REACTIVE INHIBITION
AND EVOKED CORTICAL RESPONSES

by Marilyn Fenton

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CURRICULUM STUDIORUM

Marilyn Fenton was born December 11, 1940, in Russell, Manitoba, Canada. She received the Bachelor of Arts degree from the University of Manitoba, Winnipeg, in May 1962.

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INTRODUCTION

The construct of inhibition has a long history in physiological psychology. Many theorists have invoked it to account for causality of behavior, and it has been dealt with on many levels, ranging from a vague molar psychological concept to a specific neurological process.

H.J. Eysenck has used the concept of inhibition in postulating constitutional cortical resistance to stimulation which differentially affects learning ability, and ultimately the development of introverted or extraverted personality traits. In developing the concept within his theory, Eysenck has leaned heavily on the Pavolvian view of the central nature of inhibition, but he has also borrowed from the behavioristic constructs of Clark Hull, which are essentially peripheralist. The most recent statement of the theory outlines a notion of inhibition that has temporal, spatial and basal components. In arriving at this position Eysenck has used the concepts of reactive inhibition, inhibition due to negative induction, and satiation, almost synonymically, and he has also assumed that they are highly related, within individuals, to a factor of basal cortical conductivity.

Many criticisms of Eysenck's grouping of these concepts into one psychoneurological construct, and of making this questionable construct the basis for his entire theory, are to be found in the literature. To date there exists little convincing evidence to justify the construct. Research in this area has been hampered by inadequate instrumentation, and contaminated by peripheral factors.

It is from this situation that the present research arose. The increasing popularity of theorizing, such as Eysenck's, which deals with the psychobiology of personality - i.e. which relates dimensions of personality to the physiological systems of the body - would seem to call for some "reality testing" on the construct level.

This dissertation reports on a study which attempts to examine the relationship between Eysenck's temporal and basal components of inhibition. Pursuit rotor reminiscence is used as the measure of temporal inhibition, while latency of evoked cortical responses is interpreted as an estimate of the potential for basal cortical conductivity. The theoretical hypothesis is that should these measures be significantly positively correlated, a commonality may be inferred which would lend a degree of support to the broader construct.

The thesis is divided into three chapters. Chapter one is concerned with the review of the literature. The development of Eysenck's theory of inhibition is outlined, along with pertinent studies of reminiscence and latency of evoked potentials. A theoretical and practical justification for the study is also presented. Chapter two is devoted to the experimental design, including a description of the sample, the tools and techniques of the research, the experimental procedures and the methods of data analysis. Chapter three presents the results of the investigation, and their interpretation. The subsequent discussion centers around the possible weaknesses of the design, and of Eysenck's theory. The conclusions drawn are followed by some suggestions for further research.

CHAPTER I

REVIEW OF THE LITERATURE

This chapter presents a discussion of the psycho-neurological construct of inhibition, as it is used by Eysenck as the cornerstone for his structural analysis of personality. Section 1 will present the development and present status of the construct, within the context of the theory. Sections 2 and 3 will deal with the measurable manifestations of inhibition pertinent to our study, namely, reminiscence and latency of evoked cortical potentials. A theoretical and practical justification for the present research will be put forward (Section 4) prior to the statement of the hypothesis to be tested.

1. The Eysenckian Theory of Reactive Cortical Inhibition.

H.J. Eysenck of Maudsley Hospital is one of the most prolific, if not the most popular, present day theorist in the realm of personality. The research with which he substantiates his theory is well known - if not for its substance for its magnitude - to psychologists and psychiatrists alike. By means of factor analysis, Eysenck obtained what for him are the general descriptive dimensions of personality, namely, Introversion-Extraversion, and

Neuroticism.[1] Following the initial research he published two volumes dealing with the existing literature on the structure of human personality,[2] and amassing evidence for his dimensional analysis.[3] Having established his nosological framework and demonstrated its validity through laboratory tests of behavioral phenomena, he turned to an investigation of the fundamental processes which underlie individual differences on his postulated dimensions.[4] In view of the ultimate aim of the theorist - that of effecting a rapprochement between psychology, psychiatry and neurophysiology by means of providing them with a theory of personality which is "workable" and at the same time whose elements are basic to them all - it is not surprising that he should choose reductive concepts[5] to account for etiology

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1 H.J. Eysenck, Dimensions of Personality, London, Routledge and Kegan Paul, 1947, xi-308 p.

2 --------, The Structure of Human Personality, New York, John Wiley and Sons, 1953, xix-348 p.

3 --------, The Scientific Study of Personality, London, Routledge and Kegan Paul, 1952, xiii-320 p.

4 --------, "A Dynamic Theory of Anxiety and Hysteria", in Journal of Mental Science, Vol. 101, 1955, p. 28-51.

5 As used here, a "reductive concept" is an explanatory concept "whose usefulness does not depend on neurophysiological facts, but the originator (or subsequent users) made it clear that he was thinking of possible neurophysiological counterparts of physiological mechanisms that might lie behind the behavioral process or state". See Benton J. Underwood, Psychological Research, New York, Appleton-Century-Crofts, 1957, p. 227.

of behavior. Excitation and inhibition are the constructs which provide the base for the entire theory, and in Eysenck's own words:

> It is of course very likely, and may almost be taken as axiomatic, that these molar psychological concepts of 'excitation' and 'inhibition' will have recognizable physiological counterparts.[6]

It is with the latter construct, inhibition, that this review is specifically concerned.

Eysenck is indebted to Pavlov,[7] who first introduced the concept of inhibition to account for the decreased responsiveness exhibited by his dogs under conditions of experimental extinction. Individual differences were noted in the intensity of the inhibitory effects. Pavlov conceived of several forms of inhibition, the major types being "internal" and "external", and he located the processes in the cells of the cortex. Eysenck holds tenaciously to the Pavlovian view of inhibition as being a central phenomenon, for the centrality hypothesis, by nature of its breadth, allows him to postulate differential effects on the level of personality. In 1955 he stated:

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6 H.J. Eysenck, Experiments with Drugs, New York, Macmillan, 1963, p. ix.

7 I.P. Pavlov, Conditioned Reflexes, An Investigation of the Physiological Activity of the Cerebral Cortex, London, Oxford University Press, 1927, xv-430 p.

> (...) our search for a causal factor responsible for extraverted behavior should be concentrated on properties of the central nervous system, and more particularly the cortex, as it is unlikely that peripheral factors could be responsible for the far-reaching and complex differences observed between extraverts and introverts.[8]

He goes on to maintain that his explanatory theory is essentially a development and simplification of that of Pavlov.

Having taken his frame of reference from Pavlov, Eysenck turned to Hull,[9] whose behavioristic constructs leant themselves more readily to the formulation of exact and testable predictions. One such construct is reactive inhibition, outlined in Hull's first submolar principle:

> (...) all responses leave behind in the physical structures involved in the evocation, a state or substance which acts directly to inhibit the evocation of the activity in question. The hypothetical inhibitory condition or substance is observable through its effect upon positive reaction potentials. This negative action is called reactive inhibition. An increment of reactive inhibition (ΔI_R) is assumed to be generated by every repetition of the response (R), whether reinforced or not, and these increments are assumed to accumulate except as they spontaneously disintegrate with the passage of time.[10]

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8 H.J. Eysenck, "Cortical Inhibition, Figural Aftereffect and Theory of Personality", in Journal of Abnormal and Social Psychology, Vol. 51, 1955, p. 96.

9 C.L. Hull, Principles of Behavior, New York, Appleton-Century, 1943, x-422 p.

10 Ibid., quoted by Eysenck, "Cortical Inhibition, Figural Aftereffect and Theory of Personality", Op. Cit., p. 96.

This concept is likened to Pavlov's internal inhibition, although Hull seemingly did not intend it to be considered as a process of the cerebral cortex, but as restricted to organ or muscle complexes. In adopting it, Eysenck is quick to point out that recent evidence renders a purely peripheralist viewpoint untenable, and so he takes the liberty to "rewrite some of the Hullian postulates to make them logically consistent, and more in line with recent experimental evidence".[11]

From this selective marriage of Pavlov and Hull sprang the theory which Eysenck stated in three parts, in 1955.[12] The first two parts - the general law and the postulation of individual differences - read as follows:

> A. Whenever any stimulus-response connection is made in an organism (excitation), there also occurs simultaneously a reaction in the nervous structures mediating this connection which opposes its recurrence (inhibition).
>
> B. Human beings differ with respect to the speed with which reactive inhibition is produced, the strength of reactive inhibition, and the speed with which reactive inhibition is dissipated. These differences themselves are properties of the physical structures involved in the evocation of responses.[13]

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11 H.J. Eysenck, The Dynamics of Anxiety and Hysteria, New York, Frederick A. Praeger, 1957, p. 37.

12 --------, "Cortical Inhibition, Figural Aftereffect and Theory of Personality, Op. Cit., p. 94-106.

13 Ibid., p. 96.

This concept is not assumed to cover the additional operations such as amount of work done or strength of stimulation, which might be used to define reactive inhibition.

In the same publication Eysenck cites the figural aftereffects described by Köhler and Wallach[14] as being both a measure and an operational definition of cortical inhibition in the perceptual field. He notes that "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".[15,16] The resulting construct would seem to be more appropriately called reactive cortical inhibition.

The most recent statement of Eysenck's theory of inhibition is to be found in his 1963 publication Experiments With Drugs.[17] He says that in its broadest meaning,

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14 Wolfgang Köhler and Hans Wallach, "Figural Aftereffects: An Investigation of Visual Processes", in Proceedings of the American Philosophical Society, 88, 1944, p. 269-357.

