, he found the most pronounced inverse relationship between flexibility and rigidity[57].

The broader psychological concept of creativity has recently led to extensive empirical investigation by several authors. Golann[58] in a comprehensive review of the literature, discussed the product, process, measurement and related personality variables. According to him, most authors found creative people significantly more inner-directed and introvertive than non-creatives. Creatives are found to be more complex and independent following an internal locus of evaluation. MacKinnon[59] found them significantly more free from inhibitions and restrains.

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57 J.P. Guilford and P.R. Merrifield, "The Relations of Creative-Thinking Aptitude to Non-Aptitude Personality Traits", Report from the Psychological Laboratory, University of Southern California, No. 20, December 1957, p. 1-51.

58 Stuart E. Golann, "Psychological Study of Creativity", Psychological Bulletin, Vol. 60, No. 6, 1963, p. 548-565.

59 Donald W. MacKinnon, "The Nature and Nurture of Creative Talent", American Psychologist, Vol. 17, No. 6, 1962, p. 484-495.

Myden[60] showed experimentally that they accept their impulse life and use primary processes to a significantly greater extent than non-creatives. Stein and Meer[61] suggest that the real difference between high and low creatives may be a function of the low creatives' inhibition and defensiveness. Crutchfield[62] found that his creative subjects were perceptually more open, preferred complexity and were fluent, flexible and unique in the cognitive sphere. A high degree of perceptual functioning, goes according to Short[63] hand in hand with a high level of visual imagery as perception and imagery, in his opinion, belong to the same psychological and physiological continuum: similar mechanisms account for both.

These studies convey the picture of a creative thinker as having a mind that is neurologically, as well as psychologically, highly complex, differentiated and integrated. Maximum complexity and differentiation is sought in the

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60 Walter Myden, "Interpretation and Evaluation of certain Personality Characteristics involved in creative Production", Perceptual and Motor Skills, Vol. 9, No. 2, 1959, p. 139-158.

61 Morris I. Stein and Bernard Meer, "Perceptual Organization in a Study of Creativity", The Journal of Psychology, Vol. 37, First Half, 1954, p. 39-43.

62 R. Crutchfield, The Creative Process in Conference of the Creative Person, Berkeley, University of Southern California, 1961, quoted by Stuart E. Golann, "Psychological Study of Creativity", Psychological Bulletin, Vol. 60, No. 6, 1963, p. 558.

63 Short, Op. Cit., p. 50.

perceptual-cognitive area and an optimum level of functioning is indicated by their fluency, flexibility and originality in this sphere. In light of the theories of neural satiation, cortical inhibition and cortical conductivity and the research studies linked to them, it may follow that a high creative thinker as expressed through creative tests of a perceptual-figural nature, will show a lesser degree of retino-cortical inhibition than a low creative thinker.

Of importance and interest in this context, is the work of Jaensch[64] on eidetic imagery. He believed after-images to be a basic component of eidetic images and showed experimentally that children high in eidetic capacity, had longer after-images. He was of the opinion that the eidetic phenomenon is an expression of the close union between object and subject; of the interpenetration of psychological functions, characteristic of the minds of children and artists. He called the adult who retained the eidetic characteristics and thus long after-images, the integrate type and concluded: "The integrate mode of experience is the alphabet of art and art rests on it".[65]

The aim of the present study is an investigation of the possible relationship between retino-cortical inhibition,

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64 E.R. Jaensch, Eidetic Imagery, London, Kegan Paul, Trench and Turner, 1930, viii-136 p.

65 Jaensch, Op. Cit., p. 1-80.

as reflected in after-image sensitivity, and creative thinking. The Negative After Image Threshold Apparatus which was designed by Barry[66] based on an original device of Lehman[67], will be used. This instrument presumes to assess the degree of retino-cortical accessibility or retino-cortical reluctance present. It provides a reliable measurement of figure-ground light intensity necessary to produce a sustained negative after-image. The term Negative After Image Threshold or NAIT will be used throughout this study to denote the point or zone where loss of the image occurs as a function of the particular type of field illumination intensity. Six trials will be administered in mass practice and the difference between the after-image threshold of the first and the last trial, will be interpreted as retino-cortical inhibition.

The criterion for creative thinking will be scale scores on five selected tests from Guilford's battery of Creative Thinking[68]. The tests selected are mainly of a perceptual-figural nature and include the factors Guilford

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66 William F. Barry, An Investigation of Relationships between Introversion-Extraversion and the Negative After-Image Threshold, Unpublished Doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, 1961, 80 p.

67 H. Lehman, "Preliminary Report on a Device for the Objective Measurement of the Negative After-Image", Science, Vol. 112, No. 2903, 1950, p. 199-201.

68 Guilford, Op. Cit., p. 1-27.

found to be the most important in the process of creative thinking.

The main hypothesis is stated in the null-form as follows: There is no significant correlation between Negative After Image Threshold scores interpreted as retino-cortical inhibition and Guilford tests scores interpreted as creative thinking.

As five creativity tests will be employed measuring each an independent factor, the possible relationship between each test score and the NAIT scores will be investigated through the following subhypothesis: There is no significant correlation between Negative After Image Threshold scores interpreted as retino-cortical inhibition and each of the subtest scores of the Guilford tests interpreted as distinctive measures of creative thinking.

The next chapter will be devoted to the reporting of the experimental design.

CHAPTER II

EXPERIMENTAL DESIGN

This chapter, in reporting the experimental design, is divided into the following sections. Section one introduces the psychophysiological tool, i.e. the Negative After Image Threshold Apparatus. Section two describes the sample population and the criteria for inclusion of subjects. The next section describes the psychological tool used to measure the ability of creative thinking. A description of the experimental procedures is given in section four including standardized administrative techniques and a scoring technique. The final section reports on the techniques for data evaluation, including statistical formulas employed.

