THE RELATION OF AFTER-IMAGE DURATION TO CERTAIN ASPECTS OF PERSONALITY

by

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CHAPTER I

INTRODUCTION

Recent trends in psychological thinking and research have emphasized the role of subjective experience in perceptual organization. The work of Murray (43), Bruner, Postman, and McGinnies (9, 10, 37, 45, 46), Klein (27), and others has shown that how people understand what they perceive is determined in part by their own strivings, needs and goals. Bartlett (3) has demonstrated that what happens to be selected from a perceptual field, and later remembered, is related to cultural factors. Ames and his colleagues (35) have pointed out that what one perceives in the world about him depends on what he knows about his environment from previous experience.

All of these studies indicate that although different people may be exposed to the same physical situations, these situations are translated in some fashion so that what is perceived is in consonance with the needs, drives, experiences and cognitive organization of the individual who is doing the perceiving.

Two kinds of experimental approaches have characterized most of the study in this area of perception. Murray, Bruner, Postman, McGinnies and others who followed their lead have used perceptual stimuli or stimulus situations, such as fear-inducing stories, anxiety-inducing words, and symbols which were presumed to be related to the subjects' personal values, calculated to arouse emotional reactions. Those who have followed the lead of Ames have manipulated perceptual cues which serve as anchoring points or points of orientation for the subject by changing the height of walls, the slope of floors, cues to distance, etc. In the former instance the experimenters noted the effect of the induced stimuli on stories which the subjects told, on the speed with which they recognized certain words or objects, on the estimated sizes of certain objects, etc. In the latter instance, the experimenters studied the reactions and adaptations of the subjects to the changes in perceptual cues.

In these two approaches attention has been focused on cognitive and symbolic processes, processes in which meaning is inherent. Only Gudmund Smith (49), in his work with the negative after-image, has attempted to demonstrate that experiences which have neither specific emotion-arousing connotations nor particular importance as cues to perceptual orientation in space are also perceived by a person in such a manner that they are consonant with his psychological structure. This dissertation attempts to carry such a demonstration one step further by studying after-image duration in a frame of reference other than the heredity-oriented point of view from which Smith began.

Historical Perspective

The after-image phenomenon has a long, if somewhat obscure, history in psychology. Interest in the phenomenon has been rather sporadic. Considered by all workers to be the product of an adaptive reaction, most of the attention directed to the phenomenon has been concerned with its psychophysiological aspects. Many investigators (8, 14, 16, 18, 28, 29, 36, 41, 42, 44, 47, 49, 51) concerned themselves with the question of whether the after-image was primarily a cortical or a retinal adaptive phenomenon, a debate which seems to have ended with the conclusion that adaptation of both cortex and retina are involved (61). It has been determined, however, that the after-image is affected by the intensity of the stimulus (6, 41, 55); the color, duration and size of the stimulus (4, 6, 55, 61); the color and intensity of the projection field (55, 42); the distance of the subject from the projection field (49, 61); movement of the subject's head and eyes (52, 53, 57); degree of dark adaptation of the subject (48); the presence of other stimuli in both the stimulus and projection fields (33, 21, 57); whether the stimulus impinges foveally or extra-foveally (13, 58); the amount of oxygen available to the subject (17); mescal (28); retinal rivalry (56); the point of fixation on the projection field (22); the rate of intermittence of the stimulus light (2); and the time of day (61, 34).

Psychophysical aspects of the phenomenon, however, are not alone in their significance as variables. More germane to the present study are the frequent reports of consistent individual differences and individual patterns in after-image performance.

Miles (41), for example, noted

> ...distinct individual differences...both in the length of time that the image lasted and in the after-flight of colors...what is light of considerable intensity for some subjects and results in a very vivid play of colors in the projected image, is for others of such feeble power that it gives an image of short duration and produces only a limited series of changes. This seems to show that a regular color sequence for light of any particular physical intensity is dependent on personal characteristics and is not a result of the absolute intensity of the light.
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> ...At the outset considerable differences were noted in the way that the subjects responded to the successive tests. Some appeared to show very little variation in the duration of the image from test to test. Other subjects began with

a fairly long duration, and with each succeeding test the length of time that the image was retained diminished. A third class showed the reverse effect. In an extreme case no image was seen after the first two exposures. Then followed, at successive tests, images which lasted 47, 125 and 168 secs.

Troland (55) found that the duration of the after-image was nearly independent of wave-length and of absolute intensity, but varied radically with the diameter of the field and with the individual subject. Shuey (48) reported marked individual differences in the latency of the after-image. Berry (5), studying the flight of after-image colors, added that every subject seemed to have his or her own individual pattern in the sequence of the colored images which persisted throughout the entire series of experiments, and that there was considerable variation in duration. Young (62) found significant deviations from Emmert's law* in individuals, although averaged measures were found to approximate Emmert's law. Cooper (12) felt that the patterns he found for both length and frequency of the after-image might be regarded as individually identifying. He found individual consistency in total time for a given trial, total image time, and number of images.

Jaensch (24) reported that after-image duration varied considerably for both eidetic and non-eidetic subjects. Morsch and Abbot (42) tested 256 boys and girls in grades five to 12 of rural schools and found "enormous individual differences" in the after-images perceived. Smith (49) reported that identical twin pairs varied much more closely together than did fraternal twins in measuring the size of the after-image, but that when it came to after-image duration the differences

*The linear size (E) of the after-image stands in the same relation to the size (O) of the stimulus object as the distance between the eye and the projection screen (P) to the original fixating difference (F): $E/O = P/F$. (49)

differences between the identical twins were about as great as those between the fraternal twins.

Preliminary studies of the negative after-image by the present investigator (34) indicated that when a series of ten after-image durations was taken at one sitting with 50-second exposure periods and one-minute rest periods between trials, 20 subjects manifested obvious individual differences in the curves which were yielded by the after-image durations. Some subjects had initially long durations and maintained relatively long durations throughout the series. Others dropped sharply from initially long durations to shorter durations. Some had initially short durations which remained relatively short throughout the series, while still others who began with relatively short durations dropped to even shorter durations. Some began with relatively short durations and rose gradually to the end of the series. (cf. Miles p. 3). A comparison of a group of 14 hospitalized chronic alcoholics with a group of normal men disclosed that the alcoholics had consistently shorter after-image durations. Some patients who had had pre-frontal lobotomies had after-image durations which were not distinguishable from normals, but others, especially those who were still very sick, were found to have very short after-image durations.

Both James (25) and Erickson and Erickson (15) reported that subjects who were hypnotized and instructed to hallucinate a color invariably did so and then hallucinated the negative after-image of that color when they were asked to name the color that followed the one they originally hallucinated. Hibler (23), however, could not verify these results.

The wide range of individual differences, the lowered durations in chronic alcoholics and in some lobotomized patients, and the fact that apparently after-images could be induced hypnotically suggested that the after-image could be used to study other psychological aspects than the psychophysical. Some of the investigators attempted to tease out these aspects.

Miles (41) related after-image duration to recall. He found a "small correlation" between after-image duration and the subject's ability to recall four kinds of squares (r=.57 for 22 boys, r=.65 for 19 girls). Washburn and deVries (56) reported that subjects could increase the duration of the first after-image of a series somewhat by trying to do so, although the number of appearances of a color was not affected by effort. Travis and Hall (54) found that for a relatively high degree of attention to the after-image, the total duration of alpha waves and the mean duration of the bursts during the after-sensation periods were less, and the length of time for the first burst to appear after the light went off was greater than for a relatively low degree of attention. In the same kind of EEG study, Jasper and Cruikshank (26) found also that alpha rhythm was blocked during the presence of the negative after-image. They felt that,

> Psychologically the significance of this reaction appears to be associated with what has been termed "Attention value," the "arousal value" or the total organismic "reaction value" of a given stimulus situation rather than to the modal or intensity attributes of stimuli as such.

Jaensch (24) saw the after-image as the first step on the continum after-image--eidetic image--memory image. He used after-image duration as an indication of whether or not his subject was a good "Eidetiker" and maintained that the after-images of eidetic persons are only infrequently of short durations, sometimes lasting 400 seconds or longer. In turn, he attempted to relate eidetic ability to constitutional factors. Allport (1) disagreed with Jaensch, holding that after-images are only accidentally similar to eidetic images and eidetic images are really a limiting case of memory images. He concluded that the only thing which could account for the phenomenal projection of both the after-image and eidetic image was the attitude induced in the subject. Morsch and Abbot (42) saw the eidetic image as merely a vivid after-image and found an association between intelligence and imagery ability. They contended that such factors as expectation and suggestion on the part of the investigator as well as the subject had not been controlled in similar experiments previously.

Gudmund Smith (49), who followed the Jaensch (24) lead in his studies of twin differences, found greater similarities in the after-image phenomenon among identical twins than in fraternal twins and attributed them to "similarities in inner surroundings" or similarities in development. With respect to after-image duration he says,

> ...The differences in after-image duration sometimes corresponded to a difference in personality structure--then the more concentrated and persevering partner had the longest after-image duration; e.g., it may be assumed that he has better resisted diverting disturbances.

From his point of view, Smith concluded that the after-image duration was "peristatico-stable" (a function that is little changed in the course of development by the surroundings or objective environment). Differences in "peristatico-stable" development he interpreted as being connected with personality type. He could show no certain connection between the duration and periodicity of the after-image and personality type, however, but he found that young Eidetiker often had prolonged, continual after-image processes. He noted further that the more open and adaptable, more alert and more intelligent subjects accomodated to Emmert's law, but that the slow, "unique," or persistent subjects often worked out their own structures. He concluded further that,

> ...the after-image experiment can be looked upon as a development (an approach of the subjective world to the objective world) and that the "Einstellung" of the subject is of essential importance for the results.
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> ...only in its connection with the individual as a whole does the after-image function become peristatico-stable, i.e., peculiar for the individual and his genotype. As an isolated phenomenon--e.g., when the individual is not interested or when he has isolated his after-image from the rest of the relevent region--it is more and more brought to a common level by the surroundings and forms an unambiguous answer to its stimuli. These lower functions in their characteristics should then be fairly similar in different individuals in the same surroundings, if they were not formed by central functions and thereby extricated from these outer surroundings.

From the observations of these investigators it is apparent that when a subject takes his seat in the laboratory, fixates a simple colored stimulus and projects an after-image, he presents the psychologist with an opportunity to study much more of his functioning than just the anabolism and catabolism of visual purple in his retina or similar psychophysical factors. As a person he is not without feelings, questions, attitudes and emotions. He may wonder perhaps what this experience is all about, what the experimenter will think of him and his performance, what will happen to him in the course of or as a result of the experiment. He may look forward to the experiment with pleasure, dread, doubt, fear, anger, hostility, etc. He may dislike the experimenter, he may have just had an argument with a friend, or he may have just enjoyed a sumptuous dinner. More important than these immediate psychological states and basic to them is the subject's characteristic mode of psychological adaptation or "personality." Both the subject's characteristic mode of adaptation and the immediate psychological states which he experiences will have an effect on what and how he perceives.

The use of the terms "attention," "attitude," "arousal value," "expectation," "suggestion," "concentration," "resistance to diverting disturbances," "adaptable," "alert," "interest," etc., by previous investigators emphasizes the role of immediate psychological states in after-image performance. The work of Jaensch and especially that of Gudmund Smith, point up the fact that characteristic modes of adaptation or personality structure are reflected in the manner in which the subject perceives the after-image.

The after-image is thus seen as the result of an adaptive reaction of the human organism. In its various aspects it is closely related to the rest of the adaptive mechanisms of the person, those characteristics commonly referred to collectively as "personality." In fact, if individual differences could be systematically interpreted, the after-image performance of a person might well be able to tell us a great deal about him. As Burrow and Syz (11) point out,

> One might say that in man the eye serves as the organism's main sentinel; it is one of its chief instruments in making contact with the surrounding world. In focussing upon pertinent aspects of the environment, involuntary as well as voluntary components are involved. The eye movements

are automatically correlated with the motor patterns of the head and body, and they are at the same time influenced by the aims and attitudes of the organism as a whole. It is to be expected, therefore, that the behavior of the eye should reflect in a measure the adaptive patterns of the total organism of which it is a subservient and coordinated part.

Statement of the Problem

The importance of an attempt to relate the duration of the negative after-image to personality characteristics lies in the opportunity to make a clinical contribution to perceptual theory.

By the use of a clinical approach, the investigator brings to the perception laboratory another method of selecting and controlling the kind of subjects used in the experiment, i.e., selection of the subjects or analysis of the data on the basis of clinically determined variables. At the same time, the use of the duration of the negative after-image as a clinical instrument has certain important advantages over many other clinical instruments. The negative after-image provides the investigator with a perceptual phenomenon which is as devoid of experientially-acquired emotional connotations as any perceptual stimulus could be and which, at the same time, has little value as a cue to spatial orientation. In contrast to most clinical instruments, it is relatively simple. Only the duration of the after-image is measured. Because the goal in the experimental or test situation is not readily perceptible to the subject (long after-image durations have no particular value to the subject), there is a reasonable chance that after-image duration is independent, and the investigator may feel considerably more secure about varying other experimental conditions. In the absence of definite goals, faced with a stimulus which cannot be interpreted as can a picture or ink-blot, or copied as a design, or answered as a question, etc., the subject can only infer from what he thinks the investigator expects of him what it is he is supposed to produce in the laboratory. Thus the simplicity of the experimental situation and the independence of the stimulus variable permit a clear-cut interpersonal relationship to exist between the subject and the investigator in the context of which the behavior of the subject can be studied.

The terms "attention," "expectation," "concentration," "interest," etc., used to conceptualize psychological factors which played important roles in those subjects who reported after-images which were longer, more clearly defined or more stable than those of other subjects, would seem to indicate that the former subjects, for one reason or another, related themselves to the investigator or to the experimental situation in a more effective way than the latter.

In many experiments experimental variables are deliberately selected to make certain that the subject will relate to or become involved with the stimulus variable as the term "ego involvement" testifies. Murray (43) told his child subjects stories, for example, to arouse their interest and thereby to insure that the stimulus, fear in this case, would impinge on each of them.

In other experiments, the investigator makes certain the subject will "cooperate" by choosing college sophomores who may feel they must cooperate with the instructor, or by paying subjects, or by selecting subjects who promise to take part until the experiment is completed.

In both cases, the subject either voluntarily or by subtle forms of coercion becomes involved in the experiment. The subject is said to be motivated. He organizes himself around the experimental task while he is in the laboratory.

To organize himself around the experimental task in this particular experimental situation requires of the subject that he devote himself to fixating the stimulus and afterward to the perception of the after-image. In a sense, the subject becomes a "partner" of the investigator in the experiment. For him the experimental task is paramount and other needs, strivings and goals become secondary for the time being. He must resist distracting stimuli, whether internal or external (cf. Smith, p. 7) and apply himself unreservedly to carrying out the directions which the investigator gives him.

In order to be able to organize himself in this manner, the subject must be intelligent enough to understand the directions he is given, passive enough to accept the directions, to permit the stimulus to impinge upon him for as long as it is exposed and to permit the image to take its course, alert enough to respond immediately by whatever means the experimental situation provides, etc., and motivated to want to do whatever he will be called upon to do. A large number of personality characteristics, including various kinds of motivation, either singly or in combination, might be correlated with such an organization.

When duration is the aspect of the after-image being studied, the kind of motivation the subject brings into the laboratory becomes important because it determines how he will organize himself around the experimental task.

If the subject takes part grudgingly only because he is required to do so, he may likely do as he is instructed, but at the same time be seeking to get the task over as soon as possible and get out of the laboratory. His motivation derives from his obligation, direct or indirect, to the investigator; he experiences his participation as a debt he has incurred which must be discharged quickly so that he can go about his business. His relationship to the investigator is then a negative one from which he must escape, so he is organized around getting out of the experimental situation.

