

AN INVESTIGATION OF RELATIONSHIPS BETWEEN
TEMPORAL GRANTAS PATHOLOGY AND THE
NEGATIVE AFTER-IMAGE BY SIGHT

by Joseph S. Kovatch

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CURRICULUM STUDIORUM

Joseph D. Kevatch was born March 16, 1933, in Elizabeth, New Jersey, United States of America. He received his Bachelor of Science in Economics degree from Villanova University, Pennsylvania, in 1956.

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INTRODUCTION

Investigations into the theory of cortical inhibition received their impetus from the Pavlovian studies on conditioning of dogs. One aspect of his work was that of observing excision effects of cortical areas. The resistance the dogs had to tactual stimulation led him to postulate an inhibition process in cortical cells to account for the loss of response to stimulation that had been present prior to the cortical pathology. This explanation of the findings provided future researchers a theoretical basis from which to begin their experimentation.

Muscle reflexes, kinesthetic effects and after-image measures have been used to further the understanding of the cortical inhibition theory. Unfortunately, these studies have enlarged and extended the theory with limited factual evidence and at times appeared to be contradictory. These differences and deficiencies may have arisen from the employment of a theory that is cortically centered but the investigators utilized peripheral functions which are easily influenced or contaminated by non-cortical functions and conditions.

This dissertation reports on a study which attempts to evaluate the Pavlovian theory of cortical inhibition through measurements of after-image measurements, with massed practice, on subjects with intra cranial pathology.

Measurements of visual phenomena seemingly have an advantage of tapping a neurological function more closely associated with cortical activity than peripheral muscle activity. An additional advantage is that this task requires little training and is considered free from past learning and voluntary control.

The dissertation is divided into three chapters. Chapter One presents the development of the cortical inhibition theory together with studies of after-image measures with intra cranial pathology, studies of after-image measures with drugs and the presentation of the hypothesis tested in this study. Chapter Two describes the experimental design, which includes a description of the apparatus, the sample populations, the experimental procedures and techniques for data evaluation. Chapter Three presents the results of the investigation, a discussion of the results and some suggestions for further research.

CHAPTER I

REVIEW OF THE LITERATURE

This chapter presents the development of the cortical inhibition theory; the studies of after-image measures and intra cranial pathology; the studies of after-image measures with drugs; and the presentation of the hypothesis to be tested in this study. The sections are divided in the following way: Section 1 contains the Pavlovian theory of cortical inhibition and related studies. Section 2 describes the studies of after-image measures with drugs and intra cranial pathology.

1 - The Pavlov Theory and Related Studies.

Pavlov¹ first introduced the concept of inhibition in his conditioning experiments on dogs. He used the conditioning experiments as a tool for exploring the functions of the cerebral hemispheres. In his work he utilized two main terms, excitation and inhibition, and located these processes in the cortical cells.

One aspect of his work was that of observing excision effects upon areas of the cerebral cortex. The immediate

¹ 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.

reaction was an expected one because of previous experimentation in this field. Pavlov elaborated the reactions in the following manner:

The gyri coronarius and ectogylius anterior were removed on the left side. On the fourth day after operation conditioned reflexes belonging to the analysers other than the tactile were present. The generalized conditioned tactile reflex returned on the eighth day, but only to stimulation on the left side of the animal, and soon reached its normal magnitude.²

Subsequently Pavlov stated that the right side of the body recovered from the excision but other effects began to appear:

During the period while conditioned stimuli... had lost their positive effect they developed a definite inhibitory effect... Further, a repeated and even more markedly protracted, stimulation of these apparently ineffective places on the skin resulted in every experiment in a development of drowsiness and sleep...³

This finding seemed to indicate that an area of the cortex that was removed could exert some influence on the rest of the cortex.

Hamilton⁴ stated in discussing the cortical inhibition theory of Pavlov, "...that excitation in the cortex is a function of a localized area, and inhibition is a function

2 Ibid., p. 346.

3 Ibid., p. 347.

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

of the rest of the cortex..."⁵ Further studies have been undertaken to check these conclusions and to spur research of cortical inhibition with physiological and psychological functions.

Hull⁶ utilized some of the concepts expounded by Pavlov in his series of theoretical and experimental studies. His theory of reactive inhibition is of indirect interest to this study because Hull restricted the concept to motor reactions in muscle activity. Hull stated his postulate in the following manner:

...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.⁷

This concept is likened to that of Pavlov's internal inhibition although Hull seemingly did not intend it to be considered as a process of the cerebral cortex, but restricted to organ or muscle complexes.

5 Ibid., p. 51.

6 C.L. Hull, Principles of Behavior, New York Appleton-Century, 1943, x-422 p., quoted by H.J. Eysenck, "Cortical Inhibition, Figural After-Effect and Theory of Personality", in Journal of Abnormal and Social Psychology, Vol. 51, No. 1, July 1955, p. 94-106.

7 Idem, Ibid., p. 96.

Eysenck⁸ added to this concept by postulating that individual differences should be considered with reference to the speed with which reactive inhibition is produced and dissipated. He ascribed this inhibitory process to the cerebral cortex and utilized some of the postulates of the Köhler-Wallach satiation theory⁹ to explain the underlying physiological factors.

Köhler and Wallach¹⁰ explained the form displacement occurring during the phenomenon of figural after-effect as due to increased polarizability in the occipital lobe. They stated:

One is tempted to say that the prolonged presence of an I-object lowers the conductivity of the cortical area and adjacent regions. Actually, the change appears to be mainly an increase in polarizability of the tissue in question... If the conductivity of the area is lowered, the intensity of a current which passes through the area is at once decreased.¹¹

8 H.J. Eysenck, "Cortical Inhibition, Figural After-Effect, and Theory of Personality", in Journal of Abnormal and Social Psychology, Vol. 51, No. 1, July 1955, p. 94-106.

9 Wolfgang Köhler and Hans Wallach, "Figural After-Effects", in Proceedings of the American Philosophical Society, 88, 1944, p. 265-357, quoted by John Krauskopf, "The Magnitude of Figural After-Effects as a Function of Duration of Test Period", in American Journal of Psychology, Vol. 67, No. 4, December 1954, p. 684-690.