15 Eysenck, "Cortical Inhibition, Figural Aftereffect and Theory of Personality", Op. Cit., p. 99.

16 Köhler uses the term "satiation" to describe the localized inhibition that is brought about by the passage of an electric current through cortical cells. Polarization of the cells increases their resistance. The extent of the phenomenon is seen in the amount of figure displacement that occurs (i.e. the figural aftereffect).

17 Eysenck, Experiments with Drugs, Op. Cit., xii-421 p.

"inhibition refers to a process within the C.N.S. which interferes with the ongoing perceptual, cognitive and motor activities of the organism".[18] To clarify the type of interference intended, he refers to the two main types of inhibition, temporal and spatial, and the experimental paradigms which may be used to define the concepts operationally.

> Temporal inhibition refers to the accumulation of a performance decrement as the result of the performance itself; it is usually associated with massed practice, and can be elicited experimentally in those situations giving rise to what Pavlov has called 'internal inhibition' and Hull 'reactive inhibition'.[19]

To exemplify the operation of temporal inhibition, he cites the phenomenon of reminiscence.

> If a motor or perceptual task is carried out by the subject under conditions of massed practice, i.e. without or with minimal rest pauses, then the theory demands that he should develop temporal inhibition; this inhibition, being a fatigue-like state, should interfere with performance, and should dissipate during rest after the termination of the scheduled performance. If, then, the subject were asked to resume practice after the rest pause, then his performance should appear to have improved when a comparison is made of his scores immediately before and immediately after the rest pause. This improvement (...)is technically known as reminiscence, and(...) there is considerable agreement among experimental psychologists that it can be most readily understood in terms of temporal inhibition.[20]

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18 Eysenck, Experiments with Drugs, Op. Cit., p. 2.

19 Ibid., p. 92.

20 Ibid., p. 2, 3.

The second major type, spatial inhibition, refers to "the production of a performance decrement through some other form of action occuring simultaneously".[21] Often called "distraction", it corresponds to Pavlov's external inhibition, and is exemplified by experiments where one sensation is extinguished when another is evoked simultaneously, elsewhere in the sensory field.

In addition to the above mentioned stimulus - produced types of inhibition, Eysenck brings in a third type, in conceding that elements of truth are to be found in the postulates of Klein and Krech.[22] These authors have argued that individuals have a basal or characteristic level of cortical conductivity prior to any stimulation, which helps determine the amount of drop (inhibition) possible. Eysenck comments;

> On the purely theoretical level, of course, 'cortical conductivity' is an unavoidable construct if we postulate consistent individual differences in stimulus-produced inhibition.[23]

He speculates that individual differences in basal cortical conductivity might be attributed to a constitutional property of the central nervous system such that it is

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21 Eysenck, Experiments with Drugs, Op. Cit., p. 2.

22 George S. Klein and David Krech, "Cortical Conductivity in the Brain Injured", in Journal of Personality, Vol. 21, 1952, p. 118-148.

23 Eysenck, Experiments with Drugs, Op. Cit., p. 4.

constantly in a state of greater or lesser excitation or inhibition. To measure this "state" without the imposition of extraneous, confounding stimuli, Eysenck suggests measures of cortical conductivity, or EEG patterning.

The final Eysenckian view of inhibition, then, is tripartite, having temporal, spatial and basal components.

2. Reminiscence Studies Related to the Theory.

There are no studies in the literature which relate reminiscence to direct measures of cortical conductivity, or EEG patterning.

The reminiscence phenomenon has been used extensively as a criterion to test Eysenck's typological postulate, however. In a recent review[24] he cites twenty studies which have purported to test the hypothesis that reminiscence effects are stronger in extraverts than in introverts, or related hypotheses involving the postulation of greater inhibition effects in certain criterion groups. In evaluating the evidence, he concludes that regardless of the method of measurement or criterion used, nearly every experiment gives results which are in line with the prediction that reminiscence is greater in extraverts than in introverts.

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24 H.J. Eysenck, "Reminiscence, Drive and Personality - Revision and Extension of a Theory", in British Journal of Social and Clinical Psychology, Vol. 1, 1962, p. 127-140.

In 1956, Eysenck[25] first found significant correlations between pursuit-rotor reminiscence and extraversion as measured by the _Maudsley Personality Inventory_, but he also found a correlation between reminiscence and neuroticism. The latter he interpreted as being due to a greater amount of drive in the neurotic subjects. In pursuing this line of thought, as he does in his 1962 revision of the theory,[26] he touches upon a factor which is very closely related to basality, for the amount of drive is closely linked to level of sympathetic arousal. Direct relationships between basal and reactive inhibition are not shown, however.

The implications of drive and level of arousal, and the revision of the theory, will be treated more extensively in chapter three, under "Discussion".

3. Latency of Evoked Cortical Potentials.

In suggesting that measures of cortical conductivity, or _EEG_ patterning, might reflect aspects of central nervous system functioning basic to personality differences, Eysenck is one of many speculators. The problem of relating electrical activity of the brain to psychological phenomena

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25 H.J. Eysenck, "Reminiscence, Drive and Personality Theory", in _Journal of Abnormal and Social Psychology_, Vol. 53, 1956, p. 328-333.

26 --------, "Reminiscence, Drive and Personality - Revision and Extension of a Theory", _Op. Cit._, p. 127-140.

constituted one of the main interests of the founder of electroencephalography himself, Hans Berger. As Ertl[27] has pointed out, the failure to find significant relationships between personality and EEG variables may well be due to the nature of the EEG variables employed.

Lindsley,[28] in his quest for a closer liason between psychological and neurophysiological knowledge, suggests that an exploration of the time variable might prove fruitful. In his words:

> Many facets of reliable psychological data are open to us, especially in the areas of sensation, perception, action and learning. One of the outstanding parameters of these data is time. Stimulus properties of kind, intensity and spatiality may also be important parameters, but our most common and perhaps most useful parameter in transforming and integrating two sets of data is that of time. Furthermore, time and its derivatives, rate, rhythm, sequence and so forth seem to be fundamental properties or conditions of nervous system integration.[29]

The present research employs and EEG variable which yields data in the form of time (latency) measurements, and is also a direct measure of cortical conductivity. This variable is a visually evoked cortical potential.

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27 John P. Ertl, Intra-Cortical Delay and Intelligence, unpublished Master's thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, October 1961, vi-41 p.

28 D.B. Lindsley, "Psychological Phenomena and the EEG", in Electroencephalography and Clinical Neurophysiology, Vol. 4, 1952, p. 443-456.

29 Ibid., p. 444.

"An evoked potential may be defined as the detectable electrical change in the brain in response to deliberate stimulation of any part of the nervous system."[30] The evoked potentials differ from the spontaneous electrical activity of the brain in that they have a definite temporal relationship to the onset of the stimulus, a constant pattern of response, and a focus of maximal response in the brain.

Dawson[31] was the first to demonstrate that evoked potentials could be detected from scalp recordings. He applied a principle based on averaging numerous measurements in relation to a fixed point in time (the onset of the stimulus). Potentials unrelated to the stimulus are averaged out, while those time-locked to the stimulus summate and eventually become readily distinguishable.

Since 1947, technological advances have led to an explosion of activity in this field of research. Although the period of taxonomy is not yet passed, it is an established fact that human cerebral evoked activity can be

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30 H-T. Chang, "The Evoked Potentials", in Handbook of Physiology, Section I, J. Field, H.W. Magoun and V. Hall, Eds., American Physiological Society, Washington, D.C., 1959, p. 311.

31 G.D. Dawson, "Cerebral Responses to Electrical Stimulation of Peripheral Nerve in Man", in Journal of Neurological and Neurosurgical Psychiatry, Vol. 10, 1947, p. 134-140.

recorded from the scalp, and contains several components which exhibit statistically significant differences in responsiveness. It has also been possible to associate tentatively certain portions of the averaged waveform with specific anatomic structures.

Although there are again no studies in the literature which pertain specifically to, or are direct precursors of, the present research, one exemplary sample of the type of work that is being carried on in the field will be cited. Uttal and Cook[32] have recently made a major contribution to our knowledge of evoked potentials, from an intensive study of two male subjects. Pulse electrical stimuli were applied to the median nerve of the wrist, and the evoked potentials were picked up from the somatosensory cortex by contact electrodes. As well as providing a generally accepted nomenclature for the waveform (M, N and O waves), and descriptive details, they have contributed data on the effects of sleep on evoked potentials, the relation between amplitude of the potentials and stimuls intensity, and temporal and spatial interaction of the potentials.

Since the existing research is still of an exploratory, normative nature, the question of the parameters

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32 William R. Uttal and Louella Cook, "Systematics of the Evoked Somatosensory Cortical Potential: A Psychophysical-Electrophysiological Comparison", in <u>Annals of the New York Academy of Sciences</u>, Vol. 112, 1964, p. 60-80.

underlying measurable aspects of the evoked potentials remains open. The writer's speculation that differences in inhibitory potential (or basal inhibition) might be reflected as individual differences in response latency is not entirely unfounded. The rationale behind measuring inhibition by means of speed stems first of all from Klein and Krech's previously mentioned contention that brain injury (and hence inhibition) is manifested through reduced cortical conductivity.[33] Present knowledge of the nature of synaptic delay would seem to lend support to this contention, while an additional or alternate explanation may be gained by invoking Halstead's[34] "power factor", as Barry and Ertl[35] have done. Many more specific cues pointing to the inhibition-latency relationship are to be found in recent electroencephalographic literature. Uttal and Cook,[36] for example, were able to study the "refractory" function of the evoked potential by administering two stimuli, delayed in time. Not only were they able to show that the inhibitory

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

34 Ward C. Halstead, Brain and Intelligence, Chicago, University of Chicago Press, 1947, xiii-147 p.

35 William Barry and John Ertl, "Intra-Cortical Delay and Intelligence", in Revue de l'Université d'Ottawa, Ottawa, Canada, 1961, p. 197-202.