The subject may be organized around getting out of the experimental situation for many reasons. He may experience the investigator as a threatening figure from whom he must flee. He may dislike the investigator. He may be hostile, negativistic or aggressive and reject the investigator as he rejects most other people. He may be preoccupied with personal problems, or he may merely have an appointment with the dentist. Whatever the case, he will experience the experimental situation as somewhat frustrating, and as a result he will be less able to passively permit the stimulus to impinge upon him, and further, less able to sit patiently while the image takes its course. It would be expected therefore that his after-image durations would be relatively short.

If, conversely, the subject were organized around the experimental situation, it would be expected that his after-image durations would be relatively long. His motivation would be to remain in the experimental situation, not to flee from it. He could more freely permit the stimulus to impinge upon him; in fact he would most likely actively relate to the stimulus by concentrating on it, consciously resisting distracting stimuli and maintaining himself in an alert state of readiness to respond to the image when it appeared. In turn, he would concentrate on the image, holding on to its last vestiges, as it were, so that he would be certain of complying with the directions to accurately record the time of its appearance and disappearance. Such a subject would continue to perceive the after-image indefinitely if there were no physiological limits on the duration of the image.

The motivation to organize around the experimental situation and to remain in it must, in the absence of an attractive force from the stimulus itself, derive either from the relationship of the subject to the investigator or from the personal goals and standards of the subject himself. The subject in this particular experiment has no other cues available to him to guide his behavior. There are at least two kinds of subjects, at opposite extremes of at least one continuum, who could so organize themselves: 1) those who are strongly dependent on the investigator for approval and therefore will expend their best efforts to please him, and 2) those, who, while they are little concerned about the approval of the investigator, are driven by their own needs to do well.

The task of perceiving a negative after-image, is, however, in some respects similar to certain other visual tasks in that the subject must make a discrimination between the image and the field on which it is projected. Discrimination becomes increasingly important as the image fades and disappears. At this point deciding whether or not the image is still present is much like deciding whether or not a light is still flickering or a stimulus is bright enough to be seen. The subject finds himself in an "area of decision." If the duration of the after-image is related to the subject's ability to decide or to discriminate in this manner, then this investigator would expect after-image duration to be correlated with visual tasks in which this kind of "decision-making" plays an important role.

An exploration of the relationship between after-image duration and personality variables might therefore take as its point of departure the assessment of the role of motivation in the experimental situation and the relationship of after-image duration to visual tasks requiring discrimination or "decision-making." There are, however, no tests of personality which purport to predict motivation in an experimental situation nor is there a ready way of determining which particular visual tasks might be related to after-image duration. To take this approach one must therefore begin somewhat arbitrarily by using a commonly accepted assessment of personality variables and certain more or less widely used discriminating tasks in the hope that these might yield trends and clues which might later be followed up in more systematic fashion.

In this study, consequently, to explore the relationship of personality characteristics to after-image duration, the Minnesota Multiphasic Personality Inventory (19) was used. In addition, the Otis Self-Administering Intelligence Test, Higher Form, was used to provide a check on previous reports (42, 49) that intelligence, too, is an important factor in after-image perception. To explore possible relationships between after-image duration and visual discrimination tasks flicker-fusion thresholds and brightness thresholds for the appearance and disappearance of the negative after-image were determined.

Specifically, this study attempted to answer the following questions: Is the duration of the negative after-image related to any of the personality variables tapped by the MMPI? If it is so related, what inferences about personality structure, and especially motivation in the experimental situation, can be drawn from this relationship? Is after-image duration related to intelligence? Is the duration of the negative after-image related to flicker-fusion thresholds and to after-image appearance and disappearance thresholds? What avenues of research might yield promise of additional information about after-image duration?

CHAPTER II

EXPERIMENTAL PROCEDURES

The subjects in this study were 26 students in the Menninger Foundation School for Psychiatric Aides, 14 women and 12 men, ranging in age from 18 to 47 with a mean age of 26.3. Each subject was given the Higher Form of the Otis Self-Administering Intelligence Test and the booklet form of the Minnesota Multiphasic Personality Inventory as part of the entrance examination for the school, and was unaware of the fact that these tests would be used as part of the present study. Each subject was also tested for visual acuity by means of the Snellen Chart. Although all 32 students in the school were used throughout the study in order to arouse a minimum of question among them, six did not have 20/20 vision even with glasses and their results were therefore not included as part of the experimental data. The students were told that the procedures to which they were being subjected were being followed in an effort to learn more about how people see things.

After-Image Duration: Each subject was tested for after-image duration after he had completed his day's work at 3:30 p.m. The time of testing was held constant because of the differential between morning and afternoon results demonstrated in the pilot studies (34) and the results reported by Franz (61). After-image testing usually took about 45 minutes.

The subject was seated in a chair and rested his chin on a chin rest which was adjusted so that its height was comfortable for him. The subject saw before him at a distance of 60 inches a black square

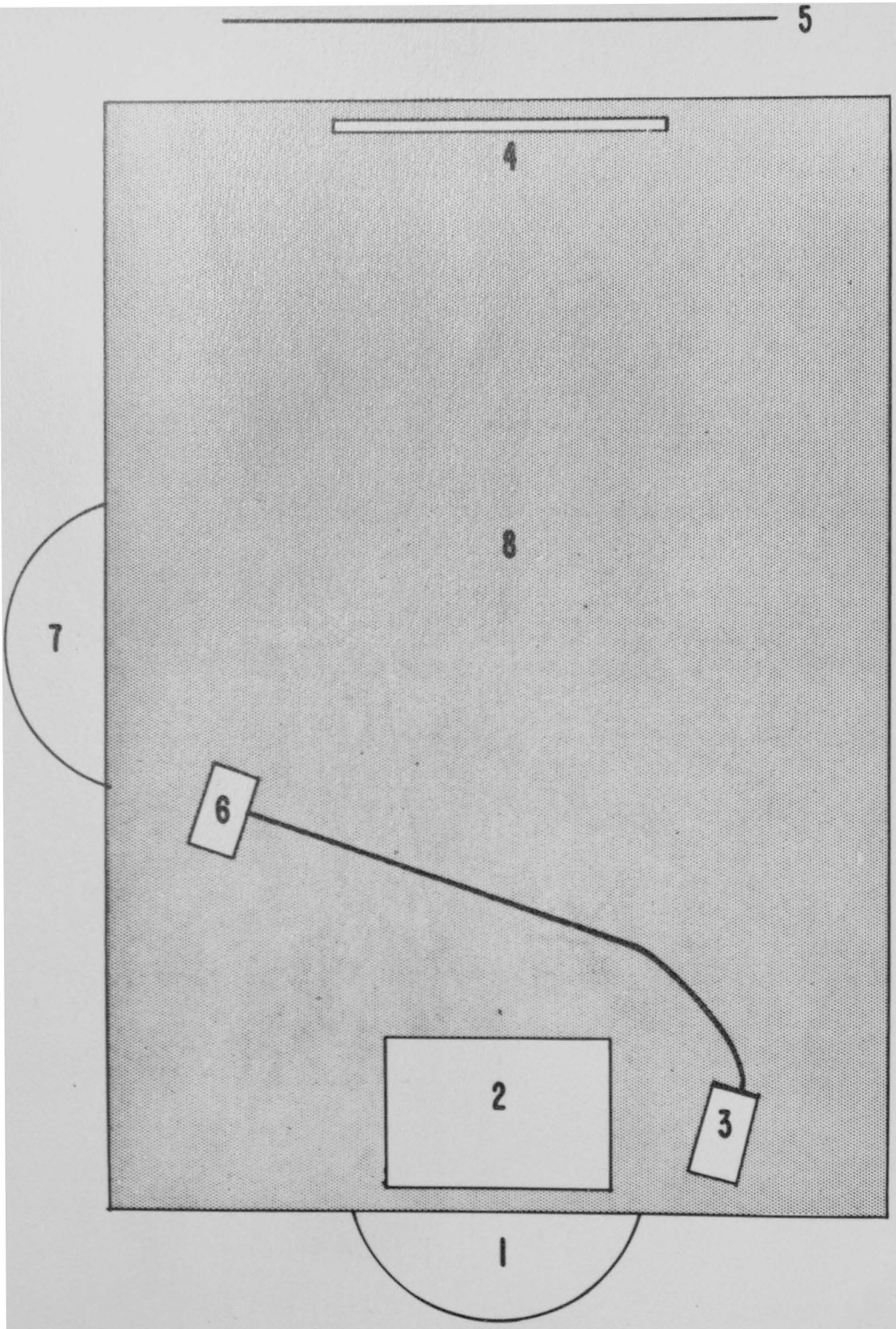

FIG. I
DIAGRAM OF EXPERIMENTAL ARRANGEMENT FOR AFTER-IMAGE DURATION

1 SUBJECT
2 CHIN REST
3 TELEGRAPH KEY
4 EXPOSURE APPARATUS
5 PROJECTION SCREEN
6 ELECTRIC TIMER
7 EXPERIMENTER
8 TABLE

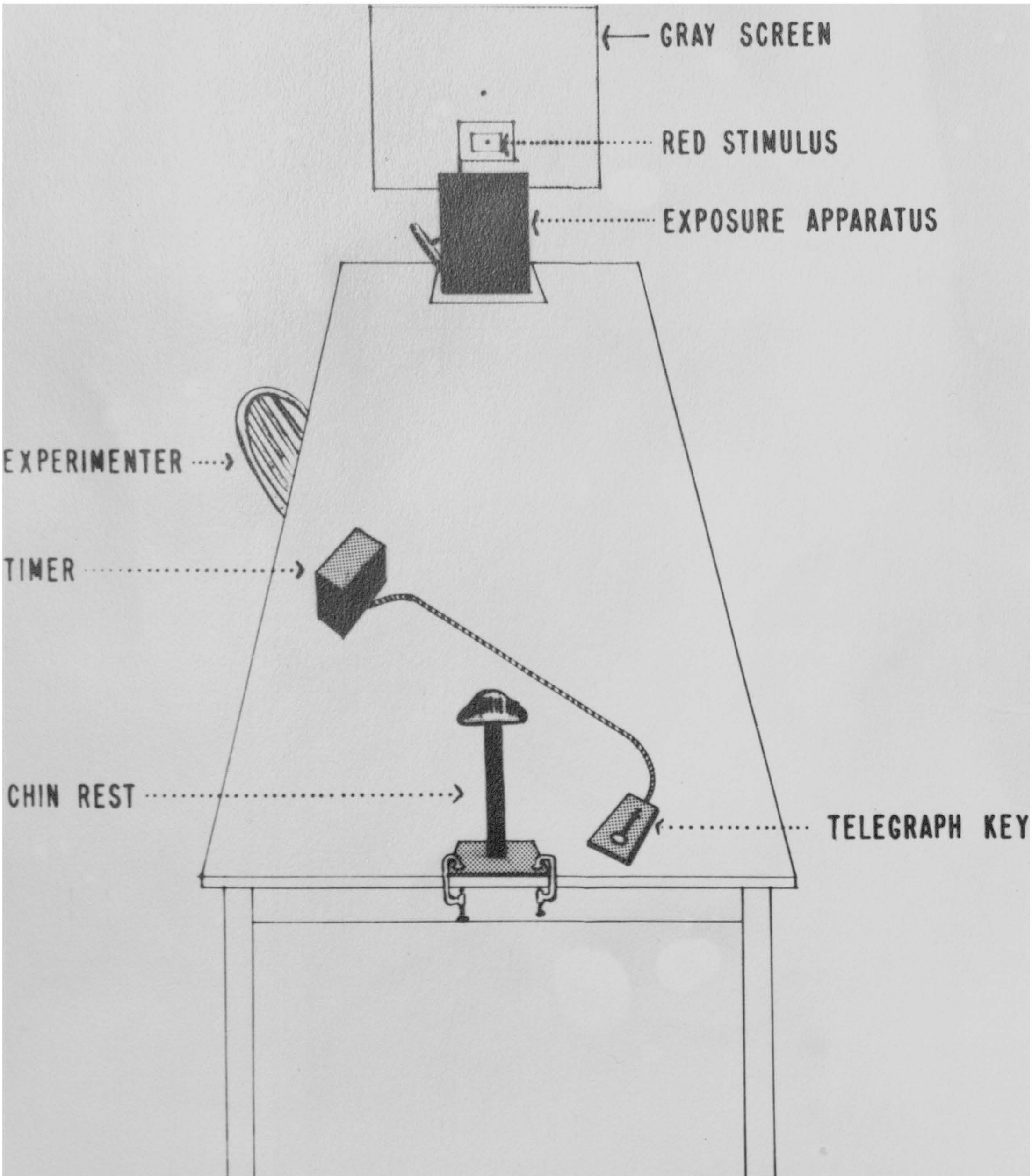

FIG. 2

AFTER-IMAGE EXPOSURE APPARATUS AS IT APPEARS TO THE SUBJECT of wood to which was attached a small handle. Two inches beyond the black wooden piece, on the wall, was a neutral gray cardboard screen, 25 inches high by 22 inches wide, with a black dot in its center. The center of the gray screen was one foot higher than the black wooden apparatus. To the subject's right was a telegraph key which was connected to a Standard Electric Timer. The experimenter sat at a 90-degree angle to the left of the subject, manipulating the apparatus and recording the data in full view of the subject, although the subject could not see the recorded data or the face of the timer.

When the experimenter pulled the handle on the black wooden apparatus, from behind the wooden piece there arose a white cardboard field, seven and one-half inches square, in the center of which was a three-inch-square red field. In the center of this red field was a black dot, plainly visible to the subject. When the experimenter released the handle, the cardboard stimulus disappeared behind the black wooden piece.

The room in which the testing was conducted had light green thick plaster walls. Its window shades were taped shut. Illumination was provided by three 25-watt white fluorescent bulbs five and one-half feet above the base of the chin rest and one foot forward from it. Similar lights illuminated the rest of the room, yielding 23 foot-candles of light on the stimulus and projection screen. From the latter 9.95 foot-candles of light was reflected. (Recorded on a Photovoltmeter, model 200.)

Each subject was instructed as follows:

> When I pull this handle like this (doing so) a red card appears. When you see the red card, fix your gaze

steadily on this black dot in the center (pointing to it). Try not to blink your eyes or move your head. As soon as the red card disappears, (dropping it) shift your gaze to this black dot on the gray cardboard (pointing to it). When you do so, you will see a green square. Sometimes it will be a dark green, other times a light green, perhaps even a bluish green. As soon as you see green, press down on this key (pointing to the telegraph key) and keep the key down until the green disappears. When the green goes away, take your finger off the key. If it comes back again, press down on the key again. Press down on the key whenever and as long as you see green. When it seems as if the green is not coming back again, keep your eyes on the black dot for a little while longer just to make sure.

The red stimulus was then exposed for 50 seconds (timed by stop-watch) after which the subject fixated the gray screen, pressing the key when the green after-image appeared and releasing the key when it disappeared. The examiner recorded the latency, the number of fluctuations of the after-image and the total time of its duration. When 15 to 20 seconds elapsed without the subject's having seen the after-image any more, the experimenter asked, "Is it all gone now?" Upon receiving an affirmative answer, the experimenter said, "Now close your eyes and tell me what you see." In most cases the subject reported that he saw a positive after-image, describing it as a red or pink square which looked like the original stimulus. Some subjects saw no positive after-image and these were instructed to keep their eyes closed for a little while to make certain that one would not appear. After reporting the presence of a positive after-image, the subject was asked to report to the examiner when it had disappeared. He was then instructed to open his eyes, to sit back and relax for a minute.

Each subject was presented with a red stimulus ten times for 50 seconds each time, with 60 seconds to rest after the positive after-image had disappeared or it was ascertained that the positive after-image would not appear. The subject did not know how many times the stimulus would be presented. After 55 seconds of the rest period had passed, the subject was asked, "Ready for the next one?", permitting him five seconds to place his chin on the chin rest and his hand on the key.

