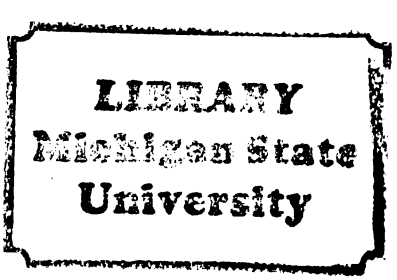
RESEARCH PROJECT



ABSTRACT

AN INVESTIGATION OF THE RELATIONSHIP BETWEEN ANXIETY LEVEL AND PUPILLARY RESPONSE

A series of recent investigations have provided data to support the existence of a relationship between pupil size and emotional excitation. The present research was an attempt to validate the pupillary response as an objective physiological measure of the generalized response by the organism to free anxiety.

It was hypothesized for the present study that the degree of pupil dilation should provide a relative measure of the degree of anxiety present in a subject during any given moment in time; a positive correlation should exist between pupil size and anxiety level.

In order to test the hypothesis, 104 male and female subjects, selected from an undergraduate social work course at Michigan State University, were asked to place their eyes against the aperture of a specially constructed, light-tight apparatus, upon which was mounted a 16 mm. camera that photographed the pupils at a rate of four frames per second. Immediately following this procedure, all subjects were administered the Taylor Manifest Anxiety Scale.

The Pearson Product Moment Correlation was computed to

determine whether or not a positive correlation existed between the scores obtained from the TMAS and those obtained from pupil measurement. The resultant correlation was .0599, obviously of a magnitude too low to be of consequence. Hence, it could not be concluded that anxiety level and pupillary response were positively correlated, at least by either measurement used in the present study. Implications of these results were discussed, and suggestions were made for further research.

AN INVESTIGATION OF THE RELATIONSHIP BETWEEN ANXIETY LEVEL AND PUPILLARY RESPONSE

A Study

Presented to

the Faculty of the Graduate School of Social Work

Michigan State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Social Work

---

by

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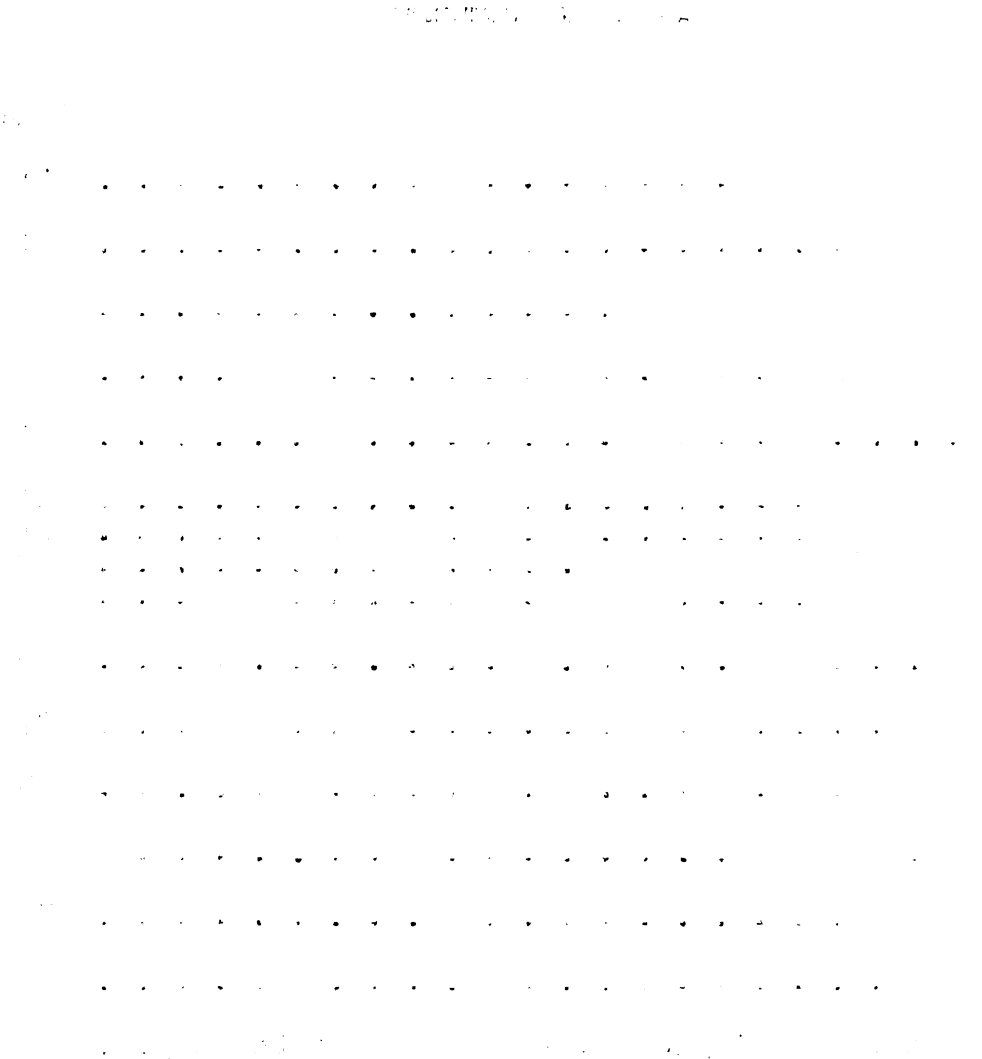