1. The Psychophysiological Tool.

Inadequate instrumentation in measuring the after-image phenomenon was a major factor responsible for the contradictory and inconclusive research work conducted in this field. To experiment with a more objective method of measuring the after-image phenomenon, Lehman[1] devised an instrument capable of sustaining a negative after-image.

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1 H. Lehman, "Preliminary Report on a Device for the Objective Measurement of the Negative After-Image", Science, Vol. 112, No. 2903, 1950, p. 199-201.

Because this instrument was subject to certain shortcomings, Barry[2] devised a new instrument partially based on Lehman's original design. A detailed description of the electro-mechanical structure and standardized methodology of this new instrument called the Negative After Image Threshold Apparatus, has been reported by Barry. Only a few essential features will be reviewed.

The instrument is designed to sustain a negative after-image in the complementary color of the original stimulus color without allowing the subject to perceive the original stimulus. The original stimulus, a red light housed in a cabinet which contains the whole stimulus system, is intermittently obscured from the subject's vision by a rotating disc with two fifteen degree 'pie cuts' at opposite ends of the diameter. This metal disc is composed of two black and one white leaf arranged to permit variation of the white-black ratio. The disk is rotated at 120 revolutions per minute by a synchronous motor and its proximal face is illuminated by two 40 watt bulbs. The measuring and regulating instruments are housed in a control cabinet. Control of the intensity of the stimulus and disk lights is done by

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2 William F. Barry, An Investigation of Relationships Between Introversion-Extraversion and the Negative After-Image Threshold, Unpublished Doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, 1961, p. 32-36, 39-43.

means of separate variacs. The control cabinet contained further two microammeters from which the light intensity of stimulus and disc lights could be read. These microammeters were, in this study, replaced by the larger, finer scaled, and more accurate Avometer. The stimulus light is kept constant during the testing session while the disc illumination is decreased at a constant rate by a motor driven variac and demonstrated on its reading meter.

2. The Sample Population.

The sample consisted of ninety-five men who participated on a voluntary basis. Thirty-five men were members of the Ottawa Fire Department. Thirty-five others were electrical and mechanical engineers from Northern Electric Company. Seventeen were chemists from the Department of Applied Chemistry of the National Research Council. The remaining eight were students: two undergraduates from Carleton University and six graduate students from the School of Psychology and Education of the University of Ottawa. The total sample was thus made up of various subsamples with the aim in mind to obtain as wide a spread as possible in creative thinking ability especially as expressed through the use of visual-figural material.

Previous studies dictated the necessity of controlling for the following variables in sample selection: freedom from serious illnesses and head injuries, from color blindness

and eye diseases and from drug medication. The criteria of sex and age were also controlled on the basis of minor evidence from the literature. Of the ninety-five volunteers, ninety met the necessary criteria and were included in this study. Color blindness was ruled out on the basis of being able to report the proper color of the negative after-image. Five were deleted because of the following reasons: two reported varying degrees of color blindness, one was under the influence of alcohol and three who participated in individual testing, were not able to join the group testing because of necessary duties. The ages ranged from twenty to sixty with a mean age of thirty-five and an educational range from grade nine to Ph.D.

3. The Psychological Tool.

The psychological tests used in this study were selected from the part of the Guilford tests[3] designed to measure creative thinking abilities. These creative thinking abilities form an integral part of Guilford's unified theory of intelligence as represented in his cubical intellect model. A brief description of this model will facilitate the understanding of the nature of the creative thinking

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

abilities that are of interest to this study. It will also illustrate their relationship toward other creative abilities as well as their place in the intellect model.

A) Guilford's Intellect Model

Factor-analytic methods led to the isolation of many intellectual factors which have been grouped in three major dimensions. In the first dimension, five fundamental kinds of operations have been isolated:

1. Cognition: discovery, rediscovery or recognition of information in various forms;
2. Memory: retention of information in any form;
3. Divergent Production: generation of new information from given information with the emphasis on a variety of output;
4. Convergent Production: generation of information from given information where emphasis falls on achieving conventionally accepted or best outcomes;
5. Evaluation: reaching decisions or making judgements concerning the corrrctness or suitability of information.

The second dimension classifies factors according to content involved:

1. Figural Content: concrete information as perceived or recalled in the form of images where "figural" implies some degree of organization;
2. Symbolic Content: consisting of conventional signs such as letters and digits;
3. Semantic Content: information in the form of verbal meanings or ideas;
4. Behavioral Content: essentially non-verbal information involved in human interactions.

The final dimension is that of products obtained when a certain kind of Operation is applied to a certain kind of Content:

1. Units: circumscribed items of information having a thing character;
2. Classes: grouped items of information according to common properties;
3. Relations: recognized connections between units of information;
4. Systems: organized aggregates of items of information;
5. Transformations: changes in known information or in its use as in production;
6. Implications: extrapolation of information in the form of predictions, antecedents and consequences.

Within these three dimensions, every kind of Content can be combined with every kind of Operation and each of these combinations can in turn be combined with every kind of Product. Each specific Operation can be tapped by tests, many of which are still in their experimental form, developed by Guilford and his associates.

B) Tests of Creative Thinking.

Guilford describes creative thinking as an invention which is a form of production. This ability is mainly tapped by the category of divergent production which includes the factors of fluency, flexibility, originality and elaboration. It covers a large scope as all the above mentioned Contents and Products can be involved. Creative thinking includes besides divergent production, redefinition abilities in the transformation layer of convergent production. It also includes sensitivity to problems which, in terms of the model, is an evaluative ability and the product can be interpreted as an implication or a transformation. Creative thinking is

thus seen in terms of factors of divergent production and certain other operations when they produce transformations.

From the battery of creative thinking tests, five were selected for this study. Criteria for selection were mainly twofold:

1. To include all the factors considered by Guilford important in this domain;
2. To select tests dealing predominantly with figural content as the interest in this study is mainly in creative thinking as reflected in dealing with visual information.

Of the five selected tests, only two have been published while three, still in their experimental form, were obtained from Guilford, Psychological Laboratory, Southern California with permission for reproduction. A brief description of the tests used, will be given.