During the rest period the experimenter asked the subject to describe what he had seen. These descriptions provided the experimenter with a check on the validity and accuracy of the subject's perception, the experimenter having learned in pilot studies the characteristics of both the positive and the negative after-image under the conditions of the present experiment.

From experience the experimenter had learned that subjects almost uniformly reported the negative after-image as a light green square, that it tended to become dimmer each time it reappeared, that it usually reappeared when the subject blinked his eyes, and that it tended to disappear by moving to the right or left lower quadrant of the projection field. Deviations from these descriptions would call the report of a subject into question. None of the reports of the experimental group were questionable.

Flicker-Fusion: The subjects reported to the laboratory a second time, at the same time of day, for tests of flicker-fusion and after-image threshold. Each subject was told that he would be permitted to become adjusted to the dark room before undertaking the task at hand. Five minutes was allowed for dark adaptation.

The flicker-fusion apparatus consisted of a General Radio Co. Strobotac, Model 631-B, which was mounted in box so that its control

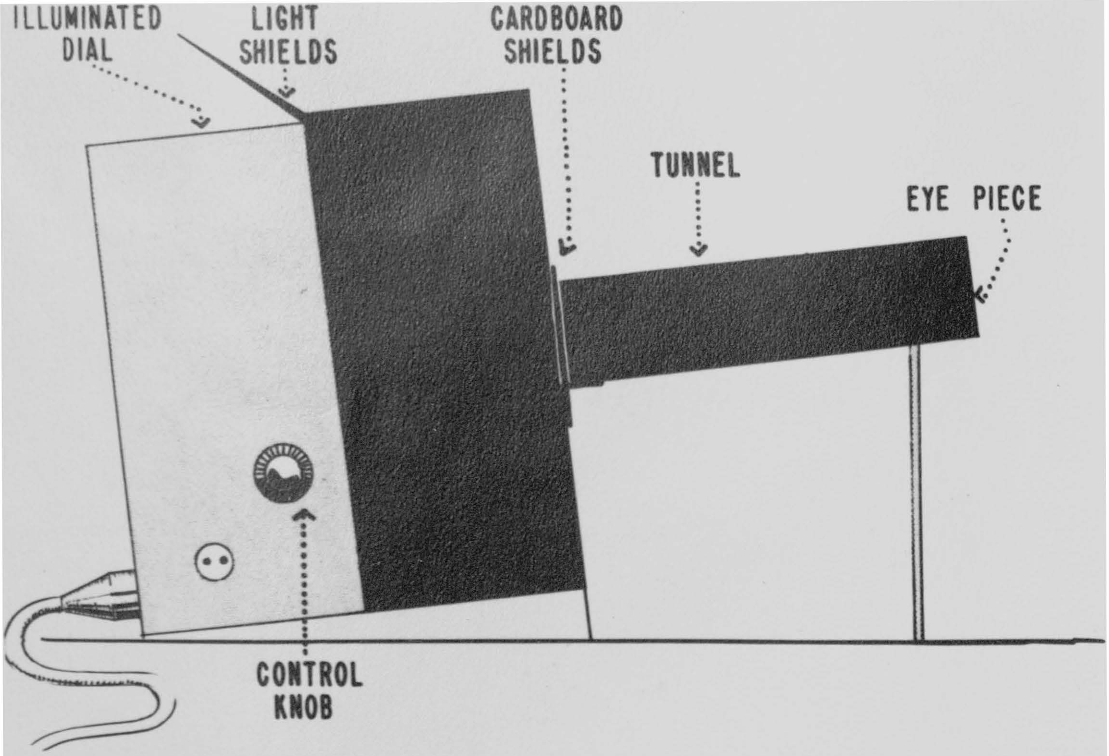

FIG. 3
FLICKER-FUSION APPARATUS
SIDE VIEW

knob projected to the left, and the experimenter was able to read its illuminated dial on top. A cardboard shield kept the light from the dial from the subject. Attached to the front of the box containing the Strobotac was a tunnel 14 inches long into which the subject was to look. The edges of the open end of the tunnel were covered with sponge rubber. Both tunnel and box were tilted to an angle of about 30 degrees to permit the subject to look into the tunnel without strain. Tunnel and box were painted black inside and outside. Between the tunnel and the box was a piece of translucent milk glass, all of which was painted black except a circle of three-fourths of an inch in diameter in its center. In addition there was a narrow slot in which were two pieces of cardboard. One piece, placed immediately in front of the milk glass, covered the face of the glass except for a hole in the center three-fourths of an inch in diameter. A second piece of cardboard could be placed in front of or removed from in front of this opening to expose or cut off the illumination.

The subject was told to put his eyes up to the tunnel. The experimenter then pulled the covering card from the apparatus showing the subject the flickering Strobotac light through the three-quarter inch opening. The experimenter then said,

> You notice that this light is flickering. When I turn the knob here on the side, the light gradually stops flickering until it gets to the point where it stops flickering completely. Then, if I turn the knob the other way, it begins to flicker again. (Turning the knob to the point of maximum flicker) Now I want you to turn this knob until the light just stops flickering.

The experimenter then placed the subject's left hand on the knob and the subject adjusted the Strobotac to the point where the light

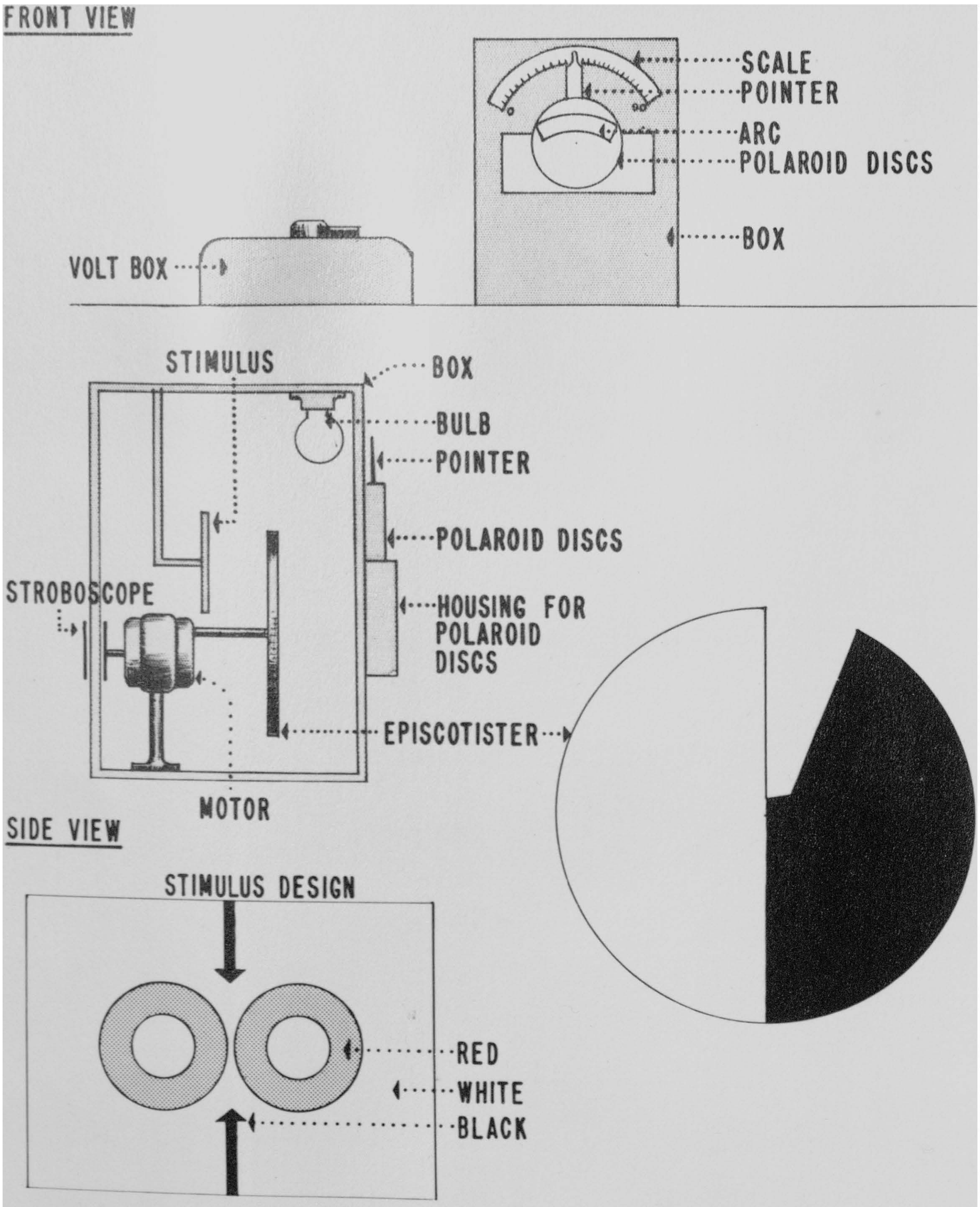

FIG. 4
AFTER-IMAGE THRESHOLD APPARATUS
(AFTER LEHMANN (32))

appeared to stop flickering. The experimenter then covered the light with the cardboard, recorded the reported experience from the dial, which indicated revolutions per minute, turned the knob to the highest fusion point, and said,

> Now adjust the knob to the point where the light just begins to flicker.

Again the subject adjusted the knob, the experimenter covered the light, read the dial and readjusted the knob. Five such readings were taken of flicker and five of fusion.

After-Image Threshold: Following the lead of Bidwell (7) and Lehmann (32), an episcotister was constructed for the measurement of the after-image threshold. From a half-black, half-white disc, 10 inches in diameter, a sector of 30 degrees was cut out to serve as window. Behind the disc, in the center of a white cardboard six inches long by five inches high, were two red circles, side by side. The circles were one and one-half inches in diameter and one-half inch wide with white centers. Both disc and card were illuminated by a 60-watt bulb above the two. A box, 18 inches high, $11\frac{1}{2}$ inches wide and $11\frac{1}{2}$ inches deep encased the entire apparatus. In the front of the box, a semi-circular arc two inches wide was cut. In the front of the arc were placed two polaroid discs four inches in diameter which could be rotated through an angle of 90 degrees. The center of the polaroid discs were eight and three-fourths inches from the top of the box. The handle by which the polaroid discs were manipulated also served as an indicator, pointing to a scale on which was calibrated degrees of angle. When the polaroid discs were placed at zero degrees, and the episcotister rotated at four cycles per second, the light reflected from the apparatus was at a maximum and the subject saw the green after-image of the two red circles. As the polaroid discs were rotated by the experimenter in the direction of 90 degrees, the light was gradually dimmed and the stimulus regained its original red color. When the polaroid discs were again rotated in the direction of 0 degrees, the green after-image reappeared. Thus two values were obtained: 1) the after-image or green threshold, and 2) the after-image disappearance or red threshold. The speed of the episcotister was controlled by a Voltbox (Superior Electroc Co.) so that it remained constant at four cps, which was found to be the most suitable speed under the present experimental conditions. A stroboscopic effect for control of speed was provided by a small black wheel with a yellow sector which was attached to the back of the motor revolving the episcotister and which could be seen through a three and one-half inch opening in the back of the box.

After having completed the flicker-fusion tests, which usually took less than 10 minutes, the subject took the chair next to the one in which he had been sitting, placed his chin on a chin rest 24 inches from the episcotister, and the light in the episcotister was turned on, the polaroid discs being at zero. The rest of the laboratory was still dark. The experimenter said:

> You will note that there are two green circles here. However, as I turn this (doing so) they grow darker and finally turn to dark red. Then when I turn this back the other way they become green again. Now, I want you to tell me at what point the circles become completely red.

The experimenter then turned the polaroid discs slowly until the subject indicated that the turning point had been reached. The

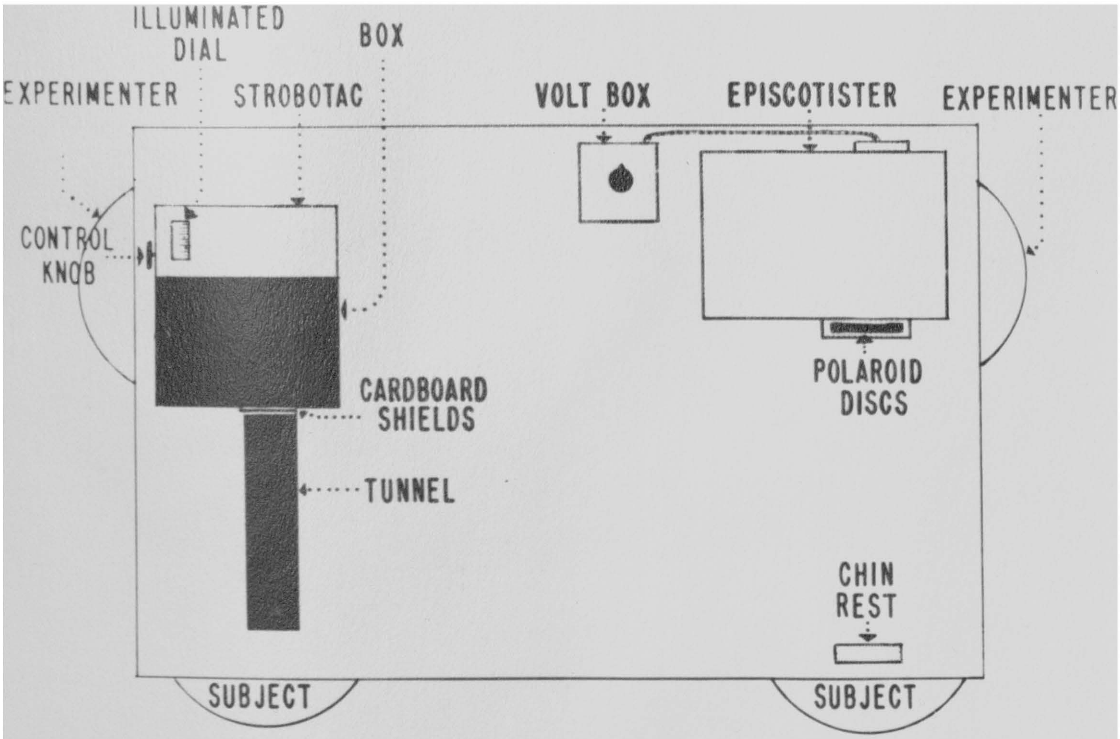

FIG. 5

DIAGRAM OF EXPERIMENTAL ARRANGEMENT FOR FLICKER-FUSION AND AFTER-IMAGE THRESHOLD experimenter then illuminated the scale from which the readings were taken with a tiny flashlight, shielding the scale so that the subject could not see it. When the measurement was recorded, the experimenter turned the dial to 90 degrees and said:

> Now I want you to tell me at what point the circles become completely green again."

The experimenter then turned the dial in the direction of zero degrees until the subject indicated that the circles were green, read the measurement and started from zero degrees again.

Five readings of the after-image threshold (green) and five readings of the after-image disappearance threshold (red) were taken in this manner. Usually these could be done in about five minutes.

This procedure completed the experimental tests.

CHAPTER III

RESULTS

The data of the after-image duration experiment are contained in detail in Table I. Subjects in this and subsequent tables and figures are numbered in the order of their mean after-image duration, the subject with the longest mean duration being number 1. The data of the flicker and fusion experiment are contained in Tables II and III, respectively. Table IV contains the after-image threshold data and Table V the data on the after-image disappearance threshold.

Data on age, I.Q., and the scores on the MMPI are presented in Table VI. The L, K, and F scores on the MMPI are not presented because all, with only minor exceptions, fell within the normal range. Only Subject 20 had an L score above 60 and that was only 63. No K score fell below 40 and only one, that of Subject 23, fell above 70 at 74. No F score fell above 60. The scores which appear in Table VI are therefore valid scores.