INTRODUCTION

Since the turn of the century there has been increased attention and research directed toward the study of psychophysionomic phenomena. The human body has repeatedly proven to be remarkably capable of demonstrating, through diverse and interrelated physiological responses, the varied effects of both internal and external stimuli. From experiments conducted to test the effects of laboratory controlled stimuli on skin response, heart palpitation, motor control, behavior extinction and pupillary response, there remains little doubt that, not only do psychophysionomic phenomena exist, but that such phenomena are directly related to the channeling of intrapsychic activity.

As recently as 1960, a novel mode of scientific inquiry into the field of human emotion was innovated, and has been rapidly evolving, coming increasingly to the foreground in the medical-psychological disciplines, as an extremely important concept relating to internal emotional states. This technique, termed "pupillometrics" by Eckhard Hess and his associates at the University of Chicago, is based upon the contention that the pupil of the eye, being a direct extension of the central nervous system, is entirely incapable of conscious control, and is therefore a valid and objective measure of the generalized

response by the individual to emotional excitation (Hunt, 1967).

Following the development of pupillometrics, increasingly frequent studies in the area have provided data to indicate that pupillary response is somehow related to affective states, i.e., to the "emotionality" of the stimuli encountered. Interestingly enough, however, no real attempts have been instigated to provide specificity to the nature of the particular affective state experienced by a given subject, as reflected in his pupillary response.

It was the purpose of this study, then, to attempt to provide increased insight into the notion of pupillary response as an indicator of a specific affective state, by comparing the manifest anxiety scores of a sample of normal subjects rated according to the Taylor Manifest Anxiety Scale, to the measured pupil responsivity of the same subjects, in order to determine whether or not a significant positive correlation does, in fact, exist between the ratings provided by each test.

The problem of anxiety occupies a central position in the theory of psychopathology and psychosomatic dysfunctions. It is frequently said to be an indicator of disorganization which, in larger quantities, leads inevitably to compounded disturbance and regression of functioning.

At all levels of anxiety, there exists various combinations

of degrees of loss in homeostatic control, and attempts at mastery to regain such control. Of primary importance to disciplines concerned with human behavior, human functioning, and with the amelioration of human misery, therefore, is not only the degree to which an individual is under the impact of anxiety, but also at which point in its development a particular technique or method of therapeutic intervention might prove most beneficial.

Although there exist enumerable sub-implications for studies such as the present one, the authors feel that the primary significance of such an undertaking lies in the realm of providing greater insight into the physiological manifestations of psychological disruption, its measurement, and resulting increased knowledge of a more accurate determination of the organism's total response to the anxious state. Knowledge so gained will not only add to general personality and psychosomatic theory, but will necessarily contribute to the effectiveness and efficiency of means by which the treatment of anxious persons may be instigated and carried out.