Match Problems measures the factor of divergent production of figural transformations and can also be called "adaptive flexibility". It calls for repeated redefinitions or transformations in solving problems made up of line elements in figures. The task consists of two parts with a time limit of seven minutes per part. The score is the total number of acceptable responses according to a separate scoring key. The alternate form coefficient of reliability obtained on a sample of 665 ninth grade students, is reported to be .70.

Making Objects test is designed to measure the factor of divergent production of figural systems and can also be

called "visual figural expressional fluency". Success in this test depends on the ability to organise figural elements into structures or patterns of different degrees of complexity with emphasis on using the same elements in different ways and combinations. Three minute working time is allowed for each of the two parts. The score is the sum total of each time a given figure is introduced in a different way. The coefficient of reliability established between the two parts of the test, is reported as .63 on a sample of 205 ninth grade students.

Figure Production measures the factor of divergent production of figural implications, also called "figural elaboration". The score is based on the degree of elaboration achieved in sketching a figure based on a given stimulus line. The test is composed of four parts with a time limit of three minutes per part. No published index of reliability is yet available as this test as well as the two to follow, are still in their experimental form.

In Seeing Problems the evaluative ability of semantic implications is measured. It tests sensitivity to problems as revealed through the ability of seeing problems that might arise in connection with common objects. The test consists of four parts with four minutes working time allowed for each part and the score is the number of acceptable problems listed.

Hidden Figures test the factor of convergent production of figural transformations, also called "figural redefinition". Here basic figures concealed in masked figures have to be identified. It calls for the ability of generating new information from given information through a continued transformation and reinterpretation of given material. Two parts are included with a working time of six minutes for each part. The score is simply the number of correctly identified basic figures.

These five selected tests were thus designed to measure the factors of fluency, flexibility, originality, elaboration, redefinition and sensitivity to problems especially as revealed through the use of visual-figural material.

4. The Experimental Procedures.

The subjects were tested during working hours and different test sessions had to be organized. The battery of creativity tests were administered to groups on six different occasions. The testing conditions were kept as uniform as possible, and none of the sessions were interrupted in any way. The procedures followed in the use of the NAIT apparatus, were the same as Barry[4] applied in his study and will be reported in detail.

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4 Barry, Op. Cit., p. 39-42.

A NAIT apparatus was installed on a table in a darkened room. The subject was seated in front of the stimulus cabinet with a distance of approximately twelve inches between the viewing port and the subject's eyes. A period of five minutes for dark adaptation was given to each subject during which general information on name, age and education was obtained. Eyesight was considered adequate if normal or corrected by glasses.

The subjects were then instructed in the following manner: "This is a special test for color vision. During the test, try hard not to move your head or your body and especially, try hard not to blink your eyes. When you look into this hole, you will see a colored circle. What color is it?" The subject could not see the color of the primary stimulus due to the particular stimulation of the rotating disc, but was aware of it in its complementary color as a continually sustained negative after-image. He tus reported the color as green, blue or turquoise. "Good. Now, gaze at the center dot in the green (or blue, etc.) circle. That green color may fade or reappear or it may get darker until it completely disappears. Before we begin the test, we will show you how this happens". A trial run then followed. The intensity of the disc light was set at ninety on the variac dial, which corresponds to 195 microamperes on the Avometer, and the disc light turn down was initiated by pressing the ON switch for the variac's servomotor. The illumination was

allowed to decrease to its lowest level before the light switches were turned back to the OFF position. No readings were taken during this trial. The operator might question the subject or answer questions to clarify the nature of the phenomenon. When he decided that the subject understood the procedure, he continued: "Now we can begin the test. Gaze at the center dot in the green circle and press this button (at this point the subject was handed the push button OFF switch) as soon as you are no longer able to see any of the green color. The green may fade or reappear or it may get darker, but you are to press the button as soon as you feel the green is all gone". The operator then placed the stimulus and disc illumination lights to the ON position. The servo motored variac gradually lowered the Avometer's range as the Subject persisted in his perception of the after-image. The point of after-image disappearance was always read from the meter in the lowest appropriate range. The disc light intensity was then returned to its initial level of brightness and the same procedure was repeated for a following trial. The mean interval between the different trials was about two seconds. Each subject was given one test session consisting of six trials in mass practice.

In previous studies with the NAIT apparatus, the microammeter readings were converted to footcandles to minimize random fluctuations and to obtain maximum linearity

from the extended meter range. This extended meter range resulted from the shifting to lower, more sensitive meter ranges during the trials. As the finer scaled, more sensitive Avometer was used in this study where all the readings could be taken within the 250 microammeter range, no necessity was felt to convert readings to footcandle units.

5. The Techniques for Data Evaluation.

The raw data obtained from the NAIT apparatus in the described manner as well as the raw data from the Creative Thinking tests, were analyzed in the following manner: alternate form reliability on the Creative Thinking test scores; statistical significance of the increment between trial one and trial six on the NAIT test interpreted as retino-cortical inhibition; an investigation of the possible relationship between the algebraic score interpreted as retino-cortical inhibition and creative thinking ability as indicated by the total score obtained from the five Guilford tests; an investigation of possible relationships between the NAIT scores and each of the subtest scores of the Guilford Creative Thinking battery.

A reliability measure of the NAIT test could not be obtained in this study. The fact that the subjects were tested during working hours, made test-retest procedures impossible, as the required time was not permitted to the examiner.

Alternate form reliability of the five Creative Thinking tests, was determined using the Pearson product moment coefficient of correlation with Spearman-Brown adjustment. The formula employed, was:

$$r_{nn} = \frac{n r_{11}}{1 + (n-1) r_{11}}$$ where n indicates the number of parts in test.