10 Idem, Ibid., p. 684.

11 Ibid.

Krauskopf¹² objected to this theory, stating:

If an increase in polarizability is the dominant result of prolonged fixation, it should be expected then that when exposures of T-objects are short, their displacement should be smaller than with longer exposures.¹³

He found that figural after-effects decreased in magnitude as a function of the length of the testing period. These findings seem to disprove the theory.

Studying cortical conductivity in the brain injured, Klein and Krech¹⁴ contributed to and modified the inhibition theory. They proposed two assumptions from which inhibition experimentation could be derived:

...the rate of transmission of excitation patterns is constant for all individuals...and is homogeneous over the entire cortical area.

...transmission rate of excitation patterns varies from individual to individual, from time to time within the same individual, and from area to area within a single cortical field at any one time.¹⁵

They stated that by utilizing the first assumption, very little can be accomplished in inhibition experimentation, but that the second allows the researcher to,

12 John Krauskopf, "The Magnitude of Figural After-Effects as a Function of Duration of Test Period", in American Journal of Psychology, Vol. 67, No. 4, December 1954, p. 684-690.

13 Ibid., p. 684.

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

15 Ibid., p. 118.

"...understand inter and intra individual differences in cortical integration and behavior".¹⁶

Rather than restricting their interpretations to the physiology of peripheral muscle activity, Klein and Krech have enlarged the concept to include cortical areas. They maintained that:

...any neural activity induces heightened resistance within the area stimulated... The current flow initiated by stimulation of a defined cortical area results in heightened resistance within that area to further electrical activity. Should further stimulation occur, the resulting patterns of electrical activity would be as a consequence of the increased resistance, be "dampened," distorted or rerouted...

...the more stimulation, the greater the drop in cortical conductivity (within certain limits). However, we would postulate another factor which contributes to the extent of drop in cortical conductivity: we would assume the over-all state of the cortex helps to determine the initial or basal value of cortical conductivity and the degree of drop possible.¹⁷

In their study with brain injured and non-brain injured subjects, the brain injured reached maximal satiation more quickly; the frequency of satiation effects were greater; and they remained in the satiated state longer. In this study inhibition was determined by a measure of kinesthetic figural after-effect.

¹⁶ Ibid.

¹⁷ Ibid., p. 120-121.

Klein,¹⁸ in a separate study, utilized the negative after-image to determine the degree of inhibition in the brain injured. Persistence of the after-image was measured as a function of the duration of stimulus exposure. The after-image durations of the brain injured were shorter than those of the non-brain injured. He also found that upon repeated exposure the rate of decrease in after-image duration was more rapid in the brain injured. Conclusions from this work must be considered carefully as no information was reported concerning the procedure, number or type of subjects utilized, and levels of significance. It was stated that the data were "collected" by Klein.

An experiment similar to that of Klein and Krech was conducted by Jaffe¹⁹ using kinesthetic figural after-effects with brain injured subjects. His findings did not substantiate the work of Klein and Krech. No significant differences were found between the control group and the brain injured group.

These studies would have been in agreement had they both utilized the same levels of significance. Jaffe found

George S. Klein, "Studies of Duration of Negative After-Image; Effect of Brain Injury", quoted by George S. Klein and David Krech, "Cortical Conductivity in the Brain Injured", in Journal of Personality, Vol. 21, No. 1, September 1952, p. 122.

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

no significant differences at the .01 level, whereas Klein and Kroch accepted levels of significance of .05 in one case, a .10 in two cases, and a .15 in a third instance. Had Klein and Kroch insisted on a .01 level in their study, they would have agreed with Jaffe that no significant differences were found between the groups.

The studies of cortical inhibition reviewed in this section have contained some disagreement between investigators. These differences may be attributed to the variations in the applications of the theory. Another aspect may be that the investigators have employed a theory that is cortically centered but have utilized motor reflexes and kinesthetic effects as independent central measurements which are easily influenced or contaminated by non-cortical functions and conditions.

2 - After-Image Studies with Drugs and Intra Cranial Pathology.

Price and Deabler²⁰ were the first to employ the Archimedes Spiral Apparatus in its relation to intra cranial pathology. This device was constructed in such a manner that when its rotating spiral was stopped, normals reported apparent movement taking place. This after-image of

20 A. Cooper Price and H.L. Deabler, "Diagnosis of Organicity by Means of Spiral After Effect", in Journal of Consulting Psychology, Vol. 19, No. 4, August 1955, p.299-302.

movement was opposite to the original motion in direction. In this study organics failed to report the phenomenon, whereas the non-organic group did report it. The authors concluded, "When failure to perceive the after-effect is found, it is almost certain that cortical involvement exists."²¹

Consistent results were found in later spiral studies until Gollin and Bradford²² included a pre-test situation. They trained brain injured subjects to respond with the proper word to describe the expansion and contraction phenomena by inflating balloons with painted lines on them. In the pre-test, seventeen subjects achieved success and 5 failed. During the spiral test six failed to report the after-image, but of these, five had failed in the pre-test situation. Further studies varied the form of the instructions and found similar results.

These findings suggest that failure by the brain injured to report the after-image was not due to perceptual failure but rather an inability to respond with the proper word or phrase to describe the situation. It would seem that a form of scoring modified to include the duration of the

²¹ Ibid., p. 301.

²² Eugene S. Gollin and Norman Bradford, "Faulty Communication and the Spiral Aftereffect: A Methodological Critique", in Journal of Abnormal and Social Psychology, Vol. 57, No. 1, July 1958, p. 122-123.

after-image might yield more positive results in the establishment of a differential effect between brain injured and non-brain injured subjects.

Eysenck, Holland and Trouton²³ investigated the effects of stimulant and depressant drugs on durations of after-images with the Archimedes Spiral Apparatus. Using sodium amylobarbitone as the depressant drug and d-amphetamine sulphate as the stimulant drug, they predicted that the stimulant drug would increase the duration of the visual after-image while the depressant drug would have the opposite effect. The results showed that the depressant drug did shorten the duration of the after-image but the stimulant drug did not have a differential effect on the phenomenon. Insufficient absorption time for the stimulant drug was given as a possible reason for the lack of a differential effect.