36 Uttal and Cook, Op. Cit., p. 60-80.

effects of the first stimulus were less serious for the M wave than for the N, but they also established differential response patterns between subjects. Further, the last phase of the wave (O) seemed to be associated with the state of alertness of the subject. Insofar as sleep, and the effects of barbiturates, can be likened to inhibitory processes, a study by Cigánek demands attention. He says: "During sleep waves I-III remain unchanged except for their significantly prolonged latency." For wave V "(...) the peak shifts along the time axis in the direction away from the stimulus".[37] The same effect is observed after the administration of barbiturates. While this study employed a graphic superimposition technique, and the numbering of the waveforms differs from those previously mentioned, the underlying principles, and their theoretical implications are identical.

4. Justification for the Study.

The primary purpose of the present research is that of construct validation. The justification for this lies basically in the controversy that surrounds Eysenck's conceptualization of inhibition. As outlined previously, he

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37 L. Cigánek, "The EEG Response (Evoked Potential) to Light Stimulus in Man", in Electroencephalography and Clinical Neurophysiology, Vol. 13, 1961, p. 165-172.

has spoken of temporal and spatial inhibition, and has assumed a commonality in them, in grouping them under the broader construct of reactive cortical inhibition. As Meyer[38] has pointed out, the three generic notions of reactive inhibition, satiation, and inhibition produced by negative induction appear to have much in common. They all imply that a continuous excitation of a sensory surface leads to some kind of process in the nervous system which causes subsequent responses to the same excitations to be altered. However, he adds:

> Unfortunately, there is, at the moment, no direct neurophysiological or psychological experimental evidence regarding the identity or lack of identity of these notions.[39]

There is even less evidence available to justify the identification of the basal notion of inhibition with the other two.

To crystallize his theoretical position, then, Eysenck has argued for a central rather than a peripheral type of inhibition. In refuting Hull's peripheralist view he cites a finding that strong reactive inhibition can be generated by a perceptual test involving a minimum of physical effort, and he also makes reference to studies of

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

39 *Ibid.*, p. 533.

bilateral reminiscence - the transfer of inhibition from one hand to the other, in certain performance tasks. This phenomenon cannot be adequately accounted for by an effector localization hypothesis of inhibition.[40] He goes on to point out, and rightly so, that any peripheral stimulus-response activity necessarily has a central transmission component.

The literature is replete with studies which relate "Level 2" phenomena such as after-image duration, conditioning, reminiscence, and figural aftereffects, to the personality dimensions of Introversion-Extraversion and Neuroticism. However, since the assumption is made that these phenomena all reflect reactive cortical inhibition, and since this construct is suspect, it would seem premature to claim that the results reported from any one study are supportive, or even comparable to, those reported for another.

The central versus peripheral question has bearing on the present research only because inasmuch as the state of the central nervous system is affected, basality is affected. Despite the locus of the inhibitory effects *per se*, our concern is with the relationship between the basal potential for conductivity, which exists prior to any

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40 Eysenck, *Anxiety and Hysteria*, *Op. Cit.*, p. 56.

stimulation, and stimulus-produced (reactive or temporal) inhibition.

The research of Becker[41] still presents the most formidable contradiction and criticism of Eysenck's theoretical "looseness". Objecting to the synonymical usage of the terms satiation, reactive inhibition, and basal cortical inhibition, he sets out to investigate their interrelationships.

> The main hypotheses to be examined are: (a) that individual differences in satiation effects and reactive inhibition effects are correlated, thus, justifying the more general concept of reactive cortical inhibition; (b) that individual differences in basal cortical inhibition are correlated with individual differences in reactive cortical inhibition, as assumed by Klein and Krech (1952); and (c) that individual differences in satiation, reactive inhibition, or basal cortical inhibition are related to individual differences in extraversion-introversion.[42]

The sample of sixty-two were tested for reactive inhibition by means of pursuit-rotor reminiscence and response alteration, and for satiation effects by a kinesthetic aftereffect test, Archimedes spiral, and Necker cube difference scores. GSR conditioning, critical fusion frequency, and aniseikonic lenses were used to measure basal inhibition.

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41 Wesley C. Becker, "Cortical Inhibition and Extraversion-Introversion", in Journal of Abnormal and Social Psychology, Vol. 61, 1960, p. 52-66.

42 Ibid., p. 53.

> The findings indicated that the concept of basal cortical inhibition (...) appeared as a unitary factor, but was not found to be related to extraversion-introversion. No empirical evidence was found to support Eysenck's assumption that satiation and reactive inhibition form a unitary trait. Satiation and reactive inhibition measures were found to have some common variance with the basal inhibition measures, but they did not covary with each other.[43]

He goes on to say that "If a relationship between reactive inhibition and extraversion exists, it is probably of such a small magnitude as to be practically and theoretically trivial."[44] Hence, though his stand with regard to extraversion-introversion is clear and strong, we are left to draw our own conclusions as to the significance of the degree of identity and specificity found among the inhibition factors.

In 1961, Kovatch[45] compared after-image threshold measures of a group of fifteen males having intracranial pathology with the scores of a group of seventy-two RCMP, in looking for reactive and basal inhibition differences. Evaluating his results in light of the postulates of Klein and Krech,[46] he concluded:

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43 Becker, Op. Cit., p. 65.

44 Ibid., p. 65.

45 J. Kovatch, Intracranial Pathology and the Negative After-Image Threshold, unpublished Master's Theses presented to the School of Psychology and Education of the University of Ottawa, Ontario, 1961, viii-43 p.

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

> (...)Their assumption that the over-all state of the cortex helps to determine the basal value of cortical conductivity and the degree of drop possible was not upheld. No significant differences were found between the basal scores of the organics and non-organics.[47]

This conclusion might be criticized on the grounds that a single index score (Trial 1) can hardly be taken as a sufficient indicator of the basal level of cortical functioning.

The most recent and convincing positive evidence for the consideration of basality in any theorizing about inhibition comes, not surprisingly, from Eysenck himself, in the form of the drug postulate. By demonstrating that depressant drugs increase inhibitory potentials and decrease excitatory ones, while stimulant drugs have the opposite effect, he has found a way to control and manipulate the independent variable of his research. Contributors to Experiments With Drugs[48] are unanimous in upholding the central cause and mediation of the behavioral changes observed. The book stresses the vistas opened by drug research, for assessment of central nervous system activity, and a cogent parallel is drawn between the general facilitatory and suppressor functions of the reticular formation

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47 Kovatch, Op. Cit., p. 38.

48 Eysenck, Experiments With Drugs, Op. Cit., xii-421 p.

and the concepts of excitation and inhibition that are used in psychological models.

In addition to construct validation, the present research can be justified from a more practical point of view. The EEG technique used in the study elicits a relatively "pure" sample of brain activity, and thereby eliminates contaminating variables encountered in previous related research. For example, Barry[49] points out that the contradictory and confusing results of various tests of Eysenck's postulates may be due to the nature of the measurements, in that peripheral functions are generally victimized by obtuse and uncontrollable variables distinct from the cortical contribution. The direct measure employed in the present study precludes such contamination. Such factors as attitude and motivation, which have been major stumbling blocks in the validation of Eysenck's principles, are eliminated as well, since the subject has no control over his responses.

The final justification for this research resides in the implications that positive results could have for future psychological theory and practice. Consider the words of Shagass and Schwartz:

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49 W.F. Barry, An Investigation of the Relationships Between Introversion-Extraversion and the Negative After-Image Threshold, unpublished doctoral dissertation presented to the School of Psychology and Education, University of Ottawa, Ontario, April 1961, ix-80 p.

> The ability to measure cortical responses in a subject who is able to report his thoughts and feelings offers exciting possibilities. For example, one thinks of attempting to find behavioral correlates for individual differences in the characteristics of evoked potentials, to study the effects of drugs on them, and to determine the manner in which they may fluctuate with changes in feeling state or under different conditions of attentiveness.[50]

In demonstrating that the later, rhythmic waves (E_4 and E_5) of evoked potentials have great inter-individual variability and seem to be influenced by psychological factors, the authors have made an important step towards the demonstration of a relationship between cortical inhibition and various aspects of personality and the thought processes. Further, Ertl,[51] in 1961, found a significant relationship between intra-cortical delay and intelligence, as measured by the Wechsler-Bellevue.

Thus, it might be said in summary: Eysenck has based his dimensional analysis of personality on the excitation-inhibition ratio. The literature does not provide sufficient evidence to justify the identification of the various concepts and manifestations of inhibition which Eysenck groups into one psychoneurological construct. The "raison d'être" of this study is to see if the basic

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50 Charles Shagass and Marvin Schwartz, "Evoked Cortical Potentials and Sensation in Man", in Journal of Neuropsychiatry, Vol. 2, 1961, p. 269.

51 Ertl, Op. Cit., vi-41 p.

concepts are firmly welded together - for there is sufficient evidence to indicate that Eysenck has been building a multi-storey structure on a shaky foundation. If the groundwork proves to be solid, the long range and worthy goal of psychological and neurological rapprochement may be sought.