As retino-cortical inhibition was interpreted and demonstrated through a rise in after-image threshold on the NAIT apparatus, Barry[5] devised a score which would reflect the increments of retino-cortical inhibition on each trial. An algebraic sum of the six trials under mass practice was taken to test the statistical significance of the mean increment between trial one and trial six for the sample of ninety subjects. If the rise between the first and the last scores could be attributed to chance fluctuations, the application of the retino-cortical inhibition theory would be inadvisable. An overall test of independence for correlated means, was thus applied. Differences between correlated means were evaluated by the following formula:

$$t = \frac{M_d}{\sqrt{\frac{\Sigma x_d^2}{N(N-1)}}}$$

where M_d = mean of the N differences of paired observations.

x_d = deviation of a difference from the mean of the differences.

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5 Barry, Op. Cit., p. 44.

The hypothesized relationship between retino-cortical inhibition and creative thinking, was next examined. Inspection of the scatter diagram obtained from plotting the NAIT scores against the sum of the Creative Thinking tests scores, revealed a slight curvature in regression. To determine if this was due merely to a chance deviation from linearity, the F test of linearity of regression was applied:

$$F = \frac{(\eta_{yx}^2 - r_{xy}^2)(N - k')}{(1 - \eta_{yx}^2)(k - 2)}$$

The correlation ratios revealing the degree of relationship between the two sets of data independent of their linearity, were computed using the following formulas:

$$\eta_{yx}^2 = \frac{N \sum \frac{(\Sigma y')^2}{f_x} - (\Sigma y')^2}{N \Sigma y'^2 - (\Sigma y')^2}$$ correlation ratio for regression of Y on X.

$$\eta_{xy}^2 = \frac{N \sum \frac{(\Sigma x')^2}{f_y} - (\Sigma x')^2}{N \Sigma x'^2 - (\Sigma x')^2}$$ correlation ratio for regression of X on Y.

If deviation from linearity was found to be insignificant, the Pearson product moment coefficient of correlation was applied to the NAIT scores as related to the sum total of the Creative Thinking test scores as well as to each of the different subtest scores. The formula employed was:

$$r = \frac{N\Sigma xy - \Sigma x \Sigma y}{\sqrt{N\Sigma x^2 - [\Sigma x]^2}\sqrt{N\Sigma y^2 - [\Sigma y]^2}}$$

CHAPTER III

RESULTS AND DISCUSSION

This chapter will be devoted to the reporting and the discussion of the experimental results. A first section will present coefficients of reliability of the NAIT apparatus as reported in previous research studies. Section two presents the reliability coefficients of the Creative Thinking tests scores. A third section deals with the estimation of the statistical significance of the algebraic scores. Correlation measures between the NAIT test scores and the Creative Thinking tests scores are presented in section four. This is followed by a final section in which the experimental results are discussed.

1. Reliability of the NAIT Test.

As mentioned in the previous chapter, reliability coefficients of the NAIT test could not be obtained in this study due to the unavailability of the experimental subjects for a retest session. Barry[1], who devised this instrument, calculated test-retest coefficients of reliability on raw

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1 William F. Barry, An Investigation of Relationships Between Introversion-Extraversion and the Negative After-Image Threshold, Unpublished Doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, 1961, p. 49-50.

scores for a sample of seventy-two males on each of the six trials for the initial and final testing sessions, as well as on the algebraic score of the six trials in both test sections. The coefficients obtained were: .781, .769, .727, .793, .618 and .866 for the six trials respectively and .730 for the algebraic score, all significant at the .01 level. These results were confirmed by Kovatch[2] who computed test-retest coefficients of reliability in an identical manner on a sample of thirteen intra-cranial pathology cases. He found an average coefficient of .705 significant at the .01 level.

2. Reliability of the Creative Thinking Tests.

Reliability estimates were derived from correlations between different parts of the tests with Spearman-Brown adjustment. The two published tests, Match Problems and Making Objects, consisted each of two parts and reliability coefficients obtained were: .724 and .672 respectively. The reliability coefficients reported in the manuals[3,4] of

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2 Joseph D. Kovatch, An Investigation of Relationships Between Intra-Cranial Pathology and the Negative After-Image Threshold, Unpublished Master's thesis presented to the School of Psychology and Education of the University of Ottawa, 1961, p. 24.

3 Sheldon Gardner, Arthur Gershon et al., Manual of Instructions and Interpretations, Beverley Hills, Sheridan Supply Co., 1963, p. 4.

4 Raymond M. Berger and J.P. Guilford, Manual of Instructions and Interpretations, Beverley Hills, Sheridan Supply Co., 1963, p. 4.

the two tests were: .72 and .63 in the same order. Inter-correlations between the different part-scores of the three tests still in experimental form, yielded the following reliability coefficients: Figure Production (3 parts) .680, Seeing Problems (4 parts) .730 and Hidden Figures (two parts) .942.

3. Significance of the Algebraic Score of the NAIT Test.

As previously stated, investigation of the significance of the algebraic scores of increments of the six trials, using trial one as the basal score, was imperative. If the rise in raw scores from trial one through six could be interpreted as a chance fluctuation, the interpretation of the increment as retino-cortical inhibition would not be applicable.

The *t* test of independence for correlated means was applied to the difference between the means of the scores of trial one and six. A *t* value significant at the .01 level was found. Table I on the following page presents this data. Thus the rise in the score observed was not attributed to chance fluctuations but interpreted as retino-cortical inhibition.

Table I.-

Data for t Test of the Difference of Correlated Means on Negative After-Image Threshold Scores Between Trial One and Trial Six. N = 90.

Stat.	Trial 1		Trial 6	Diff.		t	Sign.
M	592.42		651.94	59.52	16.05	3.708	.01
r_{12}		.739					

4. Correlations between NAIT Scores and Creative Thinking Tests Scores.

Inspection of the scatter diagram of the NAIT scores and Creative Thinking tests scores of the 90 subjects tested in this study, revealed a slight curvature in regression. This led to the computation of correlation ratios followed by F tests of linearity. The correlation ratio for the regression of Creative Thinking tests scores on NAIT scores was .523, while the correlation ratio for the regression of NAIT scores on Creative Thinking tests scores gave a value of .436. The F test of linearity however, yielded insignificant values of 1.77 and .752 respectively for the first and second correlation ratio mentioned. As the assumption of linearity was tenable, the correlation coefficient, by means of the Pearson r, was computed and resulted in a value of -.305 significant at the .01 level.