Eysenck and Aiba²⁴ conducted a similar experiment with the same drugs cited in the previous study, but employed a modified Lehmann After-Image Apparatus²⁵ to measure the

²³ H.J. Eysenck, H. Holland and D.C. Trouton, "Drugs and Personality, III. The Effects of Stimulant and Depressant Drugs on Visual After-Effects", in Journal of Mental Science, Vol. 103, 1957, p. 650-655.

²⁴ H.J. Eysenck and S. Aiba, "Drugs and Personality, V. The Effects of Stimulant and Depressant Drugs on the Suppression of the Primary Visual Stimulus", in Journal of Mental Science, Vol. 103, 1957, p. 661-665.

²⁵ H. Lehmann, "Preliminary Report on a Device for the Objective Measurement of the Negative After Image", in Science, Vol. 112, No. 2903, August 1950, p. 199-201.

after-image thresholds. In this study the stimulant drug lowered the thresholds but the depressant drug did not affect the thresholds as compared with the placebo effects. No explanations were given to account for the discrepancies.

An aspect of particular interest in both of these studies was the specific aim to demonstrate cortical involvement with the after-image phenomenon. However, Eysenck interpreted the complementary after-image as being entirely a retino-chemical process. This interpretation was not modified or altered at the conclusion of the experiments leaving the reader with doubts as to whether Eysenck intended to apply a sensory or cortical interpretation of the after-image phenomenon.

Kaplan²⁶ modified the Lehmann After-Image Apparatus in his study to determine the effects of autonomic drugs on the after-image threshold. Three sympathomimetic drugs were used: ephedrine sulfate, amphetamine and sympatol. Two parasympathomimetic drugs were used: neostigmine bromide and mecholyl. Sodium bicarbonate was used as a placebo. The findings indicated that sympathomimetic drugs reduced the ability to perceive hues of shorter wave length and the parasympathomimetic drugs had an opposite effect.

26 Solomon D. Kaplan, "Autonomic Visual Regulation; Part I. The After-Image Spectral Photometer", in Explorations in Physiology and Emotions, Psychiatric Research Reports of the American Psychiatric Association, No. 12, January 1960, p. 104-114.

These three studies with drugs lend support to the theory that the after-image is cortically influenced.

All the studies reviewed in this chapter had one aspect in common: lack of reported reliability. Despite this, consistency appeared in the findings on three points: 1) The cortex played an integral role in determining threshold levels of after-images. 2) Intra cranial pathology affected the after-image to some extent. 3) Visual measurements were sensitive to inhibition.

The particular aim of this study is an investigation of the possible relationships between intra cranial pathology and after-image sensitivity. This sensitivity is interpreted as an effect of cortical inhibition measured by the negative after-image threshold.

The Negative After-Image Threshold Apparatus, developed by Barry,²⁷ will be employed in this study. This device provided a reliable measurement of figure-ground light intensity required to produce and sustain the negative after-image phenomenon. The term "Negative After-Image Threshold" used throughout the following chapters denotes the point or zone where loss of the image occurs as a function of the particular type of field illumination intensity; and the

²⁷ William F. Barry, An Investigation of Relationships Between Introversion-Extraversion and the Negative After-Image Threshold, unpublished doctoral dissertation, University of Ottawa, 1961, 80 p.

term "inhibition score" used throughout the following chapters denotes the algebraic sum of increments of the six trials using Trial 1 score as the basal score. The inhibition score will be interpreted as a measure of retino-cortical inhibition.

The criterion for intra cranial pathology will be either positive diagnosis by a neurologist or previous hospitalization for a neurological condition. This population will be referred to as "organics" in the following chapters. The population of Barry²⁸ will constitute the comparison group, referred to as "non-organics" in this paper.

The problem is stated in the form of the null hypothesis: there will be no significant differences between the organics and non-organics mean inhibition scores as measured by the Negative After-Image Threshold Apparatus.

28 Ibid., p. 36-37.

CHAPTER II

EXPERIMENTAL DESIGN

This chapter will be devoted to the reporting of the experimental design. The Sections are divided in the following manner: Section 1 contains a brief description of the Negative After-Image Threshold Apparatus. Section 2 describes the sample populations and the criterion for inclusion of subjects. Section 3 states the experimental procedures, which includes the administration and technique for scoring. Section 4 reports on the techniques for data evaluation, including statistical formulas employed.

1 - The Negative After-Image Threshold Apparatus.

Although a detailed description of the Negative After-Image Threshold Apparatus has been reported by Barry,¹ the essential components will be reviewed. This device is designed in such a way that the Subjects are capable of sustaining the negative after-image in the complementary color of the original stimulus color without perceiving the original stimulus.

The device consists of a control cabinet which contains the measuring and regulating instruments and a second

¹ William P. Barry, An Investigation of Relationships Between Intraversion-Extraversion and the Negative After-Image Threshold, unpublished doctoral dissertation, University of Ottawa, 1961, p. 22-36.

cabinet which houses the stimulus system. The stimulus is a red light, intermittently obscured from the Subject's vision by a rotating disc with two 15 degree pie cuts at opposite ends of the diameter. The disc is assembled from three leaves, two painted white and the other painted black. This leaf arrangement permits variation of the white-black ratio of the pie arc. The disc is rotated at 120 revolutions per minute by a synchronous motor. The face of the disc is illumed by two 40 watt bulbs. The intensity of the stimulus and disc lights is read by microammeters located on the control cabinet. The intensity of the lights is controlled by means of separate variacs in the control cabinet. 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. Compensation from bulb aging is obtained by reducing the initial intensity below the maximum meter range. A constant voltage transformer protects the motors and lights against fluctuations in house flow.

2 - The Sample Populations.

The clinical sample consisted of forty-four males. Thirty-six of these were admissions for diagnosis of possible intra cranial pathology at the Neurological Ward, Ottawa General Hospital, Ottawa, Ontario. Six others were patients at the Department of Veterans Affairs Hospital, Ottawa,

Ontario. One was a client at the University of Ottawa Guidance Center, Ottawa, Ontario. The final subject was taken from the sample of Barry.² The non-organic sample consisted of seventy-two males employed by Barry³ in his study.