REVIEW OF THE LITERATURE

Although pupillometrics is a relatively new mode of scientific inquiry, it seems that its basic principle has been recognized for centuries. The notion that the eyes provide clues to the emotions -- "windows of the soul," as the French poet Guillaume de Salluste wrote -- is almost commonplace in literature and in current language. Descriptive terms such as "his eyes were like saucers" or "his eyes were pinpoints of hate" and expressions such as "beady-eyed," "bug-eyed" or "hard-eyed," are frequently employed in lay speech to connote feeling associated with eye physiology.

On still other unsophisticated levels, individuals to whom it is important to infer internal thoughts from external behavior appear to have been aware of the pupil-size phenomena for some time. It is said that magicians doing card tricks can identify the card about which a person is thinking by observing the enlargement of his pupils when the card is turned up, and that Medieval Middle Eastern rug dealers and Chinese jade merchants were aware that pupils dilated at the sight of a particularly exquisite piece of merchandise, and veiled their eyes in various ways to avoid betraying their enthusiasm, and thereby causing an increase in price (Hicks, 1966).

Psychotherapists, too, have frequently stressed the

significance of an awareness of finite movements of the client's eyes, as indices of his felt emotion.

To the authors' knowledge, the first scientific inquiry into the field of eye responsivity was accomplished by Charles Darwin, in his Expressions of Emotion in Man and Animals, in which he referred to the "widening and narrowing of the eyes," accompanying movements of the eyelids and eyebrows, as signs of human emotion. Yet, he apparently assumed that the pupil dilated and contracted only as a physiological mechanism responsive to changes in light intensity (Davidson, 1966).

Around the turn of the century, German psychologists conducted rather crude experiments which attempted to illustrate pupil dilation of subjects engaged in problem-solving behavior (Hicks, 1966). For more than thirty years, however, relatively little research was accomplished in this area. Various medical techniques were developed -- such as testing the reaction of the pupil to light, in detecting brain disease -- yet, the emotional-intrapsychic responses of the pupil remained almost totally disregarded.

Finally, in 1933, following extensive study of eye physiology and response capability, W. R. Bender, in a paper on the subject, concluded that:

> ...the iris is controlled by two reciprocating muscle fibers, the circular sphincter with oculomotor innervation

of the parasympathetic type and the radial dilator muscle fibers innervated from the superior cervical ganglion of the sympathetic type.

Bender devised an experiment for the purpose of investigating the impact of various emotional stimuli upon pupillary reflex activity. He discovered that emotional stimuli, such as a gunshot and presentation of a white rat, produced a definite and measurable effect on pupil size. He concluded, then, that pupillary alteration could be accomplished both psychically and reflexly, and that "mental" or "emotional" states of individuals were capable of producing an affect on the pupil of the eye. The results of this study, however, did not seem to create a large impact upon scientific thinking at that time. The methodology used was considered extremely primitive, and statistical treatment was not applied to the data (Davson, 1962). Yet, Bender is certainly to be credited with the innovation of the use of motion picture frames as a means to obtain a measure of pupil dilation and contraction in an "emotional" situation.

Although scientific methodology and scientific apparati have been immensely improved upon since the early experimentation by Bender, much of the literature concerning the nature of pupillary response appears to remain somewhat of a mass of confusion and contradiction. Certainly, the

greatest abundance of research seems to have been carried out in the area of pupil conditioning, and, although such studies are perhaps less applicable to the present research than more recent endeavors in the field of pupillometrics, their significance lies in the fact that they have contributed much important information regarding the nature of the pupil response.

While some researchers continue to state unequivocably that the pupil is capable of conditioning, and that its response is affected by a variety of stimuli, true scientific corroboration of such statements is greatly lacking. There continues to exist a great deal of controversy and lack of consensus as to whether or not a pupil response is capable of conditioning at all, and, if so, what experimental procedures are necessary to obtain a conditioned pupillary response.