Pearson r coefficients of correlation were also computed between the NAIT scores and each of the subtest scores of the Creative Thinking test battery. Correlation coefficients obtained between NAIT scores and scores on Hidden Figures, Figure Production, Seeing Problems, Making Objects and Match Problems were -.338, -.302, -.248, -.247 and -.180 respectively. The first two r's were found to be significant at the .01 level, the next two at the .05 level while the fifth one fell below the .05 level of significance. The

correlation coefficients and their significance is presented in table II on the following page.

5. Discussion of Results.

The discussion of the results has been divided into two subsections. Section A deals with the reliability and validity of the NAIT test as a measure of retino-cortical inhibition. In section B, the main interest in this study, the relationship between retino-cortical inhibition and creative thinking, is discussed.

A. Reliability and Validity of the NAIT Test.

The reliability coefficients of the NAIT test, as quoted from previous research workers, demonstrates the consistency of their subjects in the reporting of the after-image disappearance. Considering that variations can be expected in visual-motor judgement responses of an after-image phenomenon, especially in cases of intra-cranial pathology, their obtained reliability recommends the use of the NAIT apparatus.

The validity of the NAIT apparatus as a measuring tool of retino-cortical inhibition, is supported by the fact that the mean score increment of the sample was found to be significantly higher than expected from chance fluctuations alone. The possibility that this mean score increment could

Table II.-

Data for t Tests on Pearson r Correlations Between Negative After-Image Threshold Scores and Creative Thinking Tests Scores.

Creative Thinking Test	r	t	Sign.
Total Battery	-.305	3.022	.01
Hidden Figures	-.338	3.359	.01
Figure Production	-.302	2.959	.01
Seeing Problems	-.248	2.401	.05
Making Objects	-.247	2.391	.05
Match Problems	-.180	1.717	—

be due to other factors should be considered. Barry[5] dealt with this issue and investigated factors such as improved reaction-time, learning and errors of set or expectancy. Intratrial increment could not be due to improvement in digital reaction time as the range of classical reaction-time variability is too small to effect a significant difference on the NAIT apparatus. The observed mean increment cannot be explained in terms of learning as learning would have resulted in a declining curve. The same type of curve would be expected if errors of set or expectancy were main causative factors.

Although a significant mean score increment was demonstrated in the present study, several individual scores did show a declining curve and thus an increase in after-image awareness. In these cases learning may have played a role. Errors in judgement could also have taken place as some subjects verbalized a difficulty in deciding when the after-image had disappeared.

However, an increase in after-image awareness can possibly be accounted for in neurophysiological terms.

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5 William F. Barry, An Investigation of Relationships Between Introversion-Extraversion and the Negative After-Image Threshold, Unpublished Doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, 1961, p. 62-63.

Rotman[6] who measured satiation effects in three different sense modalities, showed that not only sensory reduction or underestimation of sensory stimuli but also augmentation or overestimation is a significant neurophysiological phenomenon. According to him, Eysenck was only concerned with stimulus reduction, which he interpreted as an effect of retino-cortical inhibition, but did not explain the phenomenon of reactive augmentation. In augmentation, according to Rotman, a lack of inhibition results in a persistence of action potentials causing an exaggeration of forthcoming judgements. This interpretation may be applicable to the cases in this study that showed an increase in after-image awareness.

Although the discussion concerning the validity of the NAIT instrument favored an interpretation of retino-cortical inhibition to account for the intratrial increment, other unknown factors may still be involved. Awaiting future research, the writer will continue to use the interpretation of retino-cortical inhibition.

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6 Bertram Rotman, Sensory Augmentation: A Possible Extension of the Eysenckian Theory of Introversion-Extraversion, Unpublished Doctoral thesis presented to the School of Psychology and Education of the University of Ottawa, 1964, p. 54-69.

B. The NAIT and Creative Thinking.

The main hypothesis was stated in the null form: there is no significant correlation between Negative After-Image Threshold test scores interpreted as retino-cortical inhibition and Guilford tests scores interpreted as creative thinking. This hypothesis was rejected as a significant correlation between these two variables was found.

The subhypothesis was formulated in the following manner: there is no significant correlation between Negative After-Image Threshold test scores interpreted as retino-cortical inhibition and each of the subtest scores of the Guilford tests interpreted as distinctive measures of creative thinking. This hypothesis was partially rejected, since all but one of the five subtests employed as measures of creative thinking, were found significantly correlated to the NAIT test scores. After-image sensitivity was found substantially correlated to three of the divergent production factors, i.e. Figural Elaboration, Sensitivity to Problems and Visual-Figural Expressional Fluency as well as to the convergent factor of Figural Redefinition.

The result of this investigation revealed that creative thinkers do not only show a characteristic lack of psychological inhibitions and restrains, but also a significantly lower index of neurophysiological inhibition as measured through the Negative After-Image Threshold apparatus.

This finding supports Eccles'[7] postulates about the creative brain being characteristically low in its inhibitory effects and consequently facilitating synaptic transmissions, which enables the brain to continuously activate its enormous amount of memory engrams into novel and interacting forms. It is also in agreement with Wyspianski's[8] study where it was found that the level of brain activity, as reflected in E.E.G. recordings, was significantly higher in creative as compared to non-creative thinkers. His study demonstrated further that the decrease in brain activity upon stimulation was less in the creative brain, which he interpreted as little effort required by the alert brain to respond adequately upon stimulation. This touches common grounds with the results of this study where prolonged stimulation caused little resistance in the creative brain, while the low creatives reflected high resistance in the form of cortical inhibition.