Of the thirty-six admissions to the Ottawa General Hospital Neurological Ward that were tested, twenty-nine were deleted because no positive evidence was found to substantiate the presence of intra cranial pathology. The remaining seven of this sample met the criterion for inclusion in the organic group. Along with the other eight, from the places stated, who also met the criterion for intra cranial pathology, the total organic group numbered fifteen. These fifteen organics received the following diagnoses: four Huntington's Chorea; three Epileptics; two Cerebral Aneurisms; two Cortical Atrophys; one Cerebral Paresis; one Cerebral Meningitis; one Cerebral Palsy; and one Parkinson's Disease with pyramidal atrophy.

The Subjects of both samples were free from drugs for at least twenty-four hours prior to the testing situation. This insistence on freedom from drug effect was dictated from the studies previously discussed. Color blindness was ruled out on the basis of being able to report the

² Ibid., p. 36.

³ Ibid., p. 36-37.

proper color of the negative after-image.

The mean age of the organic group was 40.6 years with a range from 24 to 59 years. The non-organic's ages ranged from 24 to 47 years with a mean age of 33.6 years.

3 - The Experimental Procedures.

The experimental procedures to be described in this section were the same Barry⁴ applied in his study.

A Negative After-Image Threshold Apparatus was installed on a bench thirty inches high in a darkened room. The Subject was then seated in front of the stimulus cabinet. The distance of the viewing port from the eyes of the Subject was twelve inches measured by a tape attached to the cabinet. A three minute dark adaptation period was given each Subject.

The Subjects were 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. What is more important, try hard not to blink your eyes. When you look into this hole you will see a colored circle." The disc switch is turned to ON. The operator pauses for a moment to allow the meter to operate at maximal capacity before any other switches are initiated. The stimulus and disc lights are simultaneously brought into use by pressing

⁴ Ibid., p. 39-43.

their ON switches. The intensity of the disc light was pre-set at 90 on the variac dial, which corresponds to 800 microamperes on the light meter. "What color is it"? The Subject cannot see the color of the primary stimulus and reports this color as green, blue or turquoise. "Very good." The operator places the light switches into the OFF position. "Now you are to 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 test is begun. The disc light turn down is initiated by pressing the ON switch for the variac's servo motor. No readings are taken during this trial. "Tell me when the green color is all gone." The illumination is allowed to decrease to its lowest level and then the light switches are placed into the OFF position. The disc illumination is reset to 90 on the variac dial. The operator may question the Subject or answer questions to clarify the nature of the phenomenon. When the operator decides that the Subject understands the procedure, he continues, "Now we can begin the test. You are to gaze at the center dot in the green circle. You are to press this button (at this point the Subject is handed the push button OFF switch) as soon as you are no longer able to see any of the green color. The green color may fade or reappear, or it may get darker.

as you have seen, but, you are to press the button as soon as you feel that the green is all gone. Ready"? The operator places the stimulus and disc illumination lights to the ON position. As the Subject persists in his perception of the after-image, the servo motored variac lowers the microammeter's range. The point of after-image disappearance is always read from the meter in the lowest appropriate range. As soon as the Subject presses the OFF switch, the operator takes the visual reading of the meter; places the stimulus light in the OFF position; sets the microammeter range switch to SHORT; returns the disc light intensity to its initial level of brightness; engages the stimulus and disc illumination light switches to the ON position; and repeats the testing. Recordings of the reading are made at this time.

Each subject is given six trials which constitutes one testing session, followed by a three minute rest to allow for the dissipation of visual satiation, and then given another six trials. The instructions of the re-test include the last few words of the previous instruction. "Now we can begin again. You are to gaze at the center dot in the green circle. You are to press the button as soon as you are no longer able to see any of the green color. The green color may fade or reappear, or it may get darker as you have seen, but, you are to press the button as soon

as you feel that the green color is all gone."

The readings were then converted from microamperes to footcandles in order to minimize random fluctuations in the meter measurements, and to obtain maximum linearity from the extended meter range. The technique for obtaining the conversion data and the conversion table for changing microampere readings are found in the work by Barry.⁵

4 - Techniques for Data Evaluation.

The raw data obtained from a six trial test-retest on fifteen organics were analyzed in the following manner: test-retest reliability of the raw trial scores in footcandles; test-retest reliability of the inhibition scores; statistical significance of the increment between trial one and trial six, interpreted as cortical inhibition; statistical analysis on the significance of means and standard deviations for each trial on test-retest; and an investigation of the possible difference between the organics and non-organics basal (Trial 1) and inhibition scores.

A measure of reliability was obtained by correlating the Subject's raw footcandle score for the initial testing session with his corresponding raw footcandle score for the final testing session. The reliability of the inhibition scores of both testing sessions was also estimated.

⁵ Ibid., p. 45-46.

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

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

A statistical test between the mean increments of Trials one and six for both sessions was undertaken. If the rise between the first and last scores could be attributed to chance fluctuations, the application of the inhibition theory would be inadvisable. Initially, an over-all test of independence for correlated variances was undertaken using the following formula:⁶

$$t = \frac{(\sigma_1^2 - \sigma_2^2)\sqrt{N-2}}{\sqrt{4\sigma_1^2\sigma_2^2(1-r_{12}^2)}}$$

where $\sigma^2 = \frac{\sum (X-M)^2}{N}$

A t test for independence for correlated variances was applied to the six trials of both sessions in order to investigate the possibility of combining the separate curves into one.