If the scores in Table VI were normally distributed, seven of them would be expected to fall two sigmas from the mean (below 30 or above 70). Actually five scores do so, and of the five, three fall in the Mf scale, which is primarily an interest scale. It may be safely said, then, that the scores in Table VI are derived from a population which is essentially free of psychopathology, as far as this test is concerned.

From Table I it can be seen that there are wide variations in after-image duration among the 26 subjects on each of the ten trials, especially on the first trial, and in the mean durations for the ten

TABLE I

AFTER-IMAGE DURATION IN SECONDS OF 26 SUBJECTS FOR TEN TRIALS
(Stimulus Duration = 50 seconds)

Sub-ject	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10	Mean	S.D.
1	71.18	55.15	51.15	43.80	43.62	45.24	44.22	26.92	32.03	33.13	44.49	3.85
2	71.53	36.75	46.48	39.04	42.42	31.15	21.15	22.81	25.58	21.57	35.85	14.68
3	81.45	34.34	22.48	31.03	34.61	28.61	25.03	25.19	30.15	17.79	33.07	16.88
4	41.89	31.10	25.21	27.92	24.70	24.89	25.67	23.54	25.79	19.25	27.00	5.70
5	90.90	27.55	18.90	19.87	14.49	14.19	21.50	15.94	21.61	16.72	26.17	21.90
6	41.19	15.10	27.43	25.99	30.17	23.61	21.08	18.91	27.14	22.88	25.35	6.44
7	22.20	21.04	27.68	29.71	29.24	24.93	21.87	25.06	22.61	23.00	24.73	3.02
8	52.17	15.69	15.59	30.61	21.48	21.91	27.37	20.29	17.84	21.23	22.86	12.45
9	42.72	21.74	15.82	24.44	16.49	17.47	16.04	23.95	15.88	22.37	21.69	7.75
10	44.25	29.93	19.07	17.61	20.79	19.70	19.01	11.27	18.85	15.42	21.59	8.76
11	82.07	19.68	15.58	15.27	10.08	11.71	13.07	11.70	10.94	11.05	20.12	20.82
12	22.32	10.33	17.42	18.75	15.87	18.46	18.31	22.67	17.76	13.35	17.52	3.54
13	20.94	19.64	21.15	13.73	17.59	15.02	12.74	22.17	15.42	14.39	17.28	3.28
14	35.57	19.46	18.71	16.68	17.25	15.02	15.66	9.91	8.20	13.14	16.96	7.08
15	33.67	18.86	19.53	14.22	11.16	13.03	12.56	16.48	9.67	6.68	15.59	7.10
16	29.06	24.44	17.29	11.19	13.15	17.05	7.46	13.97	9.87	11.24	15.47	6.43
17	6.19	13.71	12.24	11.46	15.38	16.49	19.17	14.37	19.80	13.23	14.20	3.74
18	19.29	15.40	17.63	16.55	13.49	10.13	11.03	13.20	9.64	11.14	13.75	3.17
19	28.24	18.77	14.48	12.53	10.94	12.16	7.78	11.46	3.12	15.86	13.53	6.21
20	26.54	7.40	3.67	5.08	17.90	17.41	16.03	10.77	7.87	15.39	12.81	6.72
21	30.45	15.56	9.56	8.20	10.78	9.32	13.24	8.05	10.11	8.54	12.38	6.43
22	11.68	11.80	15.64	13.21	11.27	12.63	8.39	14.58	12.04	9.26	12.05	2.06
23	16.45	11.31	15.57	14.54	12.67	11.27	7.61	8.92	8.71	12.33	11.94	2.82
24	18.79	19.58	7.06	14.77	16.73	6.41	8.96	8.43	10.29	8.01	11.90	4.80
25	17.40	13.04	5.78	5.44	11.32	11.83	9.73	6.72	8.71	11.04	10.10	3.48
26	5.08	11.31	6.89	6.97	6.79	9.10	12.18	9.35	17.81	14.78	10.03	3.79
Mean	37.05	20.71	18.76	18.77	18.86	17.64	16.80	16.02	16.06	15.49	19.62	
S.D.	23.76	10.12	16.32	7.83	9.56	8.25	7.99	6.22	7.83	5.83	13.02	

TABLE II

FLICKER THRESHOLDS IN R.P.M. OF 26 SUBJECTS FOR FIVE TRIALS
(Multiply each figure x 100)

Subject	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	S.D.
1	23.1	20.0	20.4	19.7	16.8	20.00	2.00
2	23.6	23.5	22.6	22.6	21.2	22.70	.27
3	15.4	15.0	16.2	14.1	14.3	15.00	.24
4	33.8	34.2	35.1	35.2	33.0	34.26	.25
5	32.5	31.6	28.2	28.6	28.6	29.90	1.78
6	28.4	25.2	20.5	20.2	22.0	23.26	3.10
7	31.8	30.8	32.9	32.8	35.4	32.74	1.53
8	34.1	30.8	29.8	30.1	30.1	30.98	1.59
9	23.1	21.0	20.1	19.9	20.2	20.86	1.17
10	24.9	23.4	25.1	24.9	23.6	24.38	.23
11	26.5	24.5	25.0	24.5	24.0	24.90	.27
12	32.7	27.4	25.6	24.0	27.7	27.48	2.92
13	32.0	30.5	29.3	28.1	34.8	30.94	2.32
14	24.5	28.2	27.3	25.7	26.8	26.50	1.28
15	23.4	21.6	22.9	24.0	24.5	23.28	1.00
16	32.0	33.0	27.9	27.1	30.8	30.16	2.29
17	24.0	23.8	23.4	23.4	21.3	23.18	.28
18	37.0	33.9	32.6	33.5	34.0	34.20	1.48
19	22.3	21.7	22.0	21.8	22.2	22.00	.22
20	34.1	30.3	31.7	28.4	32.9	31.48	1.98
21	32.6	30.5	28.5	29.4	29.5	30.10	1.40
22	22.8	24.1	24.6	24.4	23.7	23.92	.29
23	25.2	24.5	24.5	23.5	22.9	24.12	.25
24	30.1	30.3	29.5	28.6	29.3	29.56	.19
25	31.0	29.1	27.5	26.1	27.3	28.20	1.69
26	28.9	27.0	29.2	31.0	29.9	29.20	1.31
Mean	28.1	26.8	26.2	25.8	26.4	26.67	
S.D.	4.9	4.5	4.7	4.8	5.6	4.66	

TABLE III

FUSION THRESHOLDS IN R.P.M. FOR 26 SUBJECTS FOR FIVE TRIALS
(Multiply each figure x 100)

Subject	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	S.D.
1	21.0	21.8	22.9	23.2	22.5	22.28	.25
2	25.4	23.0	22.3	22.7	21.9	23.06	1.22
3	15.5	15.5	16.6	16.3	16.8	16.04	1.87
4	27.3	27.4	28.3	28.2	30.4	28.32	1.11
5	26.1	28.7	26.3	26.1	26.5	26.74	.21
6	22.4	22.9	22.2	22.4	22.3	22.44	.24
7	29.9	28.6	30.2	32.4	35.4	31.10	3.49
8	32.5	32.3	30.4	29.9	30.9	31.20	1.02
9	17.2	19.3	19.3	19.5	19.3	18.92	.27
10	24.4	24.5	24.8	24.7	24.3	24.54	.20
11	19.4	21.9	21.8	22.8	22.5	21.68	1.20
12	23.3	24.9	24.1	24.8	23.4	24.10	.21
13	24.3	21.7	21.3	22.8	21.5	22.32	1.11
14	22.9	23.5	23.0	24.8	23.6	23.56	.21
15	26.6	23.0	23.5	23.8	24.3	24.24	1.25
16	26.5	26.0	25.8	25.0	26.1	25.88	.50
17	19.7	21.2	21.7	21.9	20.7	21.04	.24
18	31.0	37.0	28.7	33.8	35.0	33.10	2.93
19	20.8	21.0	21.8	21.9	22.1	21.52	.16
20	31.3	30.0	29.3	27.6	27.6	29.16	1.42
21	27.1	24.5	24.2	23.8	23.5	24.62	4.06
22	16.9	19.5	19.4	20.0	19.0	18.96	1.07
23	18.4	23.2	24.0	25.0	22.7	22.66	2.47
24	24.2	26.9	26.8	25.5	26.5	25.98	1.01
25	22.0	23.4	23.1	22.0	22.1	22.52	.19
26	25.1	26.5	24.2	24.1	25.4	25.06	.27
Mean	23.9	24.5	24.1	24.4	24.5	24.19	
S.D.	4.4	4.6	3.1	3.6	4.2	4.36	

TABLE IV

AFTER-IMAGE THRESHOLDS (In degrees of arc) OF 26 SUBJECTS FOR FIVE TRIALS

Subject	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	S.D.
1	57.5	45.0	49.0	42.5	47.5	48.30	5.10
2	47.0	52.0	44.0	44.0	45.5	46.50	2.96
3	35.5	27.5	35.0	29.0	36.0	32.60	3.59
4	45.5	35.5	43.0	42.5	40.5	41.40	3.35
5	51.5	49.5	52.5	49.0	43.5	49.20	3.12
6	35.5	41.0	35.0	34.0	35.5	36.20	2.46
7	63.5	60.0	64.5	61.5	65.0	62.90	1.88
8	23.0	24.0	27.0	28.0	38.0	28.00	5.32
9	47.0	44.5	46.5	50.5	54.0	48.50	3.36
10	52.0	49.5	44.5	45.0	44.0	47.00	3.17
11	34.0	22.0	20.0	30.5	21.5	25.60	5.58
12	41.0	51.5	45.5	46.0	42.5	45.30	3.61
13	39.0	37.0	35.5	36.0	33.5	36.20	1.80
14	39.0	34.5	40.5	45.5	39.0	39.70	3.52
15	11.5	18.5	9.0	9.0	16.0	12.80	3.82
16	51.0	55.0	59.0	49.0	35.5	49.90	7.97
17	44.5	56.5	56.0	57.5	57.5	54.50	4.98
18	41.5	39.0	42.0	43.5	58.0	44.80	6.75
19	50.0	40.0	46.0	33.5	33.5	40.60	6.61
20	43.5	14.5	40.0	37.0	43.0	35.60	10.80
21	50.0	40.0	48.5	47.5	47.0	46.60	3.45
22	35.0	41.0	46.5	39.0	48.0	41.90	4.80
23	41.0	26.5	37.0	37.0	39.5	36.20	5.08
24	57.5	53.5	52.5	54.5	55.0	54.60	1.68
25	44.5	45.5	55.0	50.0	55.5	50.10	4.59
26	44.5	46.0	42.0	47.0	40.0	43.90	2.57
Mean	43.2	40.3	42.9	41.8	42.8	42.26	
S.D.	5.3	12.2	4.6	10.7	11.0	10.10	

TABLE V

AFTER-IMAGE DISAPPEARANCE THRESHOLDS (In degrees of arc) OF 26 SUBJECTS FOR FIVE TRIALS

Subject	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	S.D.
1	56.5	47.0	49.5	55.5	61.5	54.00	5.17
2	59.5	70.0	46.5	58.0	56.5	58.10	6.79
3	63.0	57.5	54.0	55.0	65.0	58.90	4.36
4	60.5	68.0	65.5	68.0	61.0	64.60	3.27
5	69.5	61.0	62.5	62.0	68.5	64.70	3.55
6	65.5	59.0	56.0	60.5	59.0	60.00	3.11
7	86.0	86.0	84.5	83.5	86.0	85.20	1.02
8	46.0	44.0	33.0	40.0	54.0	43.40	6.91
9	83.0	73.5	77.0	75.0	81.0	77.90	2.99
10	66.0	64.0	60.5	58.0	59.0	61.50	3.03
11	75.5	79.5	80.5	81.5	83.5	80.10	2.65
12	73.5	65.5	61.0	67.5	65.5	66.60	4.05
13	68.0	67.5	62.0	67.5	67.5	66.50	2.25
14	54.0	55.5	53.5	53.5	58.5	55.00	1.90
15	45.0	44.0	45.0	47.5	37.0	43.70	3.54
16	66.0	69.0	77.5	70.5	63.0	69.20	4.88
17	66.0	66.5	68.0	73.0	73.0	69.30	3.09
18	83.0	75.5	79.5	74.5	73.0	77.10	3.63
19	50.0	54.0	57.5	49.5	55.0	53.20	3.04
20	77.5	82.0	63.5	69.0	63.0	71.00	7.58
21	51.0	51.0	50.0	54.5	56.5	52.60	2.47
22	60.0	70.0	56.0	58.5	58.0	60.50	4.91
23	53.0	59.5	49.5	66.0	56.0	56.80	5.66
24	71.0	71.5	72.5	66.0	65.5	69.30	2.94
25	69.0	66.5	62.0	53.0	53.0	60.70	6.67
26	52.5	64.5	67.5	54.5	67.0	61.20	6.40
Mean	64.2	64.3	61.3	62.3	63.3	63.19	
S.D.	11.4	10.8	3.9	7.5	10.3	9.60	

TABLE VI

AGE, I.Q., AND MINNESOTA MULTIPHASIC SCORES OF 26 SUBJECTS

Sub-ject	Age	I.Q.	Minnesota Multiphasic Hs+5k	D	Hy	Pd+4k	MF	Pa	Pt+1k	Sc+1k	Ma+2k
1	22	107	50	59	58	53	48	64	74	61	66
2	37	113	54	51	48	43	51	50	51	52	43
3	21	119	60	55	58	55	41	56	58	58	68
4	27	103	48	51	56	48	63	56	51	54	49
5	18	114	49	39	60	55	51	56	54	57	66
6	31	108	49	46	62	66	71	41	56	72	72
7	27	113	44	42	52	53	63	53	46	50	58
8	23	116	54	51	56	55	69	56	44	49	55
9	28	117	47	46	54	50	57	44	52	46	50
10	22	97	50	51	50	53	63	47	59	56	70
11	36	117	49	58	56	59	86	56	60	63	66
12	19	117	52	61	50	68	26	47	58	50	58
13	25	131	44	51	50	57	65	67	50	54	52
14	19	107	50	55	52	44	63	64	53	54	40
15	28	99	58	36	54	39	53	61	46	55	60
16	21	116	44	34	43	51	63	50	44	52	40
17	26	104	50	47	56	55	43	44	50	46	63
18	27	99	41	47	52	68	88	53	58	46	66
19	24	121	47	39	45	62	57	50	50	51	60
20	27	107	46	51	46	55	43	58	55	58	52
21	31	115	44	38	40	43	30	53	38	41	60
22	20	98	37	44	45	48	53	50	43	41	63
23	30	107	54	58	56	67	63	56	58	65	66
24	23	95	41	44	34	41	90	53	44	50	60
25	47	113	42	44	43	48	49	53	36	36	40
26	27	106	50	51	52	57	48	41	43	44	43
Mean	26.3	109.96	48.23	48.04	51.08	53.58	57.58	53.08	51.19	52.35	57.54
S.D.	6.7	8.48	5.24	7.18	6.46	8.02	15.39	6.27	7.97	7.80	7.08

trials. The longest after-image duration is that of Subject 5 on Trial 1, 90.90 seconds, and the shortest that of Subject 20 on Trial 3, 3.67 seconds. The mean after-image duration for all 26 subjects on all ten trials is 19.62 seconds.

From Figure 6 it can be seen that the typical curve for after-image duration for ten trials is hyperbolic, sloping sharply from the first trial to the second, sloping less sharply from Trial 2 to Trial 3, maintaining a plateau over Trials 3 to 5 and then sloping asymptotically for the remaining trials. This curve is the inverse of the usual learning curve in that the optimal performance here occurs on the first trial. The subject's after-image duration, as a rule, does not increase, but more likely decreases after the first trial, suggesting the probability that inhibiting factors come into play and their effects cumulate as the trials progress.