The present experimental results add corroborative evidence to the theories of neural satiation, cortical inhibition and cortical conductivity in their description of retino-cortical inhibition as a neurophysiological state which lowers cortical conductivity and decreases functional

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7 Vide, Study, Section 3, p. 23.

8 Vide, Study, Section 3, p. 24.

communication between different cortical areas. Klein and Krech's[9] postulates about cortical conductivity as a crucial parameter of cortical integration, cognitive functioning and the degree of functional communication between cortical areas, receives support from the correlation found between retino-cortical inhibition and creative thinking. Their hypothesized behavioral correlates of cortical conductivity, i.e. a narrowing of awareness and rigidity resulting from low cortical conductivity and alertness and hypersensitivity to various stimuli manifested in conditions of high cortical conductivity, can fruitfully be compared with the low creative thinker's "functional fixedness" in dealing with the test material in contrast to the high creative thinker who drew answers to problems in a sensitive, flexible and original way.

As low inhibition seems to facilitate an optimum level of perceptual-cognitive functioning, Klein's[10] belief that satiation may play a determining role in perceptual-cognitive attitudes, like leveling where maximum simplicity is sought, and sharpening where complexity is preferred, can be supported. Cortical inhibition theories may provide a fruitful vantage point for the study of basic individual differences in various perceptual-cognitive attitudes.

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9 Vide, Study, Section 1, p. 6-7.

10 Vide, Study, Section 2, p. 19-20.

The preceding discussion of the experimental results was rather global and an oversimplification of an enormously complex issue involved. The ability of creative thinking calls for a maximum degree of psychological and neurophysiological differentiation and integration. Creative thinking does not only require the accumulation of an enormous amount of memory engrams but also an accessibility to unconscious processes or, in gross neurophysiological terms, a high degree of interaction between cortical and subcortical areas. The inhibition phenomenon, on the other hand, is also of a highly complex character — little is known about its differential functioning. Although neural satiation, cortical inhibition and cortical conductivity theories all deal with the neurophysiological inhibition phenomenon as resulting from prolonged stimulation of a sensory surface, the complexity of the neurophysiological mechanisms underlying this phenomenon are not sufficiently taken into account. These theories, especially those of Eysenck and Klein and Krech, consequently carry a loose character. The use of different and often inadequate response measures yielded numerous difficulties, not only in terms of experimental verification, but also in terms of adequate interpretation. To arrive at a deeper understanding of the low but substantial correlation found in the present research study, it will be necessary to investigate the possible neural mechanisms which underlie the inhibition phenomenon and to relate this knowledge to

conditions that play a role in creative thinking.

The excitation-inhibition balance which formed the basis for Eysenck's theory of cortical inhibition, was first formulated by Pavlov and seen by him as forming the basis of the neurodynamic functioning of the central nervous system. According to Pavlov[11], the whole learning process is based on this excitation-inhibition balance through a continuous process of conditioning. The latter is facilitated by excitation and hampered by inhibition. Pavlov saw inhibition and excitation as cortical phenomena. Eysenck who formulated his theory mainly on the basis of Pavlovian principles, consequently described inhibition also as cortical in nature. Recent neurophysiological research, based on the work of Pavlov, has demonstrated, however, that the genesis of inhibitory processes and of conditioning are subcortical rather than cortical in nature. On the basis of electrical recordings and pharmacological studies, a main inhibitory role and the locus of the establishment of conditioned reflexes, is assigned to reticular formation activity. It also appears to play an important role in sensory discrimination and perceptual processes. Brief attention will be paid to these research studies in an attempt to arrive at a deeper

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11 I.P. Pavlov, Conditioned Reflexes, An Investigation of the Physiological Activity of the Cerebral Cortex, Translated and Edited by G.V. Anrep, London, Oxford University Press, 1927, xv-430 p.

understanding of the origin and the role of inhibition as relevant to the main interest of the present study.

The first step in the establishment of all conditioned responses, is the initiating of the orienting reflex which leads to the excitatory process. The purpose of the orienting reflex, according to Kupalov[12], is to change excitability and efficiency to prepare the brain for further activity. An orienting reflex is induced whenever a new stimulus is discordant with preceding stimulation. The main activating regulatory system in evoking the orienting reflex is, according to Sokolov[13] and several other authors, the reticular formation. When successive stimuli are in accordance, no orienting reflex is evoked, but inhibition is built up through which the pathways to the reticular formation are gradually blocked, depriving the cortex of its subcortical energy resources. Sokolov writes:

> During repeated stimulation of the same stimulation... an increase in inhibition is observed. This can be explained by two functional systems of the reticular formation. One is inhibitory in its influence on the cortex and the other is an activating one... high frequency stimulation of the reticular formation activated in the cortex, slow stimulation of the reticular formation produces an increase in activity of these inhibitory systems.[14]

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12 P.S. Kupalov, "Discussion, Part I: Structure and Function", Annals of the New York Academy of Sciences, Pavlovian Conference on Higher Nervous Activity, Vol. 92, New York, Academy of Sciences, 1961, p. 895-897.

13 Eugene Nikolaievich Sokolov, "Neuronal Models and the Orienting Reflex", The Central Nervous System and Behaviour, New York, Macy Jr. Foundation, 1960, p. 187-276.

14 Sokolov, Op. Cit., p. 238-239.

Inhibition is thus described not as cortical, but as resulting from subcortical activity.

Recently, the conditioned reflex, which follows the orienting reaction, has been found to be a function of cortical-subcortical interactions and reticular formation activity. Yoshii and his associates[15] recorded electrical activity directly from subcortical structures during the conditioning process and concluded that the iterative conditioned response appears in subcortical structures, notably in midbrain reticular formation, much earlier and longer lasting than in the cortex. Gastaut[16] in a similar way proposed that closure in conditioned learning is established through subcortical connections especially through the reticular formation primarily at the thalamic level.