Various examiners have reported positive results in attempts to condition pupil responsivity (Watson, 1916; Carson, 1922; Hudgins, 1933, 1935; Baker, 1938; Netzner and Baker, 1939; Harlow, 1940; Girden, 1942; Crasilneck and McCranie, 1956; and Gerall and Woodward, 1958). However, replications, sometimes coupled with new and original attempts, have yielded negative results (Stickle and Brenshaw, 1934; Stickle, 1936; Wedell, Taylor and Skolnick, 1940; Hilgard, Miller and Olson,

1941; Stern, 1948; Hilgard, Dutton, and Helmick, 1949; Young, 1954; Crasilneck and McCranie, 1956; and Young, 1958). Explanations of such conflicting findings are not convincing, and they vary from procedural differences to hippus -- a disturbance of the integration of sympathetic and parasympathetic actions (Crasilneck and McCranie, 1956).

Other researchers (Young, 1958 and 1965; Sampson and Boslow, 1957; Gerall and Obrist, 1955; Young and Biersdorf, 1954; Girden, 1942) have indicated that pupillary conditioning could be obtained, but that the conditioned response was not stable or easily elicited when changes in light intensity or sound were used as the conditioned stimuli. Guinan (1966) introduces, as a possible explanation for this, the fact that the pupil response to light itself may have some of the characteristics of a conditioned response. Lowenstein and Loewenfeld (1952) obtained results which indicated that pupil response to changes in light intensity was not difficult to extinguish.

A major criticism which may be directed against the above studies is that in every case except one (Guinan, 1966), there was a definite failure to adequately control the homogeneity of the visual field. Typically, the pupil was observed by use of a telescope, and the presence of a lens resulted in differential intensities of reflected light across

the subject's visual field. Interestingly enough, there exist no published reports of failure to obtain conditioning when the unconditioned stimulus was electric shock or pain. Such stimuli are usually described as "emotional" (Young, 1965; Hilgard, Dutton and Helnick, 1949; and Girden, 1942).

Lowenstein and Loewenfeld (1962) have provided a description of the physiological mechanisms of the pupillary response, by pointing out that the iris is representative of all smooth muscle structures that are reciprocally innervated by the sympathetic system, while the pupillary sphincter, which controls pupil constriction, is innervated by parasympathetic activity. Physiologically, then, there exists some evidence to support the reasoning that pupil responsivity should be associated with stimuli that are emotionally laden. A more recent publication in this area (Morgan, 1965), corroborated Lowenstein's and Loewenfeld's findings, again indicating that a sympathetic effect which may be observed during the experiencing of a strong emotion is that of pupil dilation.

There continues to exist, however, a great deal of contradiction in the literature in regard to a directionality factor in pupil reactivity. Hess and Polt (1965), in their experimentation with visual stimuli, have found that there is a range of pupil response from extreme dilation for pleasing stimuli, to extreme constriction for unpleasant stimuli. Yet,

Bender's results indicated that painful and unpleasant stimuli elicited pupil dilation. Bender is supported by Young (1965), who found that conditioning of pupillary constriction is impossible, in that such constriction is not part of the generalized unconditioned autonomic response to psychic stimuli.

Several authors have suggested that pupillary response is representative of a generalized autonomic response to noxious or emotional stimuli. Young (1965) pointed out that such a response is modified during conditioning so that alterations in pupil size are indicative of changes that are occurring within the autonomic nervous system. Girden (1942) stated that pupillary dilation is a function of generalized response of the individual to noxious stimuli. McGinnies (1956) operationally defined "emotionality" as generalized autonomic activity, as measured by the galvanic skin response, without the presence or absence of phenomenological content. Hence, while it may be hypothesized that pupil responsivity is related to emotionality, dilation or constriction in response to specific affective states remains speculative.

A series of recent publications by Hess and Polt (Hess and Polt, 1965; Hess and Polt, 1964; and Hess and Polt, 1960) offer evidence that pupillary response may be utilized as a measure of affective states. In these studies, employing an improved upon photographic technique, the authors

were able to measure the diameter of each subject's pupil in relation to the manifest content of the visual stimuli presented. In one report (Hess and Polt, 1964) a measurement of the subject's pupil size was obtained during simple problem-solving procedures. The data collected from these studies demonstrates the existence of a correlation between pupil size and psychological effects of visual and other stimulation on complex mental activities, on interests and attitudes, and on states of emotional excitation. In another study (Hess, Seltzer and Schlien, 1965) -- his most recently published -- Hess has reported that he was able to differentiate homosexual from heterosexual males by obtaining a measurement of pupil responsivity to visual stimuli.