Figure 7, which contrasts the mean after-image duration curves of the 13 subjects with the longest mean after-image duration for 10 trials and the 13 subjects with the shortest mean after-image duration for 10 trials, indicates that the two groups differ most sharply in the mean duration of the first after-image, although the mean level which the longer after-image duration subjects maintain is consistently higher than that of the shorter after-image subjects.

Table I indicates also that there tends to be less variation among the subjects as the trials progress and this is borne out further by Figure 8.

Figure 8 indicates that there is a characteristic curve for each subject. It emphasizes further that the duration of the initial after-image and the rate of decrease between the first and second

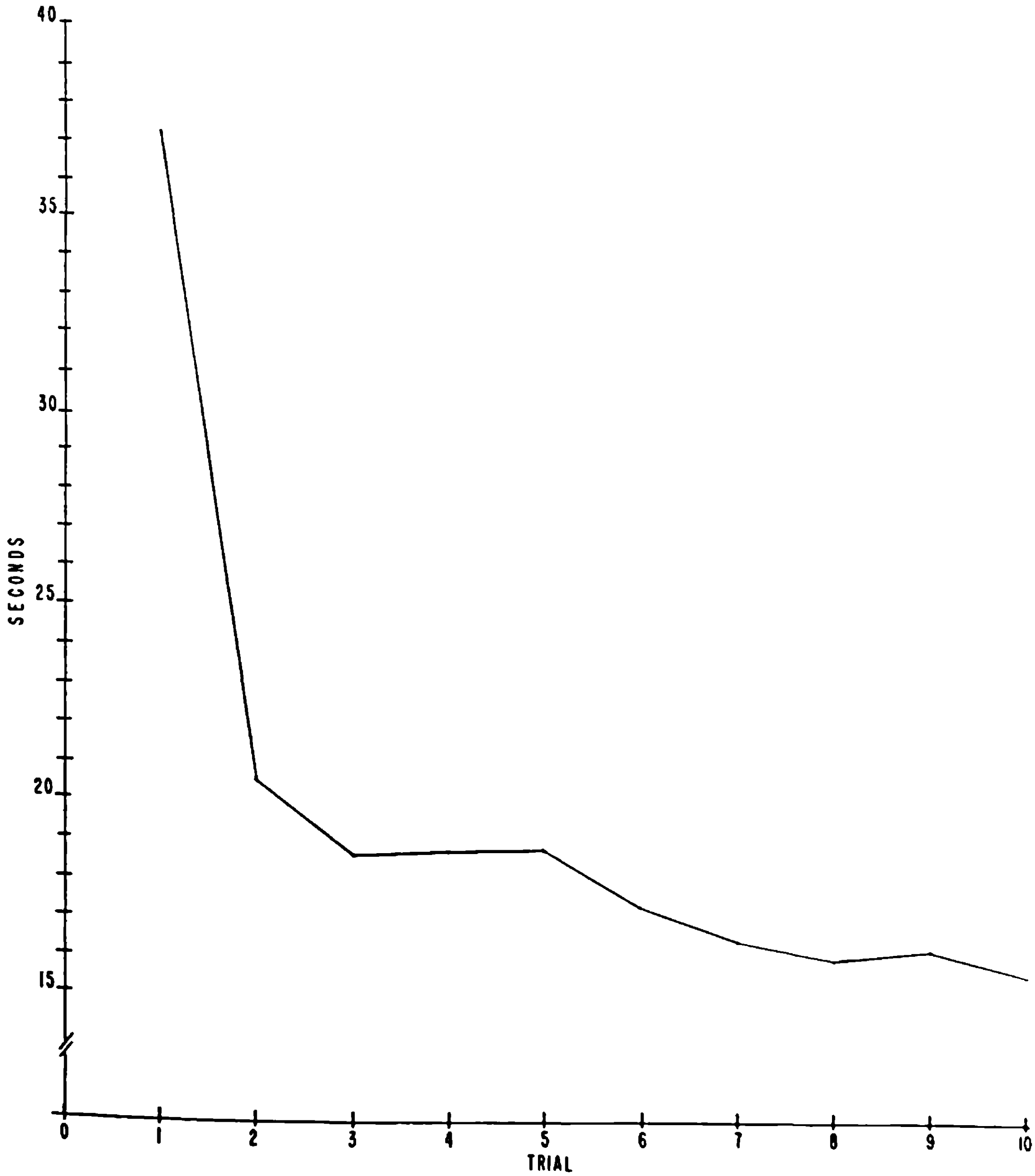

Figure 6
Mean after-image durations of 26 subjects for 10 trials.
(Stimulus Duration = 50")

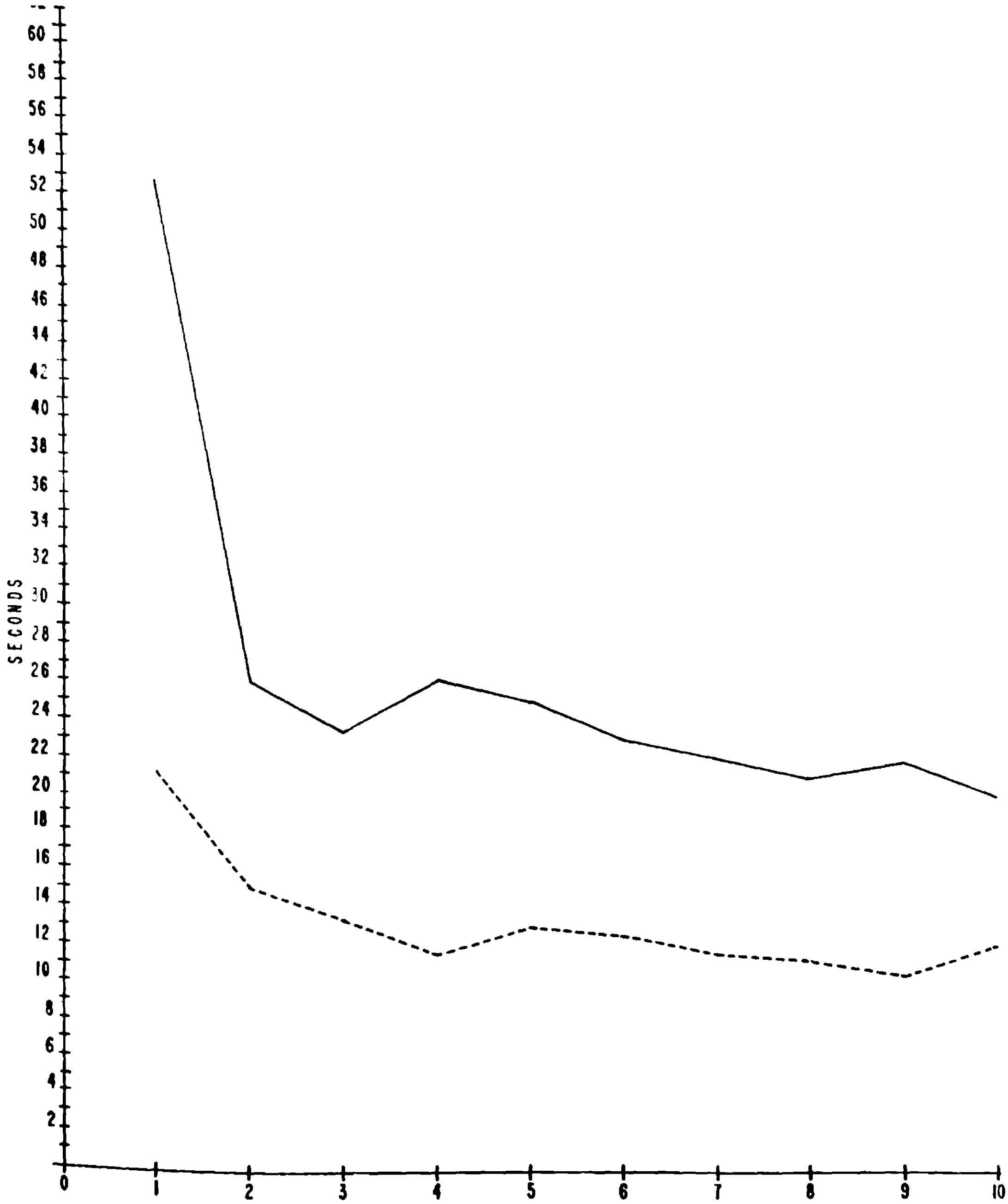

Figure 7
Mean after-image durations in seconds for 10 trials of 13 subjects with long mean after-image durations and 13 subjects with short mean after-image durations. (Stimulus Duration=50")

KEY
Mean of long mean AID subjects ━━━
Mean of short mean AID subjects ┅┅┅

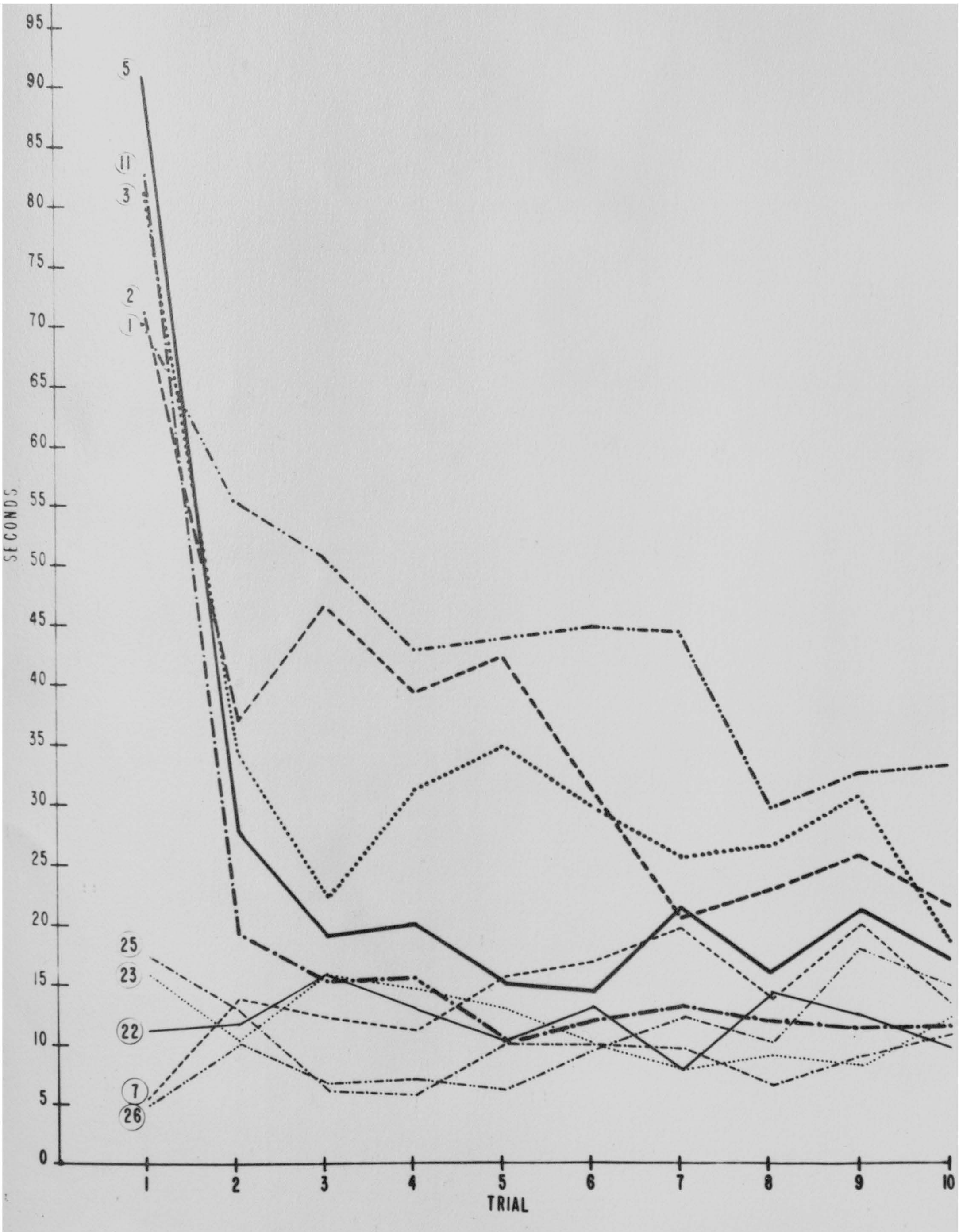

Figure 8
After-image durations for 10 trials of 5 subjects with longest initial durations and 5 subjects with shortest initial durations. (Stimulus Duration = 50")
(Circled numbers identify subjects)

KEY
Highest ▬▬ Lowest ——

after-image are significant aspects of the after-image phenomenon, and that it is in the first trial that the greatest variation among subjects occurs. For some subjects, however, the initial after-image differs little in duration from the other nine images; for other subjects the initial after-image is shorter than the remaining images.

Figure 8 demonstrates in another way what Figure 7 also shows. In Figure 8 the curves illustrative of those five subjects with the longest initial after-images differ markedly from those of the five subjects with the shortest initial after-images, the latter curves tending to approach a flat straight line in contrast to the hyperbolic curves of the former.

Efforts to quantify the relationship between the initial after-image and the remaining images by computing an index of after-image duration for each subject yielded no measure which was more meaningful and discriminating than the mean duration of the ten trials.

To determine the relationship of the duration of the negative after-image to the other variables followed in this study, the subjects were divided into two groups, the 13 having the longest mean after-image durations and the 13 having the shortest mean after-image durations. The differences between the means of these two groups on the other variables followed were then tested for their significance. Table VII illustrates these differences and their significance. In Table VIII are listed the Pearson product moment correlations between after-image duration and the other variables.

From Table VII it can be seen that of all the procedures used, only the Hy scale of the MMPI yielded highly significant differences

TABLE VII

SIGNIFICANCE OF DIFFERENCES BETWEEN 13 SUBJECTS WITH LONGEST MEAN AFTER-IMAGE DURATIONS AND 13 SUBJECTS WITH SHORTEST MEAN AFTER-IMAGE DURATIONS ON OTHER VARIABLES

Variable	Mean of Subjects With Long Mean AI Durations (N=13)	Mean of Subjects With Short Mean AI Durations (N=13)	Difference	t	P
I.Q.	108.6	106.7	1.9	.51	-----
Age	25.8	27.1	1.3	.56	-----
Flicker	25.9	27.3	1.4	.75	-----
Fusion	23.9	24.7	0.8	.51	-----
After-Image Threshold	42.2	41.8	0.4	.09	-----
After-Image Disappearance Threshold	64.8	61.5	3.3	.84	-----
Minnesota Multiphasic					
Hs + 5k	50.0	46.5	3.5	1.76	-----
D	50.8	45.2	5.6	2.09	5%
Hy	54.6	47.5	7.1	3.24	<1%
Pd + 4k	55.0	52.2	2.8	.99	-----
MF	58.0	57.2	0.8	.14	-----
Pa	53.3	52.8	0.5	.19	-----
Pt + 1k	54.8	47.5	7.3	2.55	2%
Sc + 1k	55.5	49.2	6.3	2.39	5%
Ma + 2k	59.5	54.8	4.7	1.21	-----

TABLE VIII

PRODUCT MOMENT CORRELATIONS OF MEAN AFTER-IMAGE DURATION WITH OTHER VARIABLES FOR 26 SUBJECTS

Variable	Correlation With Mean After-Image Duration	P
I.Q.	.17	-
Age	-.08	-
Flicker	-.38	appr.5%
Fusion	-.06	-
After-Image Threshold	.09	-
After-Image Disappearance Threshold	.23	-
Minnesota Multiphasic		
Hs/ 5k	.44	5%
D	.33	-
Hy	.53	1%
Pd/ 4k	-.05	-
MF	-.07	-
Pa	.26	-
Pt/ 1k	.59	1%
Sc/ 1k	.45	5%
Ma/ 2k	.15	-

(P= <1%) between subjects with long mean after-image durations and subjects with short mean after-image durations, although the Pt scale yielded differences which may be accepted as significant (2% level). The D scale and the Sc scale yielded differences significant at the 5% level, a finding not unexpected inasmuch as Sc is known to be correlated with Pt (r=+ .83 among normal cases in the validation population) and high D scores are often found with high Hy scores (37)).