This study purports, then, to take a measure of temporal inhibition, and one of basal inhibition, and examine whether there is sufficient relationship between them to postulate a commonality. Stated in the null form the hypothesis is: There is no significant, positive relationship between reactive inhibition, as measured (and defined) by motor reminiscence, and latency of evoked cortical potentials (time of arrival of stimulus effect at the motor cortex).

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

CHAPTER II

EXPERIMENTAL DESIGN

This chapter outlines the experimental design used to test the hypothesis proposed in the foregoing chapter. Section 1 of the chapter will be a description of the experimental sample. Section 2 will deal with the instrument used to measure reactive inhibition, while Section 3 will describe the psychophysiological technique. The experimental procedures, and the techniques for data evaluation, comprise Sections 4 and 5, respectively.

1. The Experimental Sample.

The sample consisted of forty-six "normal" males whose ages ranged from 15 to 41 years, with a mean age of 26.1 years. These subjects were obtained from two sources: the School of Psychology and Education of the University of Ottawa, and the Initiative and Leadership Patrol of the Cameron Highlanders of Ottawa. Of the forty-six volunteers, ten were deleted - five for whom pursuit-rotor data could not be obtained, and five others from whom satisfactory evoked potentials could not be recorded. The thirty-six remaining subjects conformed to a number of criteria, dictated by the nature of the study. Firstly, sex differences in the ability to perform the pursuit-rotor task necessitated an homogeneous group.[1] Secondly, the age range was delimited to preclude possible cortical variables attributable to maturational level. Thirdly, any reported motor disability led to automatic exclusion. In addition, the subjects reported no organic brain damage or history of head injury, no ingestion of stimulants just prior to testing, and abstention from drugs or other medication. (The latter stimpulation stemmed from the previously mentioned effects of drugs on basal level of cortical activity.)

2. The Tool for Measurement of Reactive Inhibition.

The instrument chosen to generate and measure reactive inhibition was a pursuit rotor - a tool which is well known and widely used in the study of learning phenomena.

The particular pursuit rotor employed in this experiment was built to comply with recognized standards for apparatus of this type, in accordance with variables known to be involved in the execution of the task.[2] It consists

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1 C.E. Buxton and D.A. Grant, "Retroaction and Gains in Motor Learning: II. Sex Differences, and a Further Analysis of Gains", in Journal of Experimental Psychology, Vol. 25, 1939, p. 198-208.

2 R.B. Ammons, "Rotary Pursuit Apparatus: I. Survey of Variables", in Psychological Bulletin, Vol. 52, 1955, p. 69-76.

of a cabinet fourteen inches by sixteen inches, and six inches in height, into which is set a revolving bakelite turntable, nine inches in diameter. A small copper disc (the target) is set flush into the turntable, one half inch from its outer rim. The stylus, which is to be kept in contact with the target, consists of an articulated metal rod with a plastic handle-grip. The apparatus is wired in such a way that whenever stylus-target contact is made, a current activates an electric timer which records time on target for each consecutive tenth of a second. The device is powered by a 110-120 volt motor (Singer, model RF35-8), which is connected to a constant voltage transformer to insure constancy of speed of rotation. Being reversible, the motor allows the turntable to revolve either clockwise or counter-clockwise. Speed can be varied from one to eighty revolutions per minute.

The pursuit-rotor task was chosen as the criterion variable for two main reasons. Firstly, since it is a well known and proven measure of motor learning (and such concomitants as spaced practice versus massed practice, reminiscence, et cetera) there exists a wealth of literature pertaining to the acquisition of the skill, its quantitative and qualitative components, and theoretical formulations regarding its nature.[3] Secondly, the pursuit-rotor measure has long been one of the objective indices used by Eysenck in his experimental work to test predictions made from behavior theory in conjunction with his typological postulates.[4] Much evidence from motor reminiscence has been put forth both in support and refutation of Eysenckian theory. In a recent publication[5] Eysenck cites twenty different studies - thirteen of them employing the pursuit rotor - which have led him to revise his theoretical position with regard to the drive and inhibitory components of reminiscence. Hence, use of the pursuit rotor not only provides for a theoretical backdrop against which to view the present study and from which to draw implications for the results, but it also renders the present results comparable to previous research on reactive inhibition, and more specifically to Eysenck's reminiscence studies.

3. The Psychophysiological Technique.

The instrumentation employed in this study, for the evocation and recording of cortical potentials, will now be described.

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3 John A. McGeoch and Arthur L. Irion, The Psychology of Human Learning, New York, David McKay Co., Inc., 1952, xxii-595 p.

4 H. J. Eysenck, The Dynamics of Anxiety and Hysteria, New York, Frederick A. Praeger, 1957, xiii-311 p.

5 --------, "Reminiscence, Drive and Personality - Revision and Extension of a Theory", in British Journal of Social and Clinical Psychology, Vol. 1, 1962, p. 127-140.

EEG recordings were obtained by a two channel system, consisting of low noise pre-amplifiers, an oscilloscope, and a polaroid camera attachment. Stimuli were delivered by a Model PS-2 Grass photic stimulator, and Raymond type contact electrodes were used.

The technique for the detection of evoked potentials is fully described in a paper by Ertl.[6] In reporting the method, he says:

> The technique consists of detection and display of zero crossings of EEGs in a manner which facilitates the summation of all such events occuring within a finite time window after a stimulus. This is accomplished by generating a pulse at each zero crossing. The pulses are used to intensity modulate a CRT (cathode ray tube). The horizontal sweep may be triggered by the stimulus generator. Apparatus required consists of EEG amplifiers, Schmitt trigger to detect zero crossing and trigger a pulse generator, a CRO (cathode ray oscilloscope) and an incremental DC voltage source applied to the vertical amplifier to indent the trace.
>
> The instrumentation used in producing the data of Fig. 1 was a Hewlet Packard Frequency Meter model 500BR which has a Schmitt trigger circuit and was fired by a 0.2V signal and had a 35V negative output pulse for each cycle of input. The trace was indented after each sweep by applying DC to the input of the CRO from a decade voltage divider.
>
> The EEG amplifier gain was adjusted so that a 3 microvolt signal would produce a pulse. The CRO sweep was randomly triggered by a photostimulator and the EEG obtained from bipolar electrodes over the motor area. It is important to note that it is necessary to indicate the beginning of the sweep (solid line Fig. 1a,c,) as a zero crossing will not always occur when the sweep is triggered by the stimulus.[7]

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6 John P. Ertl, Detection of Evoked Potentials by Zero Crossing Analysis, 1964,(to appear).

7 Ibid.

4. The Experimental Procedures.

This section of the chapter will outline the procedures that were followed for the collection of the data. Conditions were standardized as much as possible, for the entire sample.

Upon entering the testing room, each subject was asked to be seated, and the necessary information on age, handedness, freedom from head injury, et cetera, was obtained from him. He was assured that no painful stimuli would be used and that the experience would be in no way unpleasant.

The EEG recording session, which lasted from twenty to thirty minutes, followed. The bipolar Raymond type electrodes, which had been soaked in saline solution, were placed over the motor area of the cortex (right or left hemisphere, according to hand laterality). The electrodes were held in place by a head strap, and good contact with the scalp was verified before recording was begun. The photic stimulator was placed at a distance of two feet from the head of the subject, adjusted to eye level. The subject was told to relax as much as possible, and while keeping his eyes open, to avoid looking directly at the light. Several sample flashes were then produced, to accustom him to the brightness, and show him what to expect. All lights in the room were extinguished, except for one sixty watt red bulb, and noise was kept to a bare minimum.

For the testing proper, 120 stimulations (light flashes) were given to evoke and subsequently detect the cortical responses. Following this, an equal amount of data <u>without</u> stimulation (random sample of activity of the same area of the cortex) was obtained by triggering the sweep manually at random intervals. Throughout, the time base for the <u>EEG</u> was fifty milliseconds per centimeter.

Upon completion of this phase of the experiment, the subject was introduced to the pursuit-rotor apparatus and given the instructions: "This is a test of motor skill. You are to try to keep the tip of this stylus in contact with the target, while it turns around." A demonstration was then given, to be sure the task was understood. Further instructions were: "Try your very best to follow the target, and please concentrate. Think only about what you are doing. Stand directly in front of the rotor, and use a free, swinging movement from the shoulder. I'll tell you when to begin and when to stop."

The rotor was then turned on, and when the speed had stabilized, the subject was told to begin. Six minutes of continuous practice were administered, and time on target was recorded for consecutive thirty second periods. Then the subject was allowed six minutes of rest, during which time he was engaged in conversation with the experimentor, to prevent any kind of "rehearsal". After a short reiteration of the instructions, practice was resumed for two more minutes.

The speed of the rotor during all testing was 70 r.p.m. (revolutions per minute), the stability of which was measured with a strobotac to be within plus or minus two per cent. This speed was chosen, in preference to the more usual 60 r.p.m., in order to avoid a ceiling effect in the learning, which would contaminate reminiscence measures. Ammons[8] found that his group of college women attained eighty per cent efficiency at 60 r.p.m., and so it was felt that with the male group of the present study, 70 r.p.m. would assure greater task difficulty and keep performance levels low.

The turntable revolved in a clockwise direction for right-handed subjects, and counter-clockwise for those who elected to use their left hand.

The subjects returned one week later for a pursuit-rotor retest, and were submitted to identical procedures. After twenty-six retests it was obvious that numerous contaminating variables were invalidating the second reminiscence scores, and so retesting was discontinued.