The above described research certainly raises some thought provoking ideas regarding the emotional nature of pupillary response. Yet, close examination of the methodologies involved, revealed that many objections could be raised with regard to their scientific validity. On a procedural level, Hess and his associates have made no attempt to differentiate, or even operationally define such variables as "interest," "emotionality," or "attitude." To the contrary, they have hypothesized that certain visual stimuli would arouse a specified affective state, e.g., interest, and then report that the alterations in pupil size were due

to that particular affect. Further, the reports have been more of a descriptive nature, rather than an experimental one. The procedures appear to have been loosely controlled, and were not reported in sufficient detail to permit needed replication. The results were presented only in terms of direction and percentage of change, and the application of precise statistical techniques was conspicuously absent.

However, in two more recent studies by Guinan (1966) and Miller (1966), in which the authors attempted to provide some elaboration on the work of Hess and his associates, obvious gains were made in such procedural areas as more adequate statistical analysis, tighter controls, and improved apparatus. Miller introduced chromatic stimuli (red, blue and green) and an achromatic stimulus (light grey) to a sample composed of college students, and found that pupils manifested more responsivity, as measured by alteration in pupil diameter, when exposed to chromatic, i.e., "emotional," than when exposed to an achromatic, i.e., "neutral," stimulus.

Guinan's research was quite similar to that of Miller's, the major difference being the nature of stimuli to which the subjects were exposed. Instead of emotional colors as opposed to neutral colors, Miller employed "emotionally laden words" (sex, kiss, vomit) as opposed to "neutral words" (shelf, card, the) as his visual stimuli. The results of the

study indicated that the emotional words elicited significantly greater pupil responsivity than did the neutral words. Thus, these authors, with improved techniques over those of past researchers doing work in this area, have provided further evidence to support the fact that particular types of emotional stimuli produce affective states which result in pupillary reactivity. However, again, no attempt was made to define the particular affective state produced.

There exists very little research to substantiate the the theory that the affective state with which such authors as Bender, Hess and his associates, and, later, Miller and Guinan were working, was, in fact, one of anxiety. However, in view of logical assumptions which can be made regarding the nature of the stimuli with which they presented their subjects -- i.e., white rats, gun-shots, pictures of nude figures, words such as vomit and sex, and even such colors as red and blue -- a substantial possibility certainly exists to that effect.

Yet, numerous authors have pointed out that anxiety, per se, is something more than a reaction to a specific situational threat. In general, it seems that anxiety may be aroused by any condition, internal or external, which threatens the integrity of the organism (Basowitz, et al., 1955). Such affective conditions are usually termed "free

anxiety" (Grinker and Spiegel, 1945).

For May (1950) "...anxiety is the apprehension cued off by a threat to some value which the individual holds essential to his existence as a personality." Examined from this viewpoint, any stimulus may have cue status, provided that it implies a threat to an "essential value." Since these are largely determined through individual experience and learning, and the threat-forewarning cues are similarly individual products (May, 1950), it follows, then, that a diverse variety of stimuli may arouse anxiety, and that this state may be present to varying degrees in an individual during any given moment in time. As Karpas (1964) points out, anxiety is a force that confronts every person to a greater or lesser degree throughout his life.

The literature implies that differentiation is not always possible between the fear response to actual and real danger, and the anxiety response so often characterized as "objectless" (Goldstein, 1950). Again, Karpas (1964) feels that anxiety involves more than "simple fear," and derives from a basic apprehensive state within the individual, which has, as its ultimate source, unresolved archaic conflicts and strivings. Schaffer (1946) points out that anxiety is more continuous than the sort of response experienced in the advent of an immediate fear-threat situation. He feels

that, here, the situation to which the individual is seeking adjustment is not an external one, but a problem of personal adequacy, regardless of the fact that similar psychophysiomonic responses may be initiated in each. Basowitz (1955) substantiates this position, by stating that:

> States of fear are conceived as temporary, more related to external events, and preparatory to appropriate behavior of the organism; anxiety is more usually derived from internal psychological problems and therefore is chronically present... (emphasis supplied).