If the t ratios were significant at the .01 level, this test was followed by a t test for correlated groups on the difference of means and standard deviations of both

⁶ Quinn McNemar, Psychological Statistics, New York, Wiley, 1955, p. 244.

testing sessions, employing the formula:

$$t = \frac{\text{DIFF.}}{\sigma_D}$$

$$\text{where } \sigma_{D_m} = \sqrt{\sigma_{m_1}^2 + \sigma_{m_2}^2 - 2r_{12} \sigma_{m_1} \sigma_{m_2}}$$

$$\text{and } \sigma_m = \frac{\sigma}{\sqrt{N-1}}$$

$$\text{where } \sigma_{D_\sigma} = \sqrt{\sigma_{\sigma_1}^2 + \sigma_{\sigma_2}^2 - 2r_{12} \sigma_{\sigma_1} \sigma_{\sigma_2}}$$

$$\text{and } \sigma_\sigma = \frac{\sigma}{\sqrt{2N}}$$

The F test of independence for uncorrelated variances was used to compare the six trial scores and inhibition scores of the organic and non-organic groups to determine whether any over-all differences existed between the two groups. The formula employed was:

$$F = \frac{\sigma_1^2}{\sigma_2^2}$$

$$\text{where } \sigma^2 = \frac{\sum(X-M)^2}{N}$$

This test was followed by a t test for uncorrelated groups on the mean and standard deviations of combined scores of organics and two sessions of the non-organics for the six trials and inhibition scores.

CHAPTER III

RESULTS AND DISCUSSION

This chapter will be devoted to the reporting of the experimental results, a discussion of these results and their possible implications. The sections are divided in the following manner: Section 1 presents the reliability coefficients of the Negative After-Image Threshold Apparatus test raw scores for six trials and inhibition scores, and the tables of data of the $\frac{1}{2}$ test employed. Section 2 presents the estimation of the inhibition score's statistical significance. Section 3 presents the combined results of organics for the testing sessions and compares them with the results of the non-organics. Section 4 contains the discussion of the results of the reliability and validity of the Negative After-Image Threshold test. Finally, the results are discussed with reference to the theory of cortical inhibition.

1 - The Reliability of the Negative After-Image Threshold Test.

Test-retest reliability coefficients were calculated on raw scores for the sample of thirteen¹ organics on each of the six trials and inhibition scores on the initial and

¹ Two organics could not be retested. One became ill and the other had an appointment in another department.

final testing sessions. The coefficients of the six trials ranged from .473 to .832, with an average correlation of .705, significant at the .01 level. The method² used was to convert the coefficients to Fischer's z scores, average them and reconvert the mean z score back to a coefficient of correlation. Specific coefficients for the six trials and inhibition scores are found in Table I on the following page.

A t test of independence for correlated variances was calculated to determine whether an average performance curve could be derived. Trial 3 had a significant t ratio at the .01 level and Trial 4 at the .05 level. Table I presents this data.

This test was followed by a t test for correlated groups on the difference of means and standard deviations to isolate the factors that effected the differential variability of the two sessions on Trial 3 and Trial 4. The mean raw scores of Trial 3 and Trial 4 on the two testing sessions were not found to be significantly different. The standard deviations of Trial 3 were found to be significantly different at the .05 level. This data is presented in Table II, page 26.

² J. F. Guilford, Fundamental Statistics in Psychology and Education, New York, McGraw-Hill, 1956, p. 325.

Table I.—

Data for t Test Between Correlated Variances on Negative After-Image Threshold Raw Scores and Inhibition Scores.
 N=13.

Trial	Session	$\Sigma(X-M)^2$	σ^2	r_{12}	t	Signif.																																																								
1	Initial	1000.31	83.36	.796	.700	—																																																								
	Final	1293.37	107.78				2	Initial	2830.77	235.00	.832	1.053	—	Final	5411.00	450.92	3	Initial	6104.31	508.69	.623	3.123	.01	Final	23988.92	1999.08	4	Initial	13807.08	1150.59	.647	2.249	.05	Final	37140.31	3095.03	5	Initial	20211.23	1684.27	.473	.639	—	Final	28325.23	2360.44	6	Initial	30380.31	2531.69	.671	.969	—	Final	46652.00	3887.67	Inhi.	Initial	26204.62	2183.73	.612	.216
2	Initial	2830.77	235.00	.832	1.053	—																																																								
	Final	5411.00	450.92				3	Initial	6104.31	508.69	.623	3.123	.01	Final	23988.92	1999.08	4	Initial	13807.08	1150.59	.647	2.249	.05	Final	37140.31	3095.03	5	Initial	20211.23	1684.27	.473	.639	—	Final	28325.23	2360.44	6	Initial	30380.31	2531.69	.671	.969	—	Final	46652.00	3887.67	Inhi.	Initial	26204.62	2183.73	.612	.216	—	Final	36287.69	3023.97						
3	Initial	6104.31	508.69	.623	3.123	.01																																																								
	Final	23988.92	1999.08				4	Initial	13807.08	1150.59	.647	2.249	.05	Final	37140.31	3095.03	5	Initial	20211.23	1684.27	.473	.639	—	Final	28325.23	2360.44	6	Initial	30380.31	2531.69	.671	.969	—	Final	46652.00	3887.67	Inhi.	Initial	26204.62	2183.73	.612	.216	—	Final	36287.69	3023.97																
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6	Initial	30380.31	2531.69	.671	.969	—																																																								
	Final	46652.00	3887.67				Inhi.	Initial	26204.62	2183.73	.612	.216	—	Final	36287.69	3023.97																																														
Inhi.	Initial	26204.62	2183.73	.612	.216	—																																																								
	Final	36287.69	3023.97																																																											

Table II.-

Data for t Tests of the Difference of Means and Standard Deviations of Negative After-Image Threshold Raw Scores on Two Sessions for Two Trials. $N=13$.

Trial	Stat.	Initial Test	Final Test	Diff.	σ_d	t	Signif.
3	M	28.77	48.92	20.15	9.882	2.039	—
	σ	21.669	42.958	21.289	7.827	2.720	.05
	σ_{E1}	6.255	12.401				
	σ_{E2}	4.250	8.425				
	r_{12}	.623					
4	M	40.58	55.77	15.39	11.782	1.306	—
	σ	32.509	53.450	20.861	9.725	2.145	—
	σ_{E1}	9.408	15.430				
	σ_{E2}	6.391	10.482				
	r_{12}	.647					

With the exception of Trial 3, which had a significant difference between standard deviations at the .05 level, all other comparisons did not differ significantly. This one deviation was not considered fundamental enough to restrict the combination of the two testing sessions into one average performance curve, and the two Subjects not included in that data were added making the total number in the group fifteen.

2 - Significance of Inhibition Score.