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8 R.B. Ammons, "Acquisition of Motor Skill: II. Rotary Pursuit Performance with Continuous Practice Before and After a Single Rest", in Journal of Experimental Psychology, Vol. 37, 1947, p. 393-411.

(This will be discussed at greater length in chapter three, under the heading "Estimation of the Reliability of the Independent Variable".)

The following section of this chapter will present the statistical methods used to analyze the data.

5. Analysis of the Data.

As outlined in the previous section, pursuit-rotor data was collected by recording time on target for consecutive thirty second periods of massed practice. Each individual's reminiscence score was obtained by subtracting his time on target during the last pre-rest thirty seconds from his time on target during the first thirty second interval after rest. Scores thus obtained were ranked from high to low.

Two measures of the reliability of the pursuit rotor itself were obtained. Split-half reliability of performance was determined for forty subjects by correlating the summed scores for the odd thirty second intervals, with those for the even (for the six pre-rest minutes). A test-retest reliability estimate was obtained for twenty-six subjects by correlating the final thirty second pre-rest interval scores with the same scores, obtained one week later.

The formula used was the Pearson product moment coefficient of correlation:

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

Application of this formula yields estimates of consistency of measurement only. Estimation of the reliability of the phenomenon of reminiscence itself will be discussed in Section 1 of the following chapter.

Statistical analysis of the photographic evoked potential data obtained by the zero-crossing method is an inherent part of the technique itself. Hence, it will be reported step by step.

a) A sheet of perspex on which parallel lines at 2 mm intervals were ruled, was placed over the photograph and the dots in each column were counted. A plot of dot count versus time[9] was made for the data with stimulus and for the data without stimulus as shown in Fig. 1.

b) The standard deviation of zero crossings was then calculated for the non stimulated sample and is indicated by σ in Fig. 1d.

c) Two and three σ confidence bands were drawn on the plot of data taken with stimulus Fig. 1b. Thus a dot count that was more than 3σ above the mean count in the 'with stimulus' sample was considered to define the temporal location of a zero crossing of an evoked potential.

d) Once the zero crossings of the evoked potentials are statistically identified and located in time, the method can be refined by reducing the width of the time interval used. This procedure serves to increase the resolution of the latency measurements.[10]

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9 The data plotted in Fig. 1b,d, were taken from two photographs with 60 stimulations on each.

10 Ertl, Op. Cit.

Figure 1.

(a) Dots represent zero crossings with stimulus. Solid line below 60 c/second calibration marks indicates start of sweep.

(c) Zero crossings without stimulus. Solid line indicates start of sweep.

(b) Plot of dot count versus time. Each point on the graph corresponds to the dot count in a column 2 mm wide, where 2 mm equals 12 msec. E_1 and E_2 are evoked potentials.

(d) Plot of dot count versus time for the non stimulated data.

Figure 1. reproduced with the permission of John Ertl.

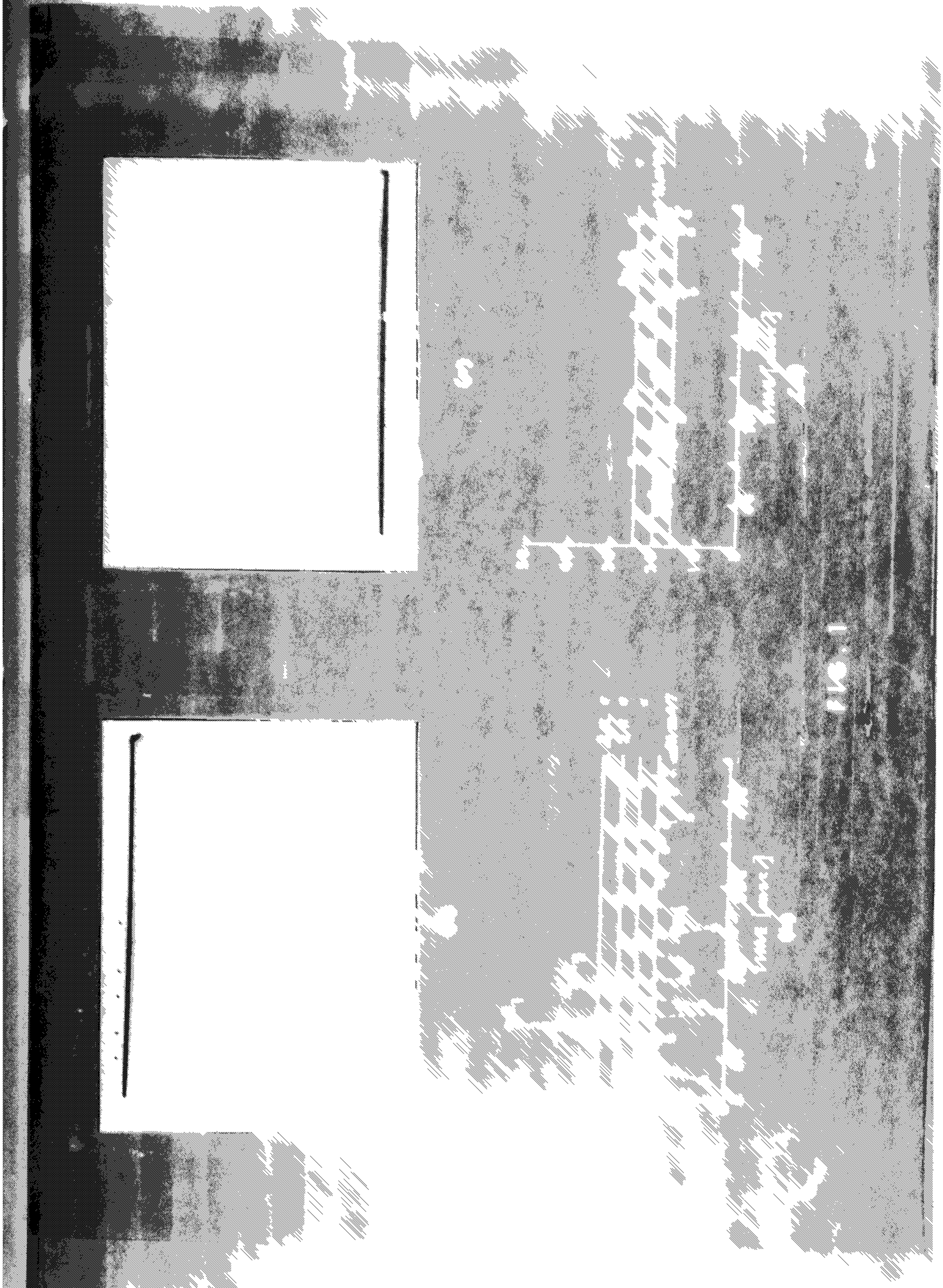

Figure 1.- Sample and Analysis of Data Obtained With (a), (b) and Without (c), (d) Stimulation.

Ertl goes on to say:

> The distribution of zero crossings with no stimulus and the eyes open was found to approximate closely the gaussian distribution for the data reported in this paper and also for the data obtained from 50 other subjects. Statistics based on this distribution were therefore used.[11]

Thus, using confidence bands of two standard deviations above and below the mean, five measures of latency (E_1 - E_5) were located, although all five were not present for each individual.

In testing the hypothesis of no significant positive relationships between measures of reminiscence and latency of evoked cortical potentials, Spearman's rank-difference correlation method was used, the formula being:

$$\text{rho} = 1 - \frac{6\sum D^2}{N(N^2-1)}$$

where $\sum D^2$ = sum of the squared differences between ranks, and N = number of pairs of measurements. Since five measures of latency were obtained (E_1 - E_5), five correlation coefficients were calculated.

The standard error of the obtained coefficients was obtimated by the formula:

$$\sigma_{\text{rho}} = \frac{1}{\sqrt{N - 1}}$$

where N = number of cases in the sample. This value was multiplied by 2.35 to determine the rho required for

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11 Ertl, Op.Cit.

significance at the .01 level of probability (1 tail). This rho was then compared with the obtained coefficients of correlation in order to establish whether or not the latter differed significantly from zero.

It must be noted that the N was different for each calculation, since all five events were not present in the recordings for each individual. Possible reasons for this are: a) the technique was not sufficiently sensitive to detect all phases of an individual's evoked response; b) some phases of the usual response might have been absent in certain subjects; and c) perhaps the criterion for identification of responses was too high. Confidence bands of two standard deviations may have excluded a number of events.

The findings which emerged from the analysis of the data, and their interpretation, will be presented in the following chapter.

CHAPTER III

FINDINGS AND DISCUSSION

In this chapter, the findings of the experiment are presented and interpreted, in light of the proposed problem. Section 1 will deal with the reliability of the experimental variables, while Section 2 will present the findings proper - i.e. the correlations of the variables under investigation. The third and final section discusses the adequacy of the present design to test the hypothesis, and places the findings in theoretical perspective.

1. Reliability of the Experimental Variables.

Before any interpretation or discussion of results can be undertaken, it is necessary to establish the reliability of the measures obtained. This section will deal with the estimation of the reliability of the independent and dependent variables, respectively.