When each of the other experimental variables was correlated with after-image duration (Table VIII), correlations, significantly different from zero at the 1% level, were found between after-image duration and both the Hy and Pt scales, respectively +.53 and +.59. MMPI scales Hs and Sc yielded correlations of +.44 and +.45, significantly different from zero at the 5% level. The relationship between Sc and Pt has been noted above. Hs is also frequently found to vary positively with Hy (r=+.52 among normal cases in the validation population); Hs, D, and Hy are sometimes referred to as the "neurotic triad" (60).

When the after-image duration curves of the five subjects who had the highest Hy scores and those five subjects who had the lowest Hy scores were plotted as in Figure 9, little overlap was evident between the two groups. For the most part the curves of the high Hy subjects are marked by very long initial after-images, followed by a sharp decrease in duration for the remainder of the images. But even the shorter durations of the Hy subjects on Trials 2 to 10 are in general longer than those of the low Hy subjects. These differences become even more marked if only the three highest and lowest subjects are compared. The same general observations may be made of Figure 10 in which the after-image duration curves of subjects high and low on Pt

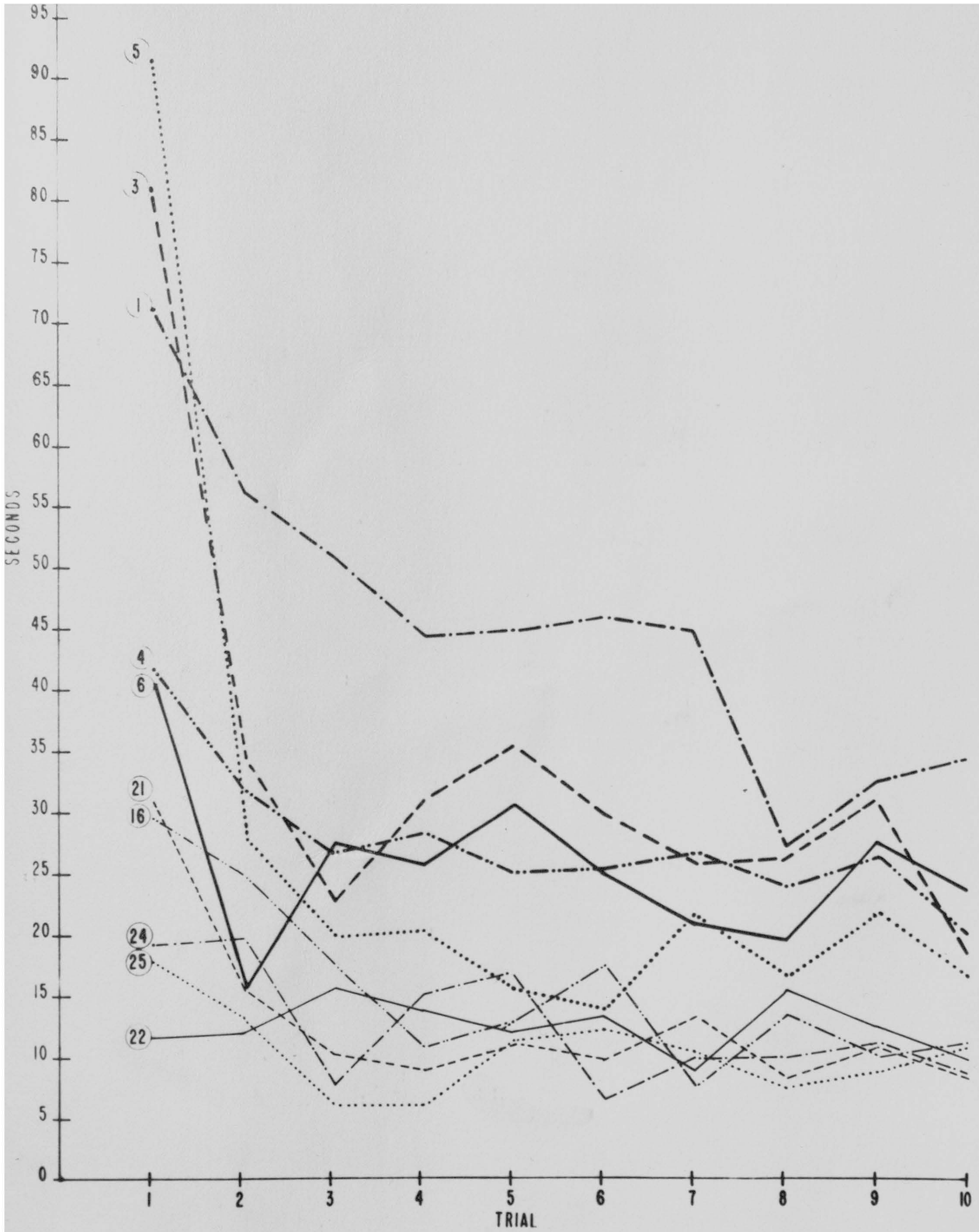

Figure 9
After-image durations of 5 subjects highest and 5 subjects lowest on MMPI Hy Scale. (Stimulus Duration = 50"). (Circled numbers identify subjects)

KEY
Highest ▬▬ Lowest ——

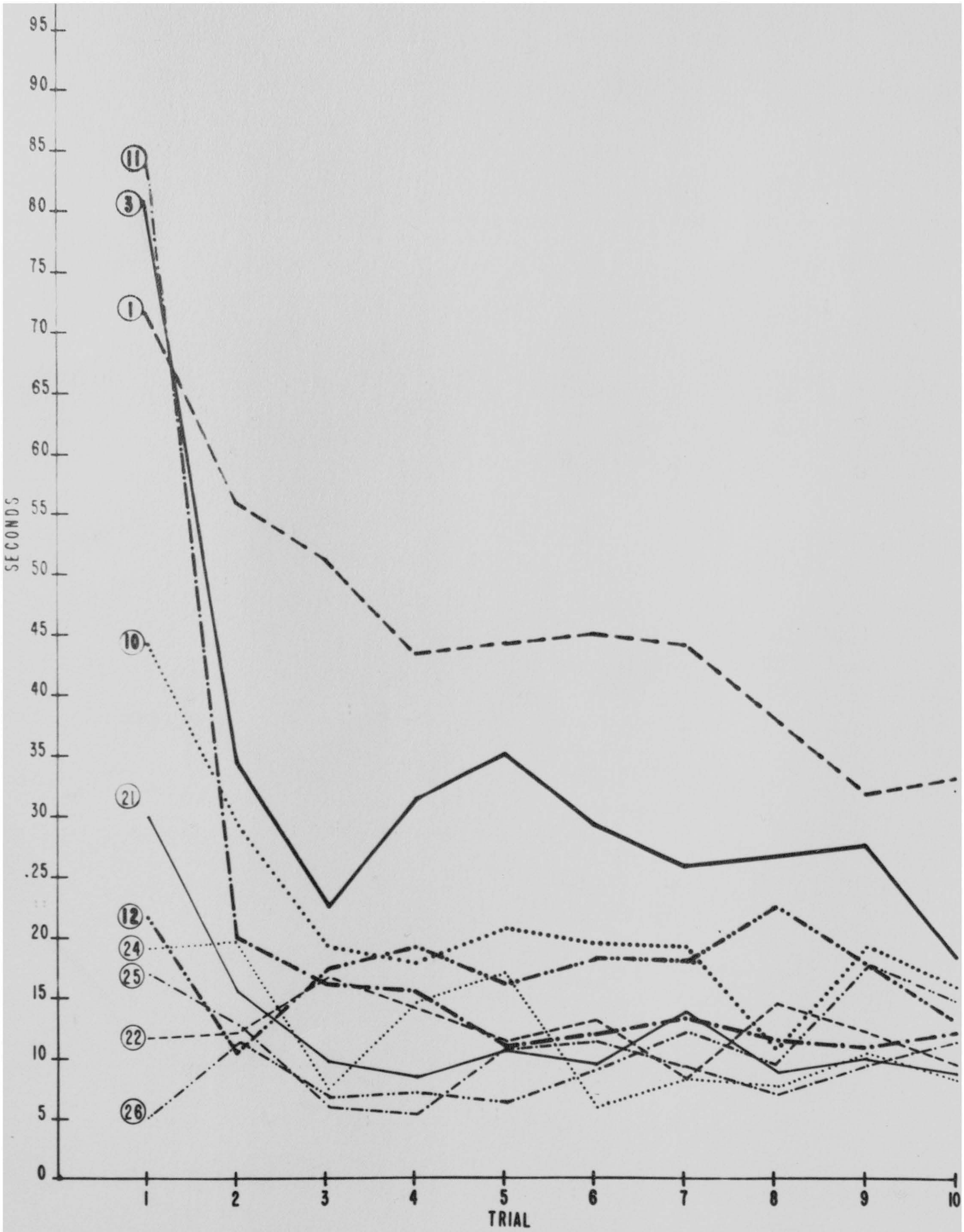

Figure 10

After-image durations for 10 trials of 5 subjects highest and 5 subjects lowest on MMPI PT Scale. (Stimulus Duration = 50")
(Circled numbers identify subjects)

KEY
Highest ▬▬ Lowest ——

are plotted, except that there tends to be slightly more overlapping on the Pt scale between the two groups and a wider variation among the subjects high on Pt.

Inasmuch as the most significant differences and most significant correlations were found to be between after-image duration and the Hy and Pt scales, item analyses of these two scales were done. These analyses are found in Tables IX and X, respectively.

Subjects with long after-image durations yielded a total of 236 answers in the direction of high Hy scores, while subjects with short after-images answered 195 times in that direction. On the Pt scale, subjects with long after-image durations gave 127 replies in the direction of high Pt scores in contrast to 103 answers by those with short after-image durations.

Further analysis of the questions disclosed that on the Hy scale, Questions 6, 12, 71, 129, 160, 163 and 201 distinguished between the long after-image duration group and the short after-image duration group on the basis of an arbitrarily adopted criterion of a difference of three answers on each question between the groups. On the Pt scale, Questions 36, 94, 152, 159, 183, 217, 337, 356, and 362 distinguished between the two groups on the same basis.

When the differences between the two groups in the numbers of answers each group gave to the respective questions were subjected to a chi square test corrected for discontinuity, a rigid test with a large correction factor which did not allow precision, only three of the questions, 129, 160 and 183 differentiated between the two groups at the 5% level of confidence as Table XI shows. By chance, from a total of 97 questions of the Hy and Pt scales five questions might

TABLE IX

ANALYSIS OF ANSWERS ON MMPI HY SCALE GIVEN BY 26 SUBJECTS

QUES-TION	KEY ANS.	LONG MEAN AFTER-IMAGE SUBJECTS													SHORT MEAN AFTER-IMAGE SUBJECTS													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
2	F												X												X		
3	F														X							X					
6	F	X		X			X		X	X		X						X	X					X			
7	F	X									X		X			X						X					
8	F												X	X				X									
9	F															X											
10	T	X																									
12	F	X		X	X	X	X	X	X			X	X		X	X			X	X				X			
23	T		X																				X				
26	F	X	X				X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X		X
30	F																				X						
32	T					X															X						
43	T		X																								
44	T																										
47	T	X	X																								
51	F								X																		
55	F	X											X			X							X				
71	F	X		X	X							X															
76	T																										
89	F		X	X	X		X	X				X			X	X					X	X		X	X		X
93	F	X	X		X	X		X	X		X	X		X	X	X	X		X		X		X			X	X
103	F	X																									
107	F								X				X														
109	F	X			X	X	X	X				X		X	X		X	X	X		X					X	X
114	T			X																							
124	F		X	X	X	X		X	X		X	X		X	X	X	X		X		X	X		X		X	X
128	F									X		X						X			X				X		
129	F		X	X	X	X	X	X	X		X	X	X				X			X				X	X		
136	F		X	X	X	X		X	X	X		X		X	X		X	X	X		X	X		X		X	X
137	F												X										X				
141	F					X			X			X	X		X		X	X					X				X
147	F			X	X	X	X	X		X		X			X		X		X	X			X	X			X
153	F																										
160	F	X			X	X						X	X														X
162	F		X	X	X	X		X	X	X	X			X	X	X	X	X		X	X		X	X			X
163	F		X	X	X		X			X		X				X											
170	F	X		X	X	X	X			X			X	X	X	X	X	X	X	X		X		X		X	X
172	F					X		X	X	X	X			X			X			X				X		X	
174	F	X				X	X		X		X	X	X		X	X		X				X		X			
175	F	X																				X					
179	T						X								X												
180	F	X	X	X		X	X	X		X	X			X			X	X	X	X	X	X				X	X
186	T	X																X									
189	T			X																							
190	F						X																				
192	F															X											
201	F		X				X	X	X	X				X			X			X							
213	F		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
230	F															X		X									
234	F			X	X	X	X		X		X						X	X	X	X				X	X		
238	T	X									X	X											X				
243	F														X												
267	F	X		X		X	X	X	X	X	X			X			X	X	X	X	X	X	X	X		X	X
274	F		X								X			X	X	X		X				X					X
279	F	X		X	X	X	X	X	X	X	X		X	X	X	X	X		X	X	X		X	X		X	X
289	F		X	X	X	X	X	X	X							X			X					X	X		X
292	F		X	X	X	X	X	X		X	X		X	X		X	X	X	X	X		X	X			X	X
TOTALS		20	18	20	18	21	19	19	18	16	16	18	17	16	17	19	18	18	16	13	14	14	13	17	8	11	17
GRAND TOTAL														236													195

TABLE X

ANALYSIS OF ANSWERS ON MMPI PT SCALE GIVEN BY 26 SUBJECTS

QUES-TION	KEY ANS.	LONG MEAN AFTER-IMAGE SUBJECTS 1	2	3	4	5	6	7	8	9	10	11	12	13	SHORT MEAN AFTER-IMAGE SUBJECTS 14	15	16	17	18	19	20	21	22	23	24	25	26
3	F														X							X					
8	F												X	X				X									
10	T	X																									
15	T			X		X	X	X	X	X				X	X	X	X	X	X	X			X				
22	T																										
32	T					X															X						
36	F	X									X	X	X	X					X								X
41	T		X				X							X		X		X									
67	T	X				X						X				X			X	X		X					
76	T																										
86	T	X	X		X								X		X										X		
94	T	X	X	X									X						X								
102	T	X				X	X	X	X	X	X		X	X	X	X		X	X	X		X	X	X	X	X	X
106	T																										
142	T	X			X				X		X		X	X	X	X		X	X		X				X		
152	F		X	X						X	X		X									X					
159	T				X	X					X																
164	F																										
178	F																										
183	T											X			X		X	X	X	X		X					X
189	T			X																							
217	T	X	X	X			X				X					X						X					
238	T	X									X	X											X				
266	T	X																									
301	T	X							X																		
304	T	X		X	X				X	X	X	X	X		X		X				X		X		X	X	X
329	F	X	X				X				X	X	X	X		X	X	X				X	X				
336	T													X	X												
337	T																	X	X	X			X				
340	T	X								X	X		X	X		X		X	X				X	X	X		
342	T											X															
343	T		X				X				X		X	X			X	X			X						
344	T									X	X					X									X		
346	T										X				X			X									
349	T	X														X											
351	T																		X								
352	T										X	X		X	X				X								
353	F	X								X		X			X	X					X		X		X		
356	T		X	X							X																
357	T	X		X			X		X	X	X	X		X		X	X		X			X		X			
358	T										X				X												
359	T		X					X		X	X					X			X	X							
360	T																										
361	T	X											X	X		X			X				X				
362	T	X					X						X	X								X					
366	T																						X				
TOTALS		19	[illegible]	8	4	5	8	3	6	9	18	10	13	15	12	14	6	11	14	6	6	11	8	2	7	2	4
GRAND TOTAL														127													103

TABLE XI

SIGNIFICANCE OF THE DIFFERENCES ON 16 SELECTED ITEMS OF THE MMPI Hy AND Pt SCALES BETWEEN 13 SUBJECTS LONGEST AND 13 SUBJECTS SHORTEST IN MEAN AFTER-IMAGE DURATION

Question No.	No. of Answers in Direction of High Hy & Pt Scores (Long Mean AI Group)	No. of Answers in Direction of High Hy & Pt Scores (Short Mean AI Group)	Chi^2 (Corrected for discontinuity) (df=1)	P
6	6	3	.61	-
12	9	4	2.46	-
36	5	2	.78	-
71	4	0	2.73	-
94	4	1	.99	-
129	10	4	3.87	.05
152	5	1	1.95	-
159	3	0	1.51	-
160	5	0	3.96	$< .05$
163	6	1	3.13	.05-.10
183	1	7	4.51	$< .05$
201	6	2	1.62	-
217	5	1	1.95	-
337	0	4	2.66	-
356	3	0	1.51	-
362	4	1	.99	-

have been expected to differentiate significantly between the two groups.