As previously stated, the inhibition score denotes the algebraic sum of increments of the six trials using the score of Trial 1 as the basal score. This score can also be obtained by subtracting the score of Trial 1 from the score of Trial 6. If the rise between the first and last scores could be attributed to chance fluctuations, the application of the inhibition theory to this data would be inadvisable.

The t test of independence for correlated groups was applied to the difference between Trial 1 score and Trial 6 score. A significant t ratio was found at the .01 level. Table III on the following page contains this data.

This test was followed by a t test of differences for correlated groups on the mean and standard deviation differences, and they were found to be significantly

Table III.-

Data for t Test of Correlated Variances on Negative After-Image Threshold Combined Test Session Raw Scores Between Trial One and Trial Six. $N=15$.

Trial	$\sum(X-M)^2$	σ^2	r_{12}	t	Signif.
1	1096.43	78.32	.574	11.639	.01
6	32879.83	2348.56			

different at .01 level. Thus, the score rise observed was not attributed to chance fluctuations. Table IV on the following page presents this data.

3 - Comparison of Organics and Non-Organics.

The F test of independence for uncorrelated variances was applied to the combined scores of the organic group and the two testing sessions of the non-organic group. The scores of the two testing sessions of the non-organic group were not combined due to fundamental difference in the variability between the two sessions.³ Trial 1 was the only non-significant ratio. All others were significant at the .01 level. Table V on page 31 and Table VI on page 32 present this data.

The t test for uncorrelated differences of means and standard deviations was calculated on Trials 2 through 6 and inhibition scores. All mean and standard deviation differences between the organic group combined raw scores and both testing session raw scores of the non-organic group were significantly different at the .01 level, except the mean differences of Trial 3, both testing sessions, and the standard deviation difference of Trial 2, second testing session, which were significantly different at the .05 level. This data is presented in Table VII, page 33 and Table VIII on page 34.

³ Barry, op. cit., p.50

Table IV.-

Data for t Tests of the Difference of Means and Standard Deviations on Negative After-Image Threshold Combined Test Session Raw Scores Between Trial One and Trial Six. $N=15$.

Stat.	Trial 1	Trial 6	Diff.	σ_d	t	Signif.
M	15.27	78.67	63.40	11.356	5.587	.01
σ	6.550	46.819	33.269	8.139	4.085	.01
σ_M	2.235	12.512				
σ_σ	1.561	8.548				
r_{12}		.574				

Table V.-

Data for F Test of Uncorrelated Variances on Negative After-Image Threshold Combined Session Raw Trial and Inhibition Scores of Organics and Session One Raw Trial and Combined Inhibition Scores of Non-Organics.

Trial	Group	N	$\sum (X-M)^2$	σ^2	F	Signif.
1	Organic	15	1096.43	78.32	1.835	—
	Non-Organic	72	3029.87	42.67		
2	Organic	15	4421.83	315.85	4.284	.01
	Non-Organic	72	5234.50	73.72		
3	Organic	15	12275.83	871.85	9.261	.01
	Non-Organic	72	6826.00	96.14		
4	Organic	15	21849.93	1560.71	14.087	.01
	Non-Organic	72	7865.99	110.79		
5	Organic	15	19144.10	1367.44	12.092	.01
	Non-Organic	72	8029.28	113.09		
6	Organic	15	32879.83	2348.56	17.684	.01
	Non-Organic	72	9429.69	132.81		
Inhi.	Organic	15	25597.10	1826.36	32.262	.01
	Non-Organic	72	4019.63	56.61		

Table VI.-

Data for F Test of Uncorrelated Variances on Negative After-Image Threshold Combined Session Raw Trial Scores of Organics and Session Two Raw Trial Scores of Non-Organics.

Trial	Group	N	$\sum(X-\bar{X})^2$	σ^2	F	Signif.
1	Organic	15	1096.43	78.32	1.130	—
	Non-Organic	72	4922.92	69.34		
2	Organic	15	4421.83	315.85	3.285	.01
	Non-Organic	72	6826.00	96.14		
3	Organic	15	12205.83	871.85	6.129	.01
	Non-Organic	72	10097.22	142.24		
4	Organic	15	21849.93	1560.71	9.630	.01
	Non-Organic	72	11506.99	162.07		
5	Organic	15	19144.10	1367.44	6.637	.01
	Non-Organic	72	14627.78	206.03		
6	Organic	15	32879.83	2348.56	12.074	.01
	Non-Organic	72	13810.61	194.52		

Table VII.--

Data for t Tests of the Difference of Means and Standard Deviations on Negative After-Image Threshold Combined Session Raw Trial and Inhibition Scores of Organics and Session One Raw Trial and Combined Inhibition Scores of Non-Organics.

Trial	Stat.	Organic N=15	Non-Org. N=72	Diff.	σ_d	t	Sig.
1	M	15.27	9.50	5.77			—
	σ	8.550	6.487	1.249			—
2	M	26.33	11.99	14.34	4.698	3.052	.01
	σ	17.170	8.527	8.643	3.215	2.688	.01
	σ_{raw}	4.588	1.012				
	σ_{inh}	3.135	.711				
3	M	41.33	14.00	27.33	11.450	2.387	.05
	σ	28.526	9.737	18.789	5.269	3.566	.01
	σ_{raw}	7.622	1.156				
	σ_{inh}	5.206	.811				
4	M	51.27	14.26	37.01	10.274	3.602	.01
	σ	38.166	10.451	27.715	7.023	3.946	.01
	σ_{raw}	10.199	1.240				
	σ_{inh}	6.968	.878				
5	M	61.90	15.69	46.21	9.629	4.799	.01
	σ	35.725	10.560	25.165	6.582	3.823	.01
	σ_{raw}	9.547	1.255				
	σ_{inh}	6.523	.880				
6	M	78.67	16.43	62.24	12.585	4.946	.01
	σ	46.819	11.444	35.375	8.601	4.113	.01
	σ_{raw}	12.512	1.358				
	σ_{inh}	8.548	.954				
Inhi.	M	63.40	7.16	56.24	11.705	5.078	.01
	σ	41.309	7.472	33.837	7.561	4.475	.01
	σ_{raw}	11.039	.837				
	σ_{inh}	7.542	.620				

Table VIII.-

Data for t Test of the Difference of Means and Standard Deviations on Negative After-Image Threshold Combined Session Raw Trial Scores of Organics and Session Two Raw Trial Scores of Non-Organics.