Reliability is of a certain instrument, applied to a certain population under certain conditions. Since it can never be taken for granted that the instrument itself is reliable, the consistency of the pursuit rotor measures had to be determined. The odd-even method, applied to the raw scores of forty subjects, yielded an internal consistency reliability coefficient (Pearson r) of .956. A test-retest reliability coefficient was calculated on performance scores at a one week interval, for twenty-six subjects, and found to be .750. Both statistics are significant at the .01 level, and closely approximate expected reliability for psychomotor tests cited by Guilford.[1]

As mentioned in chapter two, section 4, pursuit rotor retests were done on twenty-six subjects to determine the consistency of reminiscence scores. The Spearman rank-difference coefficient of correlation was -.203, which is of course unacceptable as a reliability indicator. Since we know the instrument itself was reliable, it follows that the error variance of the above coefficient lies in the phenomenon of reminiscence, and the technique used to measure it.

Four possible explanations for the lack of reliability of the reminiscence scores are offered:

1) Reliability coefficients are known to be lowered by an homogeneous population. The subjects of the present research showed almost no differences in ability to perform the required motor task.

2) The working range of the task was small, and only a limited degree of improvement was possible.

3) The nature of the reminiscence phenomenon is complex, and the underlying mechanisms equivocal. As

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1 J.P. Guilford, Fundamental Statistics in Psychology and Education, New York, McGraw-Hill, 1956, p. 444.

Jones[2] has pointed out, reminiscence is not a function of reactive inhibition alone, but also of habit strength and conditioned inhibition, which are present in varying amounts throughout the learning (practice) situation. It is sufficiently difficult to sort out the differential amounts and effects of these variables within the orthodox Hullian framework,[3] without having to account for Eysenck's lack of theoretical definitiveness in this area. Additional variables known to contaminate measures of reminiscence are drive level[4] and motivation.[5]

4) The final explanation for lack of test-retest reliability involves the learning, or practice effect. If individual differences in rate and amount of learning are not controlled or accounted for, the test-retest scores are not comparable. Commonly, in studying the reminiscence

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2 H. Gwynne Jones, "Learning and Abnormal Behavior", in Handbook of Abnormal Psychology, H.J. Eysenck, Ed., New York, Basic Books, 1961, p. 506.

3 Kay C. Montgomery, "An Experimental Investigation of Reactive Inhibition and Conditioned Inhibition", in Journal of Experimental Psychology, Vol. 41, 1951, p. 39-49.

4 H.J. Eysenck and A.E. Maxwell, "Reminiscence as a Function of Drive", in British Journal of Psychology, Vol. 52, 1961, p. 43-52.

5 G.A. Kimble, "Evidence for the Role of Motivation in Determining the Amount of Reminiscence in Pursuit Rotor Learning", in Journal of Experimental Psychology, Vol. 40, 1950, p. 248-253.

phenomenon per se, the performance of a no-rest control group is the baseline from which the improvement over rest is calculated, or else the subjects practise to a criterion level, before experimental performance begins. Practising to a criterion was precluded in this case, since it would have generated different amounts of reactive inhibition.

Eysenck's reported reliability coefficients (e.g., .44)[6] are misleading, since they represent the correlation of two reminiscence scores obtained from two rest periods in the same series of trials.

Had a control group been used in the present research, the effect of many of the contaminating variables would have been known, and a "purer" measure of reminiscence obtained. As it stands, reminiscence is here defined by the operations used to identify it. Our lack of knowledge as to its reliability in this instance, imposes serious limitations on the interpretation of the results of the experiment.

In discussing the reliability of the dependent variable of this experiment it is necessary to make a differentiation between (a)the constancy or consistency of the evoked potential phenomena themselves, and (b) the

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6 H.J. Eysenck, "Reminiscence, Drive and Personality Theory", in Journal of Abnormal and Social Psychology, Vol. 53, 1956, p. 328-333.

reliability of our measure of latency - i.e. time of arrival of the events at the motor cortex. Evidence for the former is brought in to add support to our estimation of the latter.

The fact that visual evoked responses can be reliably measured by techniques similar to the one employed in this experiment is widely reported in the literature. For example, Cobb and Dawson,[7] in speaking of the constancy of latency and form of evoked occipital potentials, report:

> Under fixed conditions of stimulation, observation of single responses suggests that they vary in size considerably from one stimulus to the next. A great part of this apparent variability may be due solely to the background of spontaneous e.e.g. activity on which the evoked potentials are superimposed. In the averaged records, however, the main characteristics of the responses in one person remain little changed over periods of 20 min. or more.[8] (The underlining is ours.)

They maintain that records taken at eleven minute and twenty-two minute intervals agree well, and give an indication of the degree of confidence which can be placed in the averaged responses obtained in this type of experiment. It should be noted that the experimentation time of the present research is within the limits mentioned by these authors.

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7 W.A. Cobb and G.D. Dawson, "The Latency and Form in Man of the Occipital Potentials Evoked by Bright Flashes", in The Journal of Physiology, Vol. 152, 1960, p. 108-121.

8 Ibid., p. 114.

In their classic study of cortical potentials evoked by visual and electrocutaneous stimuli, Shagass and Schwartz[9] found strong evidence for the stability of the phenomenon. They employed a summation technique similar in principle to that used in this study. To quote them:

> It may be noted that even though the later potentials showed great interindividual variability, the individual pattern of response appeared to be quite stable. To verify this impression of intraindividual consistency, we computed the correlations between individual points in time on the 5 msec. gate tracings for 10 subjects in whom the same stimulus was applied at intervals 1 to 3 hours apart. The mean correlation coefficient was .87 (...). Similar correlation coefficients calculated for the responses of different subjects to the same stimulus approached zero.[10]

Detailed descriptions of major components of the averaged visual evoked response, plus normative values for amplitudes and latencies, are reported by Ciganek,[11] and Kooi and Bagchi,[12] and they leave little room for doubt as to the consistency of the phenomenon.

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9 Charles Shagass and Marvin Schwartz, "Evoked Cortical Potentials and Sensation in Man", in Journal of Neuropsychiatry, Vol. 2, 1961, p. 262-270.

10 Ibid., p. 266.

11 L. Ciganek, "The EEG Response (Evoked Potential) to Light Stimulus in Man", in Electroencephalography and Clinical Neurophysiology, Vol. 13, 1961, p. 165-172.

12 Kenneth A. Kooi and B.K. Bagchi, "Visual Evoked Responses in Man: Normative Data", in Annals of the New York Academy of Sciences, Vol. 112, Art. 1, p. 254-269.

Keeping in mind the foregoing evidence for the reliability of the phenomenon itself, the reliability of the measure of latency used in this study - which is our prime consideration - will now be presented.

Inasmuch as our summation technique for the detection of evoked cortical potentials depends on the vertical lineup of dots to show the location of an event, it has a "built in" indicator of reliability. If each stimulation (producing one sweep on the oscilloscope) is considered as one trial, then the consistent occurrence of a zero-crossing at a particular point of each sweep of the beam (producing a vertical line-up of dots on the photograph of the oscilloscope screen) shows that the zero-crossing (event) is time-locked to the stimulus, and attests to the reliability of the phenomenon.

Because of the importance of procedural constants and electrode placement in determining the recorded response, exact replication of experimental conditions is almost impossible to achieve. Hence the present experiment did not undertake to retest the entire sample for the EEG variable. Retests of twelve subjects, however, yielded a reliability coefficient of .92.[13]

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13 John Ertl, Personal Communication with the author.

2. Correlations of Variables Being Studied.

The hypothesized positive relationship between reactive inhibition, as measured by motor reminiscence, and latency of evoked cortical potentials was tested five times by relating reminiscence scores to the five separate latency measures. The Spearman rank-difference coefficients of correlation obtained were -.5627, -.0294, +.3503, -.2354, and -.0241, for E_1 to E_5, respectively. The coefficients required to reject the hypothesis at the .01 level of probability (one tail test) were estimated to be .5492, .4117, .4569, .5084, and .4185, and hence the null hypothesis could not be rejected for any one of the five relationships considered. These results are presented in Table I, on the following page.

The findings indicate that there is no relationship between these measures of reactive and basal inhibition, and thus they fail to support Eysenck's identification of the two concepts.

The statistically significant inverse relationship between reminiscence and latency of E_1 is noteworthy since it goes contrary to Eysenckian expectations. Despite its statistical significance, however, the writer does not accept this as a true measure of the relationship between the two variables. Since correlation coefficients must be

Table I.-

Correlations Between Reminiscence and Latency Measures.

Event	N	Coefficient Required for Significance at .01 (1 tail)	Obtained rho[a]
1	19	.5492	-.5627
2	33	.4117	-.0294
3	27	.4569	+.3503
4	22	.5084	-.2354
5	32	.4185	-.0241

[a] Spearman's rank-difference coefficient of correlation.

interpreted in the light of the circumstances under which they were obtained, the meaning that can be given to those here presented is very qualified. Firstly, the small N of the experiment imposes undesirable statistical limitations. The magnitude of the chance factors operable cannot be determined with any certitude, and the findings cannot be generalized beyond the sample itself. Secondly, the questionable reliability of the independent variable does not allow us to say that we are measuring two different things. Thirdly, the lack of variability among the E_1 scores detracts from the meaningfulness of the obtained correlation, since the error of measurement is plus or minus six milliseconds.

Despite the above mentioned problems the findings are suggestive of a trend, and warrant further research to substantiate the "no relationship" interpretation.

3. Discussion.

The discussion of results has been divided into two subsections. Subsection A deals with the failure of the design to test the theory adequately, while Subsection B examines the strength of the theory itself.