The reticular formation is thus seen as of central importance in evoking the orienting reaction and in establishing the conditioned reflex which forms the basis for learning. It has also been described as the main locus for excitatory and inhibitory processes. Magoun writes:

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15 N. Yoshii, Y. Hasegawa et al., "Electroencephalographic Study of Defensive Conditioned Reflex in Dog", Folia Psychiatrica et Neurologica, Japan, 13, December, 1959, p. 67.

16 H. Gastaut, "Some Aspects of Neurophysiological Basis of Conditioned Reflexes and Behaviour", Neurological Basis of Behaviour, London, Churchill, 1958, p. 255-271.

> The influences of this nonspecific system in the brain are thus brought to bear upon most other portions and functions of the central nervous system, either to diminish or to raise the level of their activity, or to interrelate or integrate their several performances.[17]

Following Sharpless and Jasper[18], the diencephalic component of this activating system, alerts the central nervous system, compels attention to novel stimuli, is sensitive to the slight changes in the quality of stimuli impinging upon organ receptors, and is capable of producing rapid shifts in reactivity in the central nervous system. Gastaut[19] and others assign a main inhibitory role to the reticular formation and write further that it regulates the sensibility of the receptors of the sense organs as well as the conductivity along sensory pathways. Of special interest to the present study is Lindsley's[20] work on the role of the reticular formation in perceptual processes. He demonstrated through a series of experiments on animals and humans, that stimulation of

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17 H.W. Magoun, The Waking Brain, Springfield, Thomas, 1958, p. 13-14.

18 Seth Sharpless and Herbert Jasper, "Habituation of the Arousal Reaction", Brain, Vol. 79, Part 4, 1956, p. 655-680.

19 Henri Gastaut, "The Role of the Reticular Formation in Establishing Conditioned Reactions", Reticular Formation of the Brain, Boston, Little, 1958, p. 561-579.

20 Donald B. Lindsley, "The Reticular System and Perceptual Discrimination", Reticular Formation of the Brain, Boston, Little, 1958, p. 513-534.

the ascending reticular activating system increases the power of perceptual discrimination and decreases reaction time to visual stimuli. Fuster[21] trained monkeys to discriminate between round and cone-shaped visual objects and determined their visual discrimination threshold tachistoscopically. He found that under reticular formation stimulation, the reaction time as well as the percentage of correct responses improved to a significant degree and concluded that reticular formation facilitates central nervous processes involved in perception. After-image awareness was thus increased as a result of reticular formation stimulation. Lindsley believes the ascending reticular activating system is essential to perception and talks of augmentation and inhibition of reticular influences as providing a possible basis for understanding the mechanisms underlying perception.

Lindsley's[22] barbiturate anaesthesia experiments are also illustrative of the inhibitory functions of the reticular formation. After administration of barbiturate drugs, reticular formation activity was first blocked while the cortex still received information through sensory

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21 Joaquin M. Fuster, "Thachistoscopic Perception in Monkeys", Federation Proceedings, Vol. 16, Part 2, No. 183, 1957, p. 43.

22 Lindsley, Op. Cit., p. 517.

pathways which could be recorded as evoked potentials. However, these messages were not elaborated nor integrated and thus ineffective for discriminatory purposes. Bradley[23] also describes the inhibition phenomenon as a result of blocking of reticular formation activity. After the administration of several excitant and depressant drugs, he found that the latter acted directly on the reticular formation or on its afferent input inhibiting its activity. It can be recalled from the literature review that Eysenck, Holland and Trouton[24] found the level of retino-cortical inhibition as reflected in the duration of the Achimedes Spiral also significantly increased after the administration of depressant drugs.

The foregoing neurophysiological contributions which propose a subcortical rather than a cortical genesis for the learning process and which view inhibition as resulting from a suppression of the reticular activating system, seem to provide some insights into the low but significant inverse correlation found between retino-cortical inhibition and creative thinking. Since the creative brain is characterized by its sensory discriminative powers, its accessibility to

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23 P.B. Bradley and J. Elkes, "The Effect of Some Drugs on the Electrical Activity of the Brain", Brain, Vol. 80, Part 1, 1957, p. 77-117.

24 Vide, Study, Section 2, p. 16.

and fruitful use of unconscious resources and its high level of integration, it seems evident that the subcortical activity is high and in enduring interaction with cortical processes. The high level of cortical activity found in the creative brain points possibly to a decrease in the inhibitory functional system of the reticular formation and an increase in its excitatory functions through which the orienting reaction, the learning process, sensory discrimination and integrative functions are facilitated.

Future research is needed to deepen the understanding of the inhibition phenomenon, in particular the retinocortical inhibition as measured through the NAIT apparatus through, for instance, electroretinographic and electroencephalographic studies. Inhibition is an important, basic neurophysiological process, although it cannot be expected to explain any psychological process, as it is far too related to and dependent on other variables. As Jaspers[25] writes, to understand the integrative functions of the cortex, one must understand the significance of temporal and spatial interactions between neurons and how they are affected by the excitatory and inhibitory states built up in synaptic-dendritic structures which control the firing of

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25 Herbert H. Jasper, "Recent Advances in Our Understanding of Ascending Activities of the Reticular System", Reticular Formation of the Brain, Boston, Little, 1958, p. 319-331.

the cortical cells. Present theories of neural satiation, cortical inhibition and cortical conductivity do not take the astounding complexities of the neurophysiological processes on which they rest sufficiently into account. A reformulation of these theories in the light of modern neurophysiological knowledge and the use of adequate measuring tools, may help to overcome the inconsistencies and inconclusive character of the research stimulated by them. Although the results of the present study should also still be regarded as inconclusive, as no causality has been explained, it is hoped that it has offered some contribution to the understanding of the psychophysiological functioning of the human brain.

SUMMARY AND CONCLUSIONS

This dissertation reported on an investigation of the relationship between retino-cortical inhibition as reflected in after-image sensitivity and creative thinking as measured by the Guilford tests. Both measuring tools were of a visual-perceptual nature as the visual sense modality, because of its intimate linkage with central nervous functioning, is believed to provide the best avenue for tapping a neurophysiological phenomenon apart from direct measures of the cortex itself.