The 16 questions, together with the appropriate reply for high Hy and Pt scores and the number of subjects in the long and short after-image groups who answered in that direction, were as follows:

6. I like to read newspaper articles on crime. (F) (6-3)
12. I enjoy detective mystery stories. (F) (9-4)
36. I seldom worry about my health. (F) (5-2)
71. I think a great many people exaggerate about their misfortunes in order to gain the sympathy and help of others. (F) (4-0)
94. I do many things which I regret afterwards (I regret things more or more often than others seem to. (T) (4-1)
129. Often I can't understand why I have been so cross and grouchy. (F) (10-4)
152. Most nights I go to sleep without thoughts or ideas bothering me. (F) (5-1)
159. I cannot understand what I read as well as I used to. (T) (3-0)
160. I have never felt better in my life than I do now. (F) (5-0)
163. I do not tire quickly. (F) (6-1)
183. I am against giving money to beggars. (T) (1-7)
201. I wish I were not so shy. (F) (6-2)
217. I frequently find myself worrying about something. (T) (6-1)
337. I feel anxiety about something or someone almost all the time. (T) (0-4)
356. I have more trouble concentrating than others seem to have. (T) (3-0)
362. I am more sensitive than most other people. (T) (4-1)

Question 183, the only one on the Pt scale which differentiated significantly was answered more frequently in the direction of a high Pt score by the subjects with short mean after-image durations than those with long mean durations, while Questions 129 and 160 from the Hy scale were answered more frequently by the long after-image duration group.

<u>Flicker and Fusion</u>: The data of the flicker and fusion experiment are contained in Tables II and III respectively. The mean flicker

threshold is 2667 r.p.m. with an S.D. of 466 r.p.m., the individual means ranging from 1500 r.p.m. to 3426 r.p.m. The mean fusion threshold is 2419 r.p.m. with an S.D. of 436 r.p.m., the individual means ranging from 1604 r.p.m. to 3310 r.p.m.

When the mean flicker threshold for the 26 subjects on each of the five trials was computed and the five means were plotted, and a similar curve was taken from the means of five fusion trials for the 26 subjects, the curve of the means of five flicker trials was seen to differ markedly in both shape and level from that of the means of the five fusion trials, as Figure 10A illustrates. Seen from another point of view, when a t-test of the difference in the means of the 26 subjects on flicker and fusion was computed (Table XII), the mean difference was found to be significant beyond the 1% level of confidence, as a result of which flicker and fusion were treated separately.

The fact that flicker thresholds tend to be higher than fusion thresholds was also reported by Knox (30), although he made no statistical test of the significance of the difference. Figure 11 indicates further that the higher the flicker threshold, the greater the difference tends to be between flicker and fusion levels.

The negative correlation of -.38, approaching significance at the 5% level, found (Table VIII) between after-image duration and flicker thresholds tend to confirm the previously stated expectation that such a correlation should occur if the after-image duration were dependent in part upon such psychophysiological thresholds.

<u>After-Image (Green) and After-Image Disappearance (Red) Thresholds:</u> These thresholds, because of their wide and significant

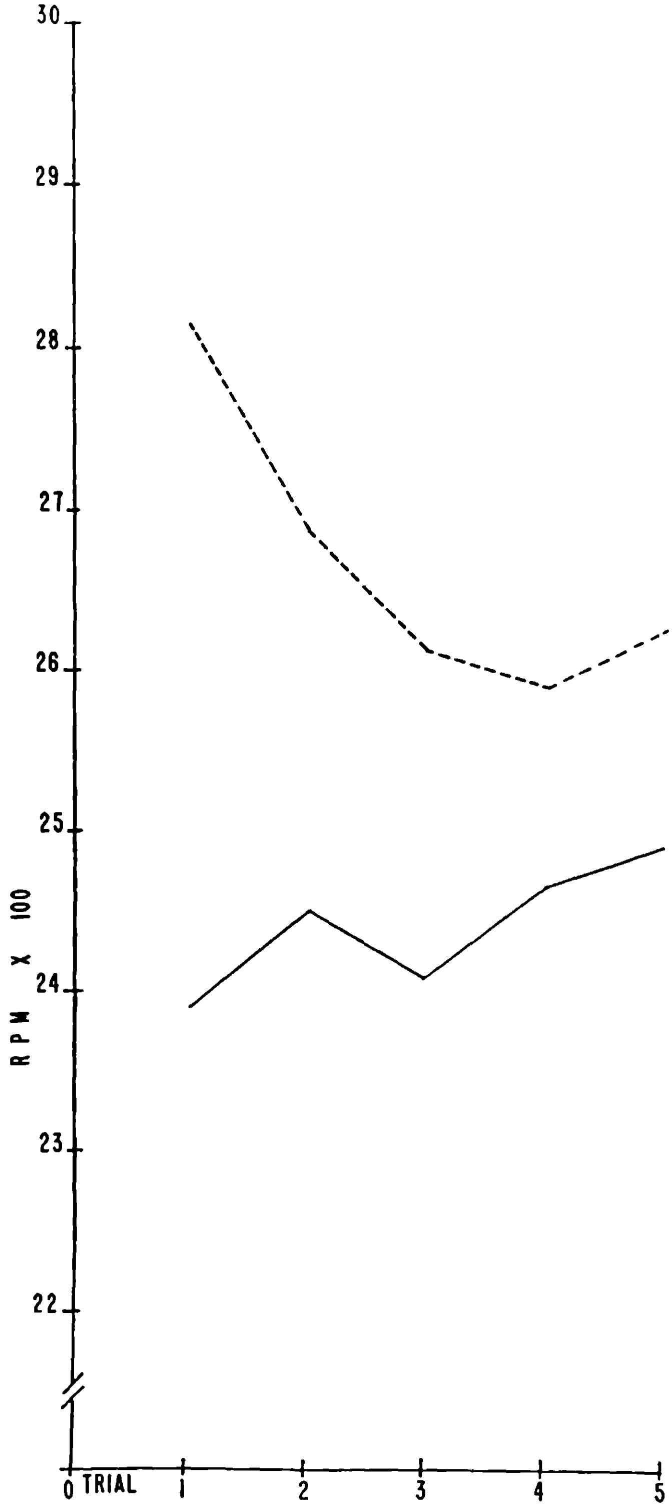

Figure 10A
Mean flicker and fusion thresholds of 26 subjects for 5 trials.
KEY
Flicker ······ Fusion —

TABLE XII

MEAN FLICKER-FUSION THRESHOLDS IN HUNDREDS OF R.P.M. OF 26 SUBJECTS FOR FIVE TRIALS

Subject	Mean Flicker Threshold	S.D.	Mean Fusion Threshold	S.D.
1	20.00	2.00	22.28	.25
2	22.70	.27	23.06	1.22
3	15.00	.24	16.04	1.87
4	34.26	.25	28.32	1.11
5	29.90	1.78	26.74	.21
6	23.26	3.10	22.44	.24
7	32.74	1.53	31.10	3.49
8	30.98	1.59	31.20	1.02
9	20.86	1.19	18.92	.27
10	24.38	.23	24.54	.20
11	24.90	.27	21.68	1.20
12	27.48	2.92	24.10	.21
13	30.94	2.32	22.32	1.11
14	26.50	1.28	23.56	.21
15	23.28	1.00	24.24	1.25
16	30.16	2.29	25.88	.50
17	23.18	.28	21.04	.24
18	34.20	1.48	33.10	2.93
19	22.00	.22	21.52	.16
20	31.48	1.98	29.16	1.42
21	30.10	1.40	24.62	4.06
22	23.92	.29	18.96	1.07
23	24.12	.25	22.66	2.47
24	29.56	.19	25.98	1.01
25	28.20	1.69	22.52	.19
26	29.20	1.31	25.06	.27
Mean	26.67		24.19	
S.D.	4.66		4.36	

Mean Difference (FL-FU) = 2.48
df = 25
t (correlated measures) = 4.62
P = $<1\%$

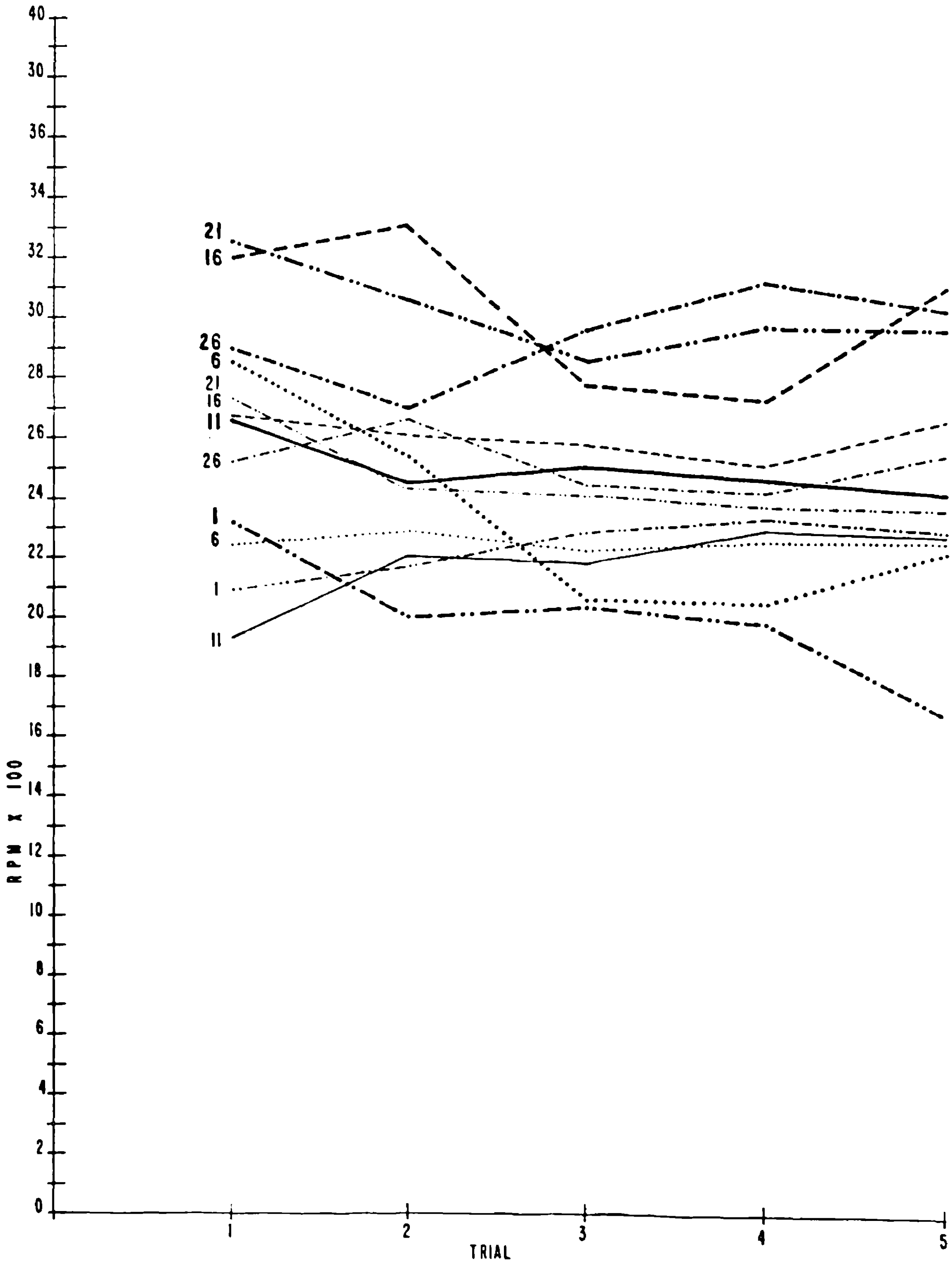

Figure II
Flicker and fusion thresholds for every fifth subject.
(Circled numbers identify subjects)
KEY
Flicker ▬ Fusion —

differences (Table XIII and Figure 12) were also treated separately. Table IV, containing the after-image threshold data, indicates that the mean after-image threshold is 42.26 degrees, S.D. 10.10 degrees, the individual means ranging from 12.80 degrees to 62.90 degrees. Table V shows the mean after-image disappearance threshold to be 63.19 degrees with an S.D. of 9.60 degrees, and the range of individual means from 43.40 degrees to 85.20 degrees. In both after-image (green) and after-image disappearance (red) thresholds, as in flicker and fusion and in after-image duration, characteristic individual differences in curves are apparent from inspection of the data.

The after-image threshold and the after-image disappearance threshold yielded insignificant correlations of +.09 and +.23 respectively, with after-image duration (Table VIII). Under the conditions of this experiment, therefore, no relationship can be said to have been shown between after-image duration and after-image threshold or after-image disappearance threshold.

Comparison of Tables V and VI with Tables II and III indicates that after-image thresholds tend to vary more widely intra-individually than do flicker and fusion thresholds and probably reflect greater error of measurement.

Discussion

Although significant differences were found on both the Hy and Pt scales of the MMPI between subjects with long and short mean after-image durations, the interpretations which can be made from these differences on the scales are somewhat limited because the literature

TABLE XIII

MEAN AFTER-IMAGE AND AFTER-IMAGE DISAPPEARANCE THRESHOLDS IN DEGREES OF ANGLE OF 26 SUBJECTS FOR FIVE TRIALS

Subject	Mean After-Image Threshold	S.D.	Mean After-Image Disappearance Threshold	S.D.
1	48.30	5.10	54.00	5.17
2	46.50	2.96	58.10	6.79
3	32.60	3.59	58.90	4.36
4	41.40	3.35	64.60	3.27
5	49.20	3.12	64.70	3.55
6	36.20	2.46	60.00	3.11
7	62.90	1.88	85.20	1.02
8	28.00	5.32	43.40	6.91
9	48.50	3.36	77.90	2.99
10	47.00	3.17	61.50	3.03
11	25.60	5.58	80.10	2.65
12	45.30	3.61	66.60	4.05
13	36.20	1.80	66.50	2.25
14	39.70	3.52	55.00	1.90
15	12.80	3.82	43.70	3.54
16	49.90	7.97	69.20	4.88
17	54.40	4.98	69.30	3.09
18	44.80	6.75	77.10	3.63
19	40.60	6.61	53.20	3.04
20	35.60	10.80	71.00	7.58
21	46.60	3.45	52.60	2.47
22	41.90	4.80	60.50	4.91
23	36.20	5.08	56.80	5.66
24	54.60	1.68	69.30	2.94
25	50.10	4.59	60.70	6.67
26	43.90	2.57	61.20	6.40
Mean	42.26		63.19	
S.D.	10.10		9.60	

Mean (AIDT-AIT) = 20.93
df. = 50
t = 2.39
P = $<2\%$

Figure 12
Mean after-image and after-image disappearance thresholds of 26 subjects for 5 trials.