A. Failure of the Design to Test the Theory Adequately.

The fact that no relationship was found between reactive and basal inhibition could well be due to the inadequacy of the experimental design employed. Some of the deficiencies of the independent and dependent variables will now be considered, in light of their contribution to the negative results.

i) The Independent Variable.- A discussion of the unreliability of the obtained measurement of reminiscence has been presented earlier in this chapter. The contaminating factors that entered into the pursuit rotor scores were most damaging, and lend support to the admonition of Bendig and Eigenbrode:[14]

> In future research, attention should be concentrated on more reliable measures of motor learning rather than unreliable reminiscence indices which may confound both reactive and conditioned inhibition.[15]

This particular method of measuring reminiscence may have disguised the reactive inhibition, or prevented its optimum accumulation or dissipation. Indeed, the validity of the technique used can be challenged on the basis that it does not meet the stipulations required by the theory. Eysenck has stated that the optimal conditions for testing the hypothesis linking extraversion and high reminiscence scores are:

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14 A.W. Bendig and C.R. Eigenbrode, "A Factor Analytic Investigation of Personality Variables and Reminiscence in Motor Learning", in Journal of Abnormal and Social Psychology, Vol. 62, 1961, p. 698-700.

15 Ibid., p. 699.

> (1) Pre-rest practice should not be too long.
> (2) The programmed rest period should be long enough to allow all of the accumulated I_R to dissipate.
> (3) The reminiscence score is determined by subtracting a pre-rest score from a post-rest score; these scores should be determined by taking periods of practice as short as possible.
> (4) The test should be carried out near the beginning of the learning curve on the particular task chosen (...)[16]

However, on the other side of the coin, the validity of the present measure is defensible, for the stipulations of the theory are far from specific. In the same publication, Eysenck adds:

> In spite of the positive conclusion regarding the relation between reminiscence and extraversion, it is clear that much more work will have to be done on the precise conditions under which this phenomenon emerges most clearly; the optimum combination of length of pre-rest practice, length of rest pause, scoring procedure, level of performance at which the measurement is taken, as well as the most suitable type of performance (pursuit rotor, inverted alphabet printing, etc.) are still to be determined.[17]

The characteristic "looseness" of Eysenck's theory is apparent here. His revisions of it at every turn inflict a severe handicap on those who would test it.

Another possibility which cannot be overlooked is the contamination of the measure of temporal inhibition by

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16 H.J. Eysenck, "Reminiscence, Drive and Personality - Revision and Extension of a Theory", in British Journal of Social and Clinical Psychology, Vol. 1, 1962, p. 129.

17 Ibid., p. 133.

spatial inhibition. Rachman[18] has demonstrated that a noise or other disturbance during massed practice exerts a disinhibiting influence, thus reducing reminiscence. Holland[19] has shown the same phenomenon in the spiral after-effect, adding that the disinhibiting factor can come from the thought processes of the subject himself. The present design is not sufficiently complex to deal with this problem.

ii) The Dependent Variable.- The writer's assumption that speed of cortical conductivity (as measured by latency) reflects basal inhibition, or is dependent upon it, may be the weak link in the proposal. In this respect the present study is necessarily exploratory, as the neurological parameters are largely unknown. Chapter one outlines the thinking behind the assumption, and the research that has led up to it - and on this rests the defense.

The applicability and value of using latency measurements rather than some other aspect of the evoked potentials might be questioned. Chang[20] has pointed out

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18 S. Rachman, "Disinhibition and the Reminiscence Effect in a Motor Learning Task", in British Journal of Psychology, (to appear).

19 P.C. Holland, "Massed Practice and Reactive Inhibition, Reminiscence, and Disinhibition in the Spiral Effect", in British Journal of Psychology, Vol. 54, 1963, p. 261-272.

20 H-T. Chang, "The Evoked Potentials", in Handbook of Physiology, Section I, J. Field, W.H. Magoun and V. Hall, Eds., American Physiological Society, Washington, D.C. 1959, p. 301.

two limitations of these measures: 1) the possible reduction in conduction velocity of impulses at nerve terminals resulting from the diminution of fiber diameter; and 2) the temporal dispersion of the pre-synaptic impulses passing along a bundle of fibers of different sizes may make the time of arrival at the point of recording vary over a wide range so that the last impulses may overlap with the post-synaptic discharge set up by the fast fibers. The latter objection is overruled by the fact that optic impulses, such as those used in the present study, are noted for their synchrony of conduction, and have a characteristic radiation potential. The first limitation, while it does affect the mechanics of neural conductivity and the accuracy of intra-individual measurements, would not hamper the measurement of inter-individual differences in inhibition, in any way. In any event, the present research was not geared towards such specific analysis of the evoked neural activity.

The measurement of basal inhibition demands greater control over the factors affecting level of central nervous system excitability than this design was able to provide. Degree of alertness, and conditioning history of the subject are reported to affect the waveform and amplitude of long latency evoked potentials.[21] While the degree of alertness is intimately related to sympathetic arousal, Claridge[22] has posited that this arousal itself is subject to reactive inhibition. Needless to say, the isolation and manipulation of these intricate and complex variables will be the task of future research.

B. Weaknesses of Eysenck's Theory.

This subsection raises the possibility that the inconclusive findings of the present study may be due to flaws in the underlying theory. Perhaps no relationship was found between the measured variables simply because no relationship exists. Certainly, this cannot be asserted on the basis of this study alone - but it is an interesting point for discussion. It could be that Eysenck has fallen into the trap that he himself has warned adherents of factor analysis to guard against - that of attributing inherent reality to the factors themselves, when in truth they are but the products of a mathematical technique.

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21 William R. Goff, Berton S. Rosner and Truett Allison, "Distribution of Cerebral Somatosensory Evoked Responses in Normal Man", in Electroencephalography and Clinical Neurophysiology, Vol. 14, 1962, p. 697-713.

22 G. Claridge, "The Excitation-Inhibition Balance in Neurotics", in Experiments in Personality, H. J. Eysenck, Ed., Vol. 2, London, Routledge and Kegan Paul, 1960, p. 107-154.

Many researchers have questioned the validity of Eysenck's dimensions and causal explanations. Sweetbaum,[23] for one, supports the Spence-Taylor "drive" hypothesis, and concludes from a conditioning study that:

> (...) Eysenck's dysthymic group and hysteric group could more parsimoniously be conceived in terms of high and low anxiety groups. Thus, it would appear that Eysenck has confounded his factor of introversion-extraversion with the concept of anxiety.[24]

Realizing the import of such criticisms, Eysenck incorporated the drive concept by espousing Kimble's[25] theory that reactive inhibition grows until it equals the positive drive under which the subject is working. This necessitated the 1962 reformulation of the theory,[26] whereby only differences in rate of development and dissipation of reactive inhibition, and not amounts, are used to account for the observed differences between extraverts and introverts in reminiscence. This reformulation is most confusing, and seems to lack internal consistency.

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23 Harvey A. Sweetbaum, "Comparison of the Effects of Introversion-Extraversion and Anxiety on Conditioning", in Journal of Abnormal and Social Psychology, Vol. 66, 1963, p. 249-254.

24 Ibid., p. 253.

25 G.A. Kimble, "An Experimental Test of a Two-Factor Theory of Inhibition", in Journal of Experimental Psychology, Vol. 39, 1949, p. 15-23.

26 Eysenck, "Reminiscence, Drive and Personality - Revision and Extension of a Theory", Op. Cit., p. 127-140.

Another weakness in Eysenck's theory, which is mentioned in chapter one as being fundamental to this research, is the synonymical usage of the various concepts of inhibition. Becker[27] and Rechstschaffen[28] have criticized this, and the findings of the study here reported lend support to their complaint. The identification of the concepts of reactive inhibition, basal inhibition and satiation remains unfounded. Rotman[29] has demonstrated that within individuals satiability alone is complex, and is not a general trait extending across modalities.

It would seem, then, that in his haste to expand his theory to great proportions, Eysenck has missed many of the underlying complexities. The excitation-inhibition balance, even at its speculative neurophysiological level, is far too simple an explanation of causality. Claridge and Herrington[30] claim that the excitation-inhibition balance is

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27 Wesley C. Becker, "Cortical Inhibition and Extraversion-Introversion", in Journal of Abnormal and Social Psychology, Vol. 61, 1960, p. 52-66.

28 A. Rechstschaffen, "Neural Satiation, Reactive Inhibition, and Introversion-Extraversion", in Journal of Abnormal and Social Psychology, Vol. 57, 1958, p. 283-291

29 Bertram T. Rotman, Sensory Augmentation: A Possible Extension of the Eysenckian Theory of Introversion-Extraversion, doctoral dissertation presented to the School of Psychology and Education of the University of Ottawa, Ontario, 1964, p. 64.

30 G.S. Claridge and R.N. Herrington, "Excitation-Inhibition and the Theory of Neurosis: A Study of the Sedation Threshold", in Experiments with Drugs, H. J. Eysenck, Ed., New York, Macmillan, 1963, p. 158.

explicable physiologically entirely in terms of autonomic functioning. They also point out that the astounding complexity of the nervous system allows the cortex to influence its own arousal level, and via the reticular formation, to modify potentials at all stages along the sensory pathways, including the receptor itself.[31] Obviously many of Eysenck's assumptions and predictions are not based on a sufficiently elaborate analysis of the underlying phenomena. It is now necessary to go back and examine the groundwork - hence the timeliness of the present research.

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31 Claridge and Herrington, Op. Cit., p. 144.