Trial	Stat.	Organic N=15	Non-Org. N=72	Diff.	σ_d	t	Sig.
1	M	15.27	11.01	4.26			—
	σ	8.550	8.269	.281			—
2	M	26.33	13.67	12.66	4.731	2.676	.01
	σ	17.170	9.737	7.433	3.238	2.296	.05
	σ_{diff}	4.588	1.156				
	σ_{diff}	3.135	.811				
3	M	41.33	15.44	25.89	11.521	2.247	.05
	σ	28.526	11.803	16.723	5.298	3.157	.01
	σ_{diff}	7.622	1.401				
	σ_{diff}	5.206	.984				
4	M	51.27	15.24	36.03	10.308	3.495	.01
	σ	38.166	12.642	25.524	7.047	3.622	.01
	σ_{diff}	10.199	1.500				
	σ_{diff}	6.968	1.054				
5	M	61.90	17.06	44.84	9.701	4.622	.01
	σ	35.725	14.529	21.196	6.634	3.195	.01
	σ_{diff}	9.547	1.724				
	σ_{diff}	6.523	1.211				
6	M	78.67	18.36	60.31	12.619	4.779	.01
	σ	46.819	13.849	32.970	8.626	3.822	.01
	σ_{diff}	12.512	1.644				
	σ_{diff}	8.548	1.154				

4 - Discussion of the Results.

The discussion of the results is divided into three subsections. Subsection A treats the reliability and validity of the Negative After-Image Threshold test as a measure of cortical inhibition. Subsection B compares the results of organics and non-organics with reference to the theories of inhibition. Subsection C presents the Summary and Conclusions with some suggestions for further research.

1 - Reliability and Validity of the Negative After-Image Threshold Test.

The reliability coefficients reported in this chapter demonstrated stability in the reporting of the negative after-image via motor response. The average coefficient of correlation found was .705, significant at the .01 level. Prior to testing, considerable variability was anticipated because of the possible difficulty organics would confront in visual-motor tasks. In the light of the obtained coefficient of correlation and the consistency between testing sessions, the apparatus and procedures employed are recommended with this type of group.

The finding that the inhibition score (algebraic sum of increments of the trial scores using Trial 1 as the basal score) could not be attributed to chance fluctuations supports the validity of the device as a measure of

retino-cortical inhibition. When Barry⁴ discussed the significant rise with his sample, factors that could have effected the rise were explored. They were: learning; improved reaction speed; and set or expectancy. These same factors were discussed in relation to the significant rise in the organic group.

Barry⁵ observed that when learning seemed evident, the curve was a declining one, thus giving the impression of an increase in after-image awareness. If judgment difficulty was also taken into consideration a similar curve was anticipated. The sharp rising curve obtained from the organics seemed to reduce the possibilities that these factors played an important role.

If there had been a loss in digital reaction time, as would be expected from an organic group, the curve would also have been depressed to some extent.

Set or expectancy errors did not appear to be operative. This possibility was ruled out on the basis that there was a consistent return to the basal level on the second testing session and the two testing session curves had no substantial variability.

In view of the preceding discussion, the writer is willing to accept the increase in threshold scores on the test resulting from cortical inhibition.

4 Ibid., p. 62-63.

5 Ibid., p. 62.

B - Comparison of Organics and Non-Organics
and Relation to Theories of Cortical Inhibition.

The null hypothesis that "there will be no significant differences between the organics and non-organics mean inhibition scores as measured by the Negative After-Image Threshold Apparatus" was rejected.

Employing the explanation that the Negative After-Image Threshold measurements are measures of retino-cortical inhibition, the results of this investigation support the theory that intra cranial pathology effects a rise in cortical inhibition.

The significant differences found between the organics and non-organics mean inhibition scores lend support to the findings of Pavlov⁶ that an area of the cortex that was pathological would exert some influence on the rest of the cortex.

The reactive inhibition concept of Hull⁷ seems to apply here, but only to the results of an increased rise in threshold increments within the group. His concept does not seem to explain the significant differences between the groups. Further, the concept need not be restricted to muscle complexes but may be extended to include cortical

6 Vide, Study, Section 1, p. 1-2.

7 Vide, Study, Section 1, p. 3.

activity as Eysenck⁸ has done.

The explanations of Klein and Krech⁹ appear to be applicable to these results but only to a limited degree. Their statements on neural activity would explain the significant rise in thresholds of the six trials, but not the differences between the two groups. 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.

C - Summary and Conclusions.

This dissertation reported on an investigation of the possible relationship between intra cranial pathology and after-image sensitivity as measured by the Negative After-Image Threshold test. The algebraic sum of increments for the six trials, using Trial 1 as the basal score, was interpreted as retino-cortical inhibition in the visual modality.

The literature showing the development of the cortical inhibition theory was presented. Studies that utilized

8 Vide, Study, Section 1, p. 3-4.

9 Vide, Study, Section 1, p. 5-6.

after-image measures with intra cranial pathology and drugs were also presented. The instrument, procedures and data analysis were presented. Test-retest reliability was expressed and the validity of the instrument as a measure of retino-cortical inhibition was discussed.

Employing t tests of significance, the differences of the mean and standard deviation test scores were investigated utilizing the hypothesis that "there will be no significant differences between the organics and non-organics mean inhibition scores as measured by the Negative After-Image Threshold Apparatus. The null hypothesis was rejected. The findings support the theory that the after-image is cortically influenced and that pathology of one area of the cortex can affect the functioning of the visual cortex.

Future research should first validate these findings. Studies with drugs should be done to determine their effect upon threshold readings of organics because it is sometimes impossible to acquire a population of this type that is not under some form of medication.

Investigations should attempt to test specific types of organics to determine if any differential effect can be found between the categories. Work in this area may give more insight into the nature of the effect taking place intra cortically.

BIBLIOGRAPHY

Barry, William F., An Investigation of Relationships Between Intraversion-Extraversion and the Negative After-Image Threshold, unpublished doctoral dissertation, University of Ottawa, 1961, 80 p.