KEY
After-image ——
After-image disappearance -----

literature on the MMPI yields little by way of description of the character structures of normal subjects who score high or low on these scales. With regard to the Pt scale, Meehl and Hathaway (46) say:

> ...It is...rather characteristic of psychasthenic persons to express high and often unattainable ideals of perfection and achievement; whereas at the same time they are prone to be excessively self-critical...

Of the hysteric subjects, Meehl (39) says only that the questions on the Hy scale indicate that these subjects think of themselves as being possessed of unusually good social and psychiatric adjustment. He reports further that the most potent items on the Hy scale for the detection of hysterics and hysteroid temperaments reflect the systematic distortion of the hysteric's conception of himself. The subjects on whom the scale was validated were selected on the basis of psychiatric diagnoses of hysteria which were based upon the classical hysterical symptomatology: belle indifference, lack of insight, facility of repression and dissociation, "impunitiveness" of reactions to frustration.

In their factor analysis of the MMPI scales of normal subjects, Wheeler, Little, and Lehner (60) found two major factors, one with its maximal loadings on Sc and Pt, and the other with its maximal loadings on Hy and K. The former factor they interpreted as indicating primarily concern with one's self. High loadings on the Sc and Pt scales seemed to them to reflect the encapsulating withdrawal of a schizoid type including excessive concern with compulsive needs. Of the Hy scale, they say only that

> ...This factor seems to reflect...the neurotic picture of adjustment...the ego defenses are intact...Perhaps one of these ego defensive mechanisms is indicated by the positive loading of .510 on the Pa scale. This suggests that the paranoid projections serve more as a neurotic defense in the normal group than as a component in the schizoid pattern indicated in Factor I.

From these considerations it may be at least tentatively concluded that subjects who score high on the Pt scale have high and exacting standards for themselves and at the same time they tend to depreciate their own efforts. In this experiment they would be expected to organize themselves around the experimental task, to accept the experimental directions and follow them as closely as they could, and to exert themselves in the performance of the task. Inasmuch as they are not likely to be satisfied with their performance of the task, especially since no definite goals are set by the investigator, it is probable that they would continue to exert themselves somewhat more than other subjects even when the task is no longer novel and their interest wanes.

Subjects who score high on the Hy scale may perhaps be said to be attempting to present to themselves and to people about them an idealistic picture of themselves. Their motivation to perform well, when they do, derives primarily from the people around them to whose demands and opinions they are attuned. In the experimental situation they would be expected to organize themselves around the experimenter, seeking to merit his approval by fulfilling the task he sets for them. In the laboratory, therefore, the hysterics, too, would be expected to accept the experimental directions, and carry them out as well as they could, and to sustain their effort more than other subjects.

It is not inappropriate, therefore, to consider that both groups of subjects, those who scored high on Pt and those who scored high on Hy, were motivated to remain in the experimental situation and that this kind of motivation reflected itself in the duration of the negative after-image when they were compared with other subjects whose mean age, mean I.Q., and visual acuity was not significantly different from their own, and who presumably were not so dependent upon the investigator or driven by their own standards.

Statistical analysis of the 16 questions from the Hy and Pt scales, which were arbitrarily chosen on the basis of a difference of three answers to each question between the groups, yielded only three questions which differentiated significantly between the long and short after-image groups. Five questions which differentiated significantly might have been expected to occur by chance in the two scales. Inferences from the three questions would therefore be highly questionable. Yet, since the two groups differed significantly on both scales, it is perhaps permissible to draw some speculative inferences from the 16 questions taken from both scales which offered the most promise of providing cues to the reasons for the differences.

Negative replies to Questions 6, 12, and 129, for example, suggest that the subjects who replied thus tend to repress their aggressions and to avoid aggressive stimuli; they are probably therefore more compliant in their relationships with others. Negative replies to Question 36 imply self-concern which in normals perhaps also includes concern about personal behavior. Negative replies to Questions 71 and 183 taken together with positive replies to Question 362, suggest sensitivity toward, feeling for and identification with others, a combination which might indicate that the behavior of the subjects involved is governed in a large measure by what they think others will think of them. Negative replies to Question 152, when seen together with positive replies to Questions 94, 217, and 356, suggest that the subjects who replied in that manner are very much concerned about what they have done or will do and that this concern is strong enough to be distracting on some occasions. Perhaps it would not be too far-fetched to assume that negative replies to Question 163 reflect the result of this conflict and concern--difficulty in sustaining interest and effort--since many of the noted replies to the five questions were given by the same subjects (see Tables IX and X).

It is interesting to note that Question 163 was answered negatively by almost half of the long after-image subjects and only one of the short after-image subjects, and further that the curve of the long after-image group in Figure 7 dropped much more sharply after the first trial than did that of the short after-image group. When this drop was pointed out above (p. 37) it was suggested that inhibiting factors might be at play. The self-depreciation of subjects high on the Pt scale might well result in a waning of interest and attention, and the long after-image subjects were seen to be higher on the Pt scale than short after-image subjects. Thus it is not unlikely that the "inhibiting factors" are waning of interest and attention.

Positive replies to Question 159 and negative replies to Question 160 would seem to fit into the self-depreciatory pattern described by Meehl and Hathaway. Negative replies to Question 201 might possibly be part of an effort to maintain an approved and acceptable front. Negative replies to Question 337 would seem to indicate that the subjects who replied negatively were relatively free from crippling anxieties.

More replies in the directions noted above were given by the long after-image group than the short after-image group. It might be said, then, that in general there appears to be a tendency for the subjects with long mean after-image durations to be more compliant, more concerned with themselves, their behavior and the fronts they present, more sensitive to the opinions of others, more driven by internal pressures to attain perfection, and more self-depreciatory than subjects with short mean after-image durations.

These general trends tend to support and make more explicit the all too brief descriptions of subjects high on the Hy and Pt scales offered by Meehl and Hathaway. They also tend to make more reasonable the tentative conclusion, drawn from Meehl's descriptions, that long after-image subjects are in general differently motivated than short after-image subjects and that the longer after-image durations reflect this different motivation.

The general descriptions of the high Pt and Hy subjects above permit the inference that these subjects have as conspicuous personality characteristics: 1) high personal standards, and 2) dependence on others for approval and self-esteem. It may be further inferred that these characteristics would serve to motivate those subjects in whom they were conspicuous in the direction of remaining psychologically in the present experimental situation when the subjects were once placed in it.

The speculative inferences drawn from the questions suggest specific underlying traits which might be further investigated.

On the basis of the inferred motivation in the experimental situation and the after-image duration results, one may speculate on what the subject experiences when he fixates the stimulus and projects an after-image. Since the individual curves of after-image duration reflect marked and characteristic individual differences and inferences about motivation can be made only in gross terms these speculations must perforce be limited to the two groups in this experiment.

When the mean after-image duration curves of those with long mean after-image durations and those with short mean after-image durations are plotted as in Figure 7, it becomes apparent that the primary difference between the two groups lies in the duration of the initial after-image. The markedly longer initial after-image of the long after-image group suggests that they "accepted" the stimulus, so to speak, remaining attentive until it disappeared, and then "attacked" the after-image actively, trying to "hold on to it" and perceive it as long as possible. Once the initial response was made, however, the attention and interest of the subjects in this group apparently began to wane somewhat. Perhaps this is to be expected as the novelty of the tasks wears off, but as noted above, self-depreciation is apparently a prominent characteristic of many subjects with long mean after-image durations. When a subject tends to depreciate his own efforts and therefore feels he is not doing well enough, he is likely to begin losing interest because success on this task is not defined and necessarily eludes him. At the same time, because of his motivation, he continues to apply himself, as the consistent difference between the two curves in Figure 7 would seem to indicate.

The mean after-image duration curve of the subjects with short mean after-image durations is without the markedly long initial after-image. This curve more nearly approaches a flat, straight line and seems to reflect a different kind of response on the part of the short after-image subjects. On the basis of the inferences about motivation, it would appear that these subjects responded to the stimulus as a matter of course with no particular investment of themselves in the task at hand, and further, that they merely tolerated the experimental situation, "avoiding" interaction with both stimulus and after-image to whatever degree the experimental situation permitted, and responding minimally in automatic fashion.

From Figure 11 it can be seen that there is a tendency for these subjects with longer mean after-image durations to have lower flicker and fusion thresholds. This tendency, together with the fact that there is a correlation of –.38 between flicker threshold and after-image duration, a relationship which approaches significance at the 5% level, indicates that the two phenomena are related in a meaningful way.

The data of the flicker-fusion experiment pose an interesting problem, which, except for Knox' (30) work, has not been considered previously in the literature to this investigator's knowledge: the fact that flicker and fusion levels differ significantly and the tendency for this difference to become more marked as the flicker threshold rises. Although incidental to the main current of this study, these findings merit comment.

Knox explains the flicker-fusion difference thus:

> ...Experiences, just like geographical objects, possess an inertia in regard to change; therefore when flicker is present to begin with, it has a tendency to continue and thus raises the cff. When the flash frequency is decreasing, fusion is present to begin with, and since experience tends to stay as it is, the appearance of flicker is delayed somewhat by this tendency. Thus, the flash frequently must be decreased a bit more before the cff is reached.

This theory is not sufficient to explain the tendency for the flicker-fusion differences to vary with the level of threshold. What accounts for differences in what Knox describes as inertia? When the subject is attempting to decide whether or not the light is still flickering, he is in an "area of decision." A subject not particularly motivated to make an accurate decision can impulsively indicate that the point of flicker or fusion is reached without doubt about the decision arising. A subject motivated to remain psychologically in the experimental situation will probably not report that the point of flicker or fusion has been reached until he is certain of it. Thus, not only will the flicker threshold of the former be higher, but also the difference between his flicker and fusion thresholds will be wider. The former subject will act in response to the stimulus almost immediately as it impinges upon him as if to "escape from the area of decision," as if to leave the experimental situation psychologically as quickly as possible. The latter subject will act only when he feels the stimulus permits him to. In terms of the discussion above, the latter subject may be said to have a difference kind of motivation in the experimental situation and as a result responds to the stimulus with an active interest and a determined effort to carry out the directions given him as accurately as possible.

These findings open up several areas for further investigation. The effect of the approval of the investigator on after-image duration might be further tested by varying investigators with different attitudes toward the same subjects. The effect of high personal standards could be tested by using among the experimental groups one group specifically chosen for this characteristic. The experimental techniques might well be further refined to introduce a phenomenological description of the subject's attitudes, feelings and motivations during the experiment, thereby producing more direct evidence of the effect of psychological factors on after-image duration.

From a theoretical point of view, the results of this study demonstrate that when a person is required to respond to a stimulus which has neither specific personal values attached to it through experience nor significance as a point of orientation in that person's world, he responds in a manner which is in keeping with his general mode of adaptation or "personality." When no point is provided in an experimental situation around which a subject can organize himself, he organizes himself in accordance with his own motivations.

When words, symbols, stories and anchoring points were used in the previously noted experiments, subjects reacted quite clearly with respect to the relationship between those stimuli and their own personalities. When no such familiar stimuli were provided in this experiment, the subjects still tended to respond in terms of their characteristic modes of adaptation, in terms of how they related the experimental situation to themselves. Here the subjects had no choice about what they were to <u>look at</u>. Each subject was required to fixate the stimulus for 50 seconds and as a result an after-image was forced upon him. But once he had initially perceived the stimulus and the image, he had some kind of experience about them, which, when conjoined with his previously organized experiences, determined what it was he "saw" psychologically and how long he saw it. What was for one subject something he wanted to live with for a while was for another something from which he wanted to escape as soon as possible. Inferences from the experimental data suggested that there were at least two gross kinds of motivation in this situation, as a result of the subject's experiences, and beyond them at least two important conditions for these motivations, which in turn showed promise of being amenable to further study. Thus there is some indication that further study might elicit more clearly the experiences underlying perceptual adaptation and perceptual organization.

Responses given by subjects in the psychophysiological laboratory reflect adaptation not only of the particular sensory organ or sensory system being studied but of the subject as a person. To fully understand the subject's reaction to the stimuli which impinge upon him, the investigator must take into account the subject's characteristic mode of adaptation. Especially important is the <u>meaning</u> of the experimental task to the subject in relation to his own goals, strivings and expectations and in relation to his interaction with the people around him. Both the investigator and the subject themselves thus become important conditions in the experiment, conditions which all too frequently have been ignored.

Attempts to relate perceptual phenomena to a personality structure which is described in terms of various kinds of typology or isolated traits will also be incomplete and inconclusive unless motivation for the experimental task is taken into account and is traced to the adaptive significance of the task for the subject, i.e., what does the task mean to the subject? What a subject perceives and how he goes about perceiving it, according to the results of this experiment, are in a large measure determined by what significance the perception has for him in his relationship to the world about him.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Twenty-six students in the Menninger Foundation School for Psychiatric Aides were tested for after-image duration, flicker-fusion, after-image brightness threshold and after-image disappearance threshold, and were given the Otis Self-Administering Intelligence Test, Higher Form, and the Minnesota Multiphasic Personality Inventory, in an attempt to explore the relationships between after-image duration, flicker-fusion, after-image brightness threshold and after-image disappearance threshold and personality characteristics.

It was found that there were wide individual differences in the curves of the durations of the negative after-images, flicker-fusion and after-image threshold.

The differences in after-image duration curves between subjects who had long mean after-image durations and subjects with short mean after-image durations lay primarily in the duration of the initial after-image.

The curves of mean flicker and fusion thresholds were found to differ from each other in both form and level and a significance difference was found between flicker and fusion thresholds. A tendency was found for the flicker and fusion thresholds to vary more widely as the level of the flicker threshold rose. A correlation of -.38 was found between flicker threshold and after-image duration which approached significance at the 5% level.

The after-image threshold experiment yielded no information of value in this experiment.

No significant relationship was found between after-image duration and age or intelligence. On the Minnesota Multiphasic significant correlations were found only between after-image duration and the Hy (+.53) and Pt (+.59) scales. Less significant correlations were found with the Sc and D scales which are known to be closely related to Pt and Hy, respectively. Item analysis of the questions on the Hy and Pt scales disclosed that 16 questions tended to distinguish between subjects with long mean after-image durations and subjects with short mean after-image durations, but only three questions differentiated significantly between the groups. Interpretations of and inferences from these 16 questions were made.

On the basis of the correlations and differences found, the duration of the negative after-image as measured in this study may be said to be significantly related to at least two aspects of personality measured by the MMPI: the hysteric and the psychasthenic. More specifically, the duration of the negative after-image apparently tends to be dependent upon the degree to which the perceiving subject has high personal standards and/or is dependent upon the investigator for approval and self-esteem. The duration of the negative after-image in this experiment was thought to be a measure of the efforts made by the subject to adapt to the experimental situation and the presence of the investigator. For those subjects who apparently adapted by organizing themselves around the experimental task and exerting maximum personal effort, after-image durations tended to be relatively long; for those subjects who apparently adapted by organizing themselves about points outside of the experimental situation and who therefore did not exert maximum personal effort, after-image durations tended to be relatively short.

Differences in flicker-fusion level were felt to be related also to the subject's motivation in the experimental situation, an hypothesis which was supported by the inverse relationship found between flicker and after-image duration.

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