SUMMARY AND CONCLUSIONS

This dissertation has reported on an investigation of the possible relationship between reactive inhibition, as measured by pursuit rotor reminiscence, and basal inhibition, as measured by latency of evoked cortical potentials. The reminiscence scores represented stimulus-produced inhibition, while the latency measurements were interpreted as a reflection of the constitutional potential for central nervous system conductivity, which exists prior to any stimulation. According to Eysenckian theory, the basal and reactive types of inhibition should be sufficiently related <u>within</u> individuals to produce differences on the level of personality <u>between</u> individuals.

Utilizing Pearson product moment coefficients of correlation, the relationships between reminiscence scores and five measures of latency were investigated, testing the null hypothesis: there is no significant, positive relationship between reactive inhibition, as measured (and defined) by motor reminiscence, and latency of evoked cortical potentials (time of arrival of stimulus effect at the motor cortex). The findings did not justify a rejection of the hypothesis, for any one of the five relationships considered. Eysenck's assumption that reactive and basal inhibition are positively related is therefore not upheld. The findings do lend support to those investigators who have challenged Eysenck's indiscriminate "lumping together" of the various concepts of inhibition, but the support is not strong, as the discussion of the imperfections of the experiment has made clear.

As is the case with all research, this study, in attempting to answer one question, has unveiled a great many more. Of the numerous possibilities for future research that suggest themselves, two will be singled out for immediate attention.

Firstly, a replication of the present study, employing more adequate controls for the measurement of reminiscence, would provide very useful supplementary information for the interpretation of the findings here presented. What is suggested, in other words, is a similar study which affords a more valid reactive inhibition measure against which the criterion variable can be evaluated.

Secondly, the relationship between cortical response latency and Eysenck's other "Level 2" observable phenomena such as figural after-effects and after-image duration, which supposedly manifest reactive cortical inhibition, should be investigated. If continued lack of correlation occurs, then it would reinforce this writer's feelings that inhibition as peripherally determined is not related to the basal measures of cortical activity, and is a hopelessly inadequate criterion from which to postulate consistent differences in human behavior.

BIBLIOGRAPHY

Becker, Wesley C., "Cortical Inhibition and Extraversion-Introversion", in the Journal of Abnormal and Social Psychology, Vol. 61, 1960, p. 52-66.

A factor analytic study of the various types of inhibition, undertaken to establish whether Eysenck's construct of reactive cortical inhibition is justifiable. Presents a major critique of Eysenckian theory, which has had a direct influence on the formulation of the present research.

Eysenck, H.J., "Cortical Inhibition, Figural Aftereffect and Theory of Personality", in Journal of Abnormal and Social Psychology, Vol. 51, 1955, p. 94-106.

In this study Eysenck outlines his concept of reactive cortical inhibition for the first time, and attempts to explain its influence on the development of personality types. His statement that the general concepts of inhibition of Pavlov and Hull are formally identical with Köhler's perceptual satiation makes this publication one of the basic catalysts of the present study.

--------, The Dynamics of Anxiety and Hysteria, New York, Frederick A. Praeger, 1957, xiii-311 p.

An experimental application of modern learning theory to psychiatry, this book reports Eysenck's early work with reminiscence, and his theoretical explanation of that phenomenon. The first chapter of this volume presents a valuable discussion of the development of the inhibition concept, as it pertains to the theory.

--------, "Reminiscence, Drive and Personality - Revision and Extension of a Theory", in British Journal of Social and Clinical Psychology, Vol. 1, 1962, p. 127-140.

This review of twenty studies relating reminiscence to extraversion and neuroticism necessitated a revision of Eysenck's theory to account for the drive factor, in the tolerance for reactive inhibition. As well as for its theoretical "about-face", this study is interesting for its summary and evaluation of reminiscence findings. The specifications outlined for the measurement of reminiscence are valuable.

--------, Experiments with Drugs, New York, Macmillan, 1963, xii-421 p.

This book is a compilation of very thorough researches which test Eysenck's drug postulate, whereby depressant drugs produce greater inhibition, and hence extraverted behavior patterns. It is prefaced by the most recent statement of Eysenckian inhibition theory - the specification of the reactive and basal components which gives the present study its theoretical foundation and point of departure.

Ertl, John P., Intra-Cortical Delay and Intelligence, Master's thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, October 1961, vi-41 p.

A study designed to show the feasibility of measuring intra-cortical delay, and of relating this electrophysiological measure to intelligence, this thesis is a good illustration of the type of relationships that can be drawn between neurological and psychological phenomena.

Klein, George S. and David Krech, "Cortical Conductivity in the Brain Injured", in Journal of Personality, Vol. 21, 1952, p. 118-148.

An important study for its theoretical contributions. They found that brain injured subjects exhibited more kinesthestic figural after-effect than normals, and postulated than brain injury (and inhibition) is reflected in reduced cortical conductivity. The basal cortical conductivity concept adopted in this thesis comes from Klein and Krech.

Kovatch, Joseph D., Intra Cranial Pathology and the Negative After-Image Threshold, Master's thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, April 1961, vi-43 p.

An investigation of cortical inhibition within the Pavlovian framework. Relevant to this study in that inhibition as measured by after images was significantly different for brain damaged and normal subjects, while no differences were found in basal inhibition estimates. The score interpreted as basal inhibition is a questionable indicator of basality.

Lindsley, D.B., "Psychological Phenomena and the EEG", in Electroencephalography and Clinical Neurophysiology, Vol. 4, 1952, p. 443-456.

An attempt to show how psychological and neurophysiological data may be amalgamated through time relationships. This exposition supports the use of latency measurements in the present study.

Shagass, Charles, and Marvin Schwartz, "Evoked Cortical Potentials and Sensation in Man", in Journal of Neuropsychiatry, Vol. 2, 1961, p. 262-270.

A classic study of cortical potentials evoked by visual and electrocutaneous stimuli. Their findings of inter-individual variability in the evoked responses suggested the worthwhileness of exploring their psychological correlates. In addition, this study provides strong evidence for the reliability of the type of EEG measure employed in the research here reported.

Uttal, William R. and Louella Cook, "Systematics of the Evoked Somatosensory Cortical Potential: A Psychophysical - Electrophysiological Comparison", in Annals of the New York Academy of Sciences, Vol. 112, 1964, p. 60-80.

Using an averaging technique, these researchers have identified the three basic waveforms (M, N and O) of somatosensory evoked potentials. Reliable results were recorded from individuals, while a wide range of individual differences were found. Studies of spatial and temporal interaction between potentials yielded results which support the contention that inhibition can be measured by this type of psychophysiological tool.

APPENDIX 1

TABULATED RAW DATA OF THE STUDY

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Table II.-

Reminiscence and Latency Measures. N:36

Subject	Reminiscence Score	Latency Measures[a] E_1	E_2	E_3	E_4	E_5
1	6.9	42	99	-	230	297
2	11.6	-	85	147	217	310
3	3.6	60	96	-	222	294
4	2.1	54	101	149	238	303
5	.4	60	-	149	245	-
6	2.4	-	90	142	205	318
7	8.2	-	89	130	-	309
8	7.0	53	89	130	196	267
9	1.9	-	91	127	253	312
10	2.1	-	90	-	-	325
11	5.9	-	-	137	207	287
12	6.4	36	88	-	-	314
13	.1	-	89	143	-	291
14	7.7	45	89	155	-	286
15	6.7	48	103	142	-	318
16	.7	-	93	126	-	307
17	6.7	45	93	143	204	317
18	.2	56	83	149	256	-
19	8.7	43	114	-	216	300
20	5.3	45	109	-	203	290
21	7.6	50	92	-	228	318
22	2.2	-	80	138	238	-
23	14.3	39	85	-	208	301
24	5.0	-	72	156	-	288
25	5.4	48	85	154	-	309
26	5.2	-	-	-	232	286
27	8.5	-	80	178	-	326
28	5.4	48	90	156	258	372
29	6.8	54	84	168	258	396
30	8.2	-	97	192	-	354
31	6.1	48	84	168	-	360
32	2.9	-	90	198	-	390
33	7.2	-	84	216	264	342
34	3.3	-	72	126	227	365
35	6.8	42	118	208	-	-
36	6.6	-	78	162	234	330

a Latency measures are in milliseconds and are mean scores.

APPENDIX 2

ABSTRACT OF

Reactive Inhibition and Evoked Cortical Responses

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Reactive Inhibition and Evoked Cortical Responses[1]

Eysenck's dimensional analysis of personality is based on the excitation/inhibition balance that characterizes the neurophysiological makeup of each individual. He has postulated three types of inhibition - temporal, spatial and basal - and regards them as being sufficiently related to operate as a general causal factor of individual behavior. Several researchers have challenged this position, and have produced evidence that fails to justify the grouping of the various types of inhibition under one psychoneurological construct.

The major aim of this study was an attempt at construct validation. The degree of relationship between two of Eysenck's three postulated inhibition components was examined. The sample consisted of thirty-six "normal" males with a mean age of 26.1 years. Pursuit rotor reminiscence scores were used as measures of temporal inhibition, while latency of visually evoked cortical

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1 Marilyn Fenton, Master's thesis presented to the School of Psychology and Education of the University of Ottawa, Ontario, 1964, ix-63 p.

responses was interpreted as an indicator of basal cortical conductivity, or basal inhibition.

The hypothesis of no significant positive correlation between reminiscence scores and latency measures was not rejected for any of the five relationships considered. Hence the findings failed to support Eysenck's identification of the two concepts. One correlation (reminiscence and E_1) was significant in the negative direction, but the degree of significance was rejected in view of the many uncontrolled factors operating, plus the small size of the sample.

Possible weaknesses in the design of this thesis and in Eysenck's theory were pointed out, and suggestions for further research were made.