His work was the major source for this study. The procedures, comparison sample and apparatus were derived from his work of cortical inhibition and the after-image.

Rysenok, H.J., "Cortical Inhibition, Figural After-Effect, and Theory of Personality", in Journal of Abnormal and Social Psychology, Vol. 51, No. 1, July 1955, p. 94-106.

This work extended the concept of reactive inhibition to include cortical activity. The work is of indirect interest because the author investigated psychological types and its relationships to cortical inhibition.

————— and S. Aiba, "Drugs and Personality, V. The Effects of Stimulus and Depressant Drugs on the Suppression of the Primary Visual Stimulus", in Journal of Mental Science, Vol. 103, 1957, p. 661-665.

This study employed a modified apparatus developed by Lehmann to investigate drug effect upon after-images. They found that the drugs cortically influenced the after-image but were confusing to the reader because they also presented a sensory interpretation of the process.

—————, H. Holland and D.S. Trouton, "Drugs and Personality, VII. The Effects of Stimulant and Depressant Drugs on Visual After-Effects", in Journal of Mental Science, Vol. 103, 1957, p. 650-655.

This study employed the spiral apparatus and found that a depressant drug shortened the duration of the after-image whereas no effects were found with the stimulant drug. This study lends support to the theory that there is cortical involvement in after-image perception.

Gollin, Eugene B. and Norman Bradford, "Aulity Communication and the Spiral Aftereffects: A Methodological Critique", in Journal of Abnormal and Social Psychology, Vol. 57, No. 1, July, 1958, p. 122-123.

The first work with the spiral apparatus that contradicted the original findings with organic groups. They trained organics to respond with the proper phrase to describe the movement phenomenon. They concluded that failure to report may be an inability to describe the situation not perceptual failure.

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

A critical review of Pavlov's experimentation of cortical inhibition clarifying the nature of inhibition as a generalized process not localized in any one specific cortical area.

Hull, C.L., Principles of Behavior, New York, Appleton-Century, 1943, x-422 p. quoted by H.J. Eysenck, "Cortical Inhibition, Figural After-Effect, and Theory of Personality", in Journal of Abnormal and Social Psychology, Vol. 51, No. 1, July 1955, p. 94-106.

A series of theoretical and experimental studies. This work is of indirect interest to the study since he restricted the reactive inhibition concept to motor reactions in muscle activity.

Jaffe, Robert, "Kinesthetic After-Effects Following Cerebral Lesions", in American Journal of Psychology, Vol. 67, No. 4, December 1954, p. 639-676.

This study was similar to that of Flein and Krech. The findings did not uphold their conclusions. He did not find any significant differences between the brain injured patients and the control group.

Laplan, Solomon, D., "Autonomic Visual Regulation; Part 1. The After-Image Spectral Photometer", in Explorations in Physiology and Emotions, Psychiatric Research Reports of the American Psychiatric Association, No. 12, January 1960, p. 104-114.

This study employed a modified device developed by Lehmann to investigate the effect of autonomic drugs upon hue sensitivity. His findings necessitated the control of drug usage by the samples compared in this study.

Klein, George S., "Studies of Duration of Negative After-Image: Effect of Brain Injury", quoted by George S. Klein and David Krech, "Cortical Conductivity in the Brain Injured", in Journal of Personality, Vol. 21, No. 1, September 1952, p. 118-148.

This report indicated that negative after-image durations were shorter with brain injured subjects than in normals. Conclusions from this study must be considered carefully since no information concerning the sample, techniques, tools or statistical data were given.

_____ and David Kreeh, "Cortical Conductivity in the Brain Injured", in Journal of Personality, Vol. 21, No. 1, September, 1942, p. 113-143.

An important study for its theoretical contributions. They found that brain injured subjects had more kinesthetic figural after-effect inhibition than normals. The main weakness was the acceptance of low significance levels.

Ehler, Wolfgang, and Hans Wallach, "Figural After-Effects", in Proceedings of the American Psychological Society, 59, 1954, p. 267-357, quoted by John Krauskopf, "The Magnitude of Test Period", in American Journal of Psychology Vol. 67, No. 4, December 1954, p. 684-690.

These authors proposed an original explanation of cortical functioning to account for the figural after-effects. The work has been criticized for using unknown neurological mechanisms.

Krauskopf, John, "The Magnitude of Figural After-Effects as a Function of Duration of Test Period", in American Journal of Psychology, Vol. 67, No. 4, December, 1954, p. 684-690.

A critical work of the Ehler-Wallach theory. He found that figural after-effects decreased as a function of the length of the testing period. The finding seems to contradict the basic postulate of the theory.

Pavlov, I.P., 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.

This book is basic to any research in this area. The text reported the initial research on the theory of cortical inhibition and the information provided was the basis for the present study.

Erica A. Cooper and E.L. Deabler, "Analysis of Organicity by Means of Spiral After Effect", in Journal of Consulting Psychology, Vol. 12, No. 4, August 1955, p. 299-302.

Original research with organics using the spiral apparatus. They found that organics failed to report the after-image of apparent movement and normals did report it. They concluded that failure to report the after-image was due to perceptual failure.

APPENDIX 1

ABSTRACT OF

An Investigation of Relationships Between Intra Cranial Pathology and the Negative After-Image Threshold.¹

Pavlov found that pathology in one cortical area had an inhibitory effect on other cortical areas. Further studies employed kinesthetic effects and motor reflexes as independent measurements and had little success.

This study investigated intra cranial pathology and after-image threshold measures by a new apparatus. With massed practice, the decreasing illumination thresholds required to maintain the after-image provided the measurements interpreted as cortical inhibition.

Employing t tests of significance, the mean and standard deviation algebraic scores of fifteen males with intra cranial pathology were significantly different at the .01 level compared to the scores of seventy-two B.M.S. No significant differences were found between the basal scores. The reliability of the test was acceptable and the validity of the test as a measure of cortical inhibition was discussed.

The findings support the theory that the after-image is cortically influenced and that pathology of one cortical area can affect the functioning of the visual cortex.

1. Joseph D. Kovatch, B.A. thesis presented to the School of Psychology and Education, University of Ottawa, Ontario, April, 1961.