In the literature review, theories of neural satiation, cortical inhibition and cortical conductivity and a neurophysiological theory of the creative brain as well as related contemporary research, was discussed. This survey indicated the possible importance of retino-cortical inhibition as an explanatory concept in the field of creative thinking. A next chapter was devoted to a description of the measuring tools, the procedures employed and an analysis of the statistical data.

The relationship between negative after-image thresholds and creative thinking ability was next investigated testing the null hypothesis: there is no significant correlation between MAIT test scores interpreted as retino-cortical inhibition and Guilford tests scores interpreted as creative thinking. The subhypothesis that there is no

significant correlation between NAIT test scores interpreted as retino-cortical inhibition and each of the subtest scores of the Guilford tests interpreted as distinctive measures of creative thinking, was partially rejected as all but one of the five subtests showed a significant correlation to the NAIT test scores.

The results supported Eccles' postulates about the creative brain being highly integrated and characteristically low in its inhibitory effects enabling the brain to maintain a high level of activity. It also added corroborative evidence to theories of neural satiation, cortical inhibition and cortical conductivity in their description of retino-cortical inhibition as a neurophysiological phenomenon which lowers cortical conductivity and decreases functional communication between different cortical areas.

In an attempt to arrive at a deeper understanding of the low but substantial correlation found between retino-cortical inhibition and creative thinking, a brief discussion of recent neurophysiological research dealing with the origin of inhibition and its influences on central nervous activity as relevant to the present study, was presented. Inhibition was described as resulting from a suppression of subcortical rather than cortical functioning, in particular a blocking of reticular formation activity. The importance of the latter in facilitating the orienting reaction, conditioning and sensory discrimination, was pointed out. It was

speculated, in the light of the results of this investigation, that the complex creative brain with its sensitivity to and fruitful use of unconscious processes and its high level of cortical activity would be characterized by a decrease in inhibitory functions of reticular formation activity, and a consequent high level of subcortical activity.

Future research should first validate the findings of this study with a larger, more homogeneous sample. An electroretinographic and electroencephalographic investigation of retino-cortical inhibition as measured by the NAIT is recommended to verify its validity as a true indicator of retino-cortical inhibition.

Suggestions for future research on retino-cortical inhibition as related to other possible psychological and neurophysiological variables, are numerous. Correlations could be sought, for example, between the NAIT variable and test performances which purport to measure other aspects of creativity, imagination and other levels of cognitive functioning. Guilford's factor-analytic model of the intellect opened a fruitful avenue for a detailed approach in investigating relationships between different intellectual factors and after-image sensitivity.

Various perceptual-cognitive attitudes like leveling-sharpening and field dependence - field independence, could also be brought into relationship to retino-cortical

inhibition — the latter may be found to be an important underlying neurophysiological factor playing a determining role in the formation of these attitudes.

NAIT test performance related to other neurophysiological measurements like E.E.G., evoked cortical potentials and C.C.F. may add valuable information to the understanding of the inhibition phenomenon. NAIT test scores should also be correlated to other existing measures of inhibition theories to evaluate its adequacy, in comparison to other response tools, as a measuring tool of retino-cortical inhibition.

Theories of neural satiation, cortical inhibition and cortical conductivity as well as their measuring tools, are in need of a thorough, critical reevaluation by means of experimental research based on modern knowledge of neurophysiology. The inhibition phenomenon may then open an important avenue for psychoneurology in its search for finding behavioural concomitants of central nervous functioning.

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In a review of the literature, Franks concludes that conditioning studies based on Eysenck's inhibition model were in general successful.

Gastaut, Henri, "The Role of the Reticular Formation in Establishing Conditioned Reactions", Reticular Formation of the Brain, Boston, Little, 1958, p. 561-579.

He attributes, on the basis of experimental studies, a main inhibitory role and closure in conditioned reflexes to Reticular Formation activity. He also proposes that reticular formation activity regulates the sensibility of the receptors of the sense organs as well as the conductivity along sensory pathways.

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Introduces a brain model with active cortical control over vegetative and reticular formation activity. Explains inhibition in terms of reticular formation functioning.

APPENDIX

ABSTRACT OF

Retino-Cortical Inhibition and Creative Thinking

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Retino-Cortical Inhibition and Creative Thinking

The neurophysiological inhibition phenomenon has been seen by various psychologists as a possible explanatory construct underlying various forms of human behaviour. Theories like neural satiation, cortical inhibition and cortical conductivity have been formulated in attempts to account for this phenomenon and have initiated numerous research studies. According to these theories, prolonged stimulation of a sensory surface leads to a central inhibitory process which raises resistance in the stimulated cortical area and lowers the level of cortical conductivity and functional communication between different parts of the brain. This inhibitory state is believed to bear a detrimental effect on the integrative and consequently on the level of cognitive functioning.

The neurophysiological description of the creative brain by Eccles as highly integrated and low in its inhibitory effects, led to an investigation of a possible relationship between the inhibition phenomenon and creative thinking ability. Cortical inhibition was measured through the visual sense modality presuming that the latter is the most fruitful modality for such measurements. The creative

thinking tests employed, were Guilford tests, also of a predominantly visual nature. These psychophysiological and psychological measuring tools were administered to ninety men. The results led to a rejection of the null hypothesis of no significant correlation between Negative After-Image Threshold scores interpreted as retino-cortical inhibition and Guilford tests scores interpreted as creative thinking.

The findings were interpreted in support of Eccles' neurophysiological theory of the creative brain and added corroborative evidence to the theories of neural satiation, cortical inhibition and creative thinking. In an attempt to arrive at a deeper understanding of the results obtained, a possible interpretation on the basis of recent neurophysiological research studies dealing with the origin of inhibition and its influence on central nervous activity, was presented.