In his study of The Problem of Anxiety, Freud (1936) pointed out that anxiety has a central position in body-mind relationships, in that it is an affective state associated with physiological changes and their perceived effects. According to Kessler (1966), too, anxiety is an emotion which has very distinctive physiological features, which occur on an intracellular level. Certainly, of the numerous studies done in the description of the neurological aspects of anxiety, most refer to the autonomic nervous system, the sympathetic and parasympathetic divisions of that system, and certain bodily changes which occur as a result of the action of these structures upon the body proper. The central element presented in the neurological studies is the fact that the anxious individual reacts in total to the apperceived disruption of his homeostatic state (May, 1950). Many such reactions which do

occur, however, are controlled by the sympathetic division of the autonomic nervous system, which is actually incapable of conscious control. More specifically, biochemical alterations are manifested through increased heart rate and heightened blood pressure, discharge of adrenalin into the vascular system as a preparation for action, and increased visual acuity, all designed to prepare the individual for fight or flight. As Liddell (1950) has stated, anxiety, as an affective state involving both somatic and psychological participation, may be conceived of as an extension of irritability and vigilance. Basowitz (1955) provides some indication that psychophysionomic responses to anxiety may be used as an index to its intensity, by pointing out that:

> ...measures of overt total behavior or performance in a specified task, psychological functions such as perception, decision, memory, etc., physiological actions of somatic musculature, cardiovascular and respiratory systems indicative of action or for its preparation, and indices of biochemical functions, all in some manner measure various aspects of anxiety.

Hence, on a physiological level, there exists some evidence to support the notion that pupillary response is regulated by precisely those portions of the autonomic nervous system which determine the organism's response to anxiety on yet other physionomic levels. Cannon (1939) described the physiological response to the affective state of anxiety in the following

manner:

> When the cortex of the brain is stimulated by a threat, it sends a stimulus down the sympathetic branch of the autonomic system to the adrenal glands. Under the influence of epinephrine, respiration deepens, the heart beats more rapidly, the arterial pressure rises; blood is shifted away from the stomach and intestines to the heart, central nervous system and the muscles; processes in the alimentary canal are inhibited; glycogenolysis is accelerated and the blood glucose level increases; the spleen contracts and discharges its store of corpuscles.

While Cannon's observations continue to serve as focal points for present thinking, evidence increases to suggest that the physiology of emotions involves the organism much more extensively, and in far more complex manners than originally recognized. Lowenstein and Lowenfeld (1962) noted an additional physiological effect produced by the secretion of the adrenal hormone, epinephrine. In their research, these authors found that epinephrine and other discharges were actually liberated into the blood stream. Such discharges were then carried to the eye, where they stimulated the dilator pupillae, which, in turn, elicited, reflexively, the pupillary response -- pupil dilation.

Hence, although, as indicated earlier, a degree of anxiety is believed to be present in each individual at any given moment in time, it is reasonable to assume that certain persons from any normal population are more anxious than others. Such

persons, according to what is known regarding the physiology of anxiety, should secrete greater quantities of epinephrine into the blood stream, which eventually arrives at the eye, and ultimately determines the degree of pupil dilation, as part of their total autonomic response in preparation for the resolution of the anxious state. The hypothesis for the present study, then, is: the degree of pupil dilation should provide a relative measure of the degree of anxiety present in a subject during any given moment in time; a positive correlation should exist between pupil size and anxiety level.

Winter, Ferreira and Ranson (1963) have indicated that, since anxiety has been a core concept in many dynamic theories of behavior, its measurement has become a major task of the behavioral sciences. There have been two popular approaches to measuring anxiety: one involves the assessment of an individual's psychological functioning, or changes therein under anxious states; another, his verbalized self-description in interviews or written questionnaires. A good deal of effort has gone into the development of adequate measuring instruments in these areas, and into analyzing the theoretical implications of their complex inter-relationships (Dahlstrom, 1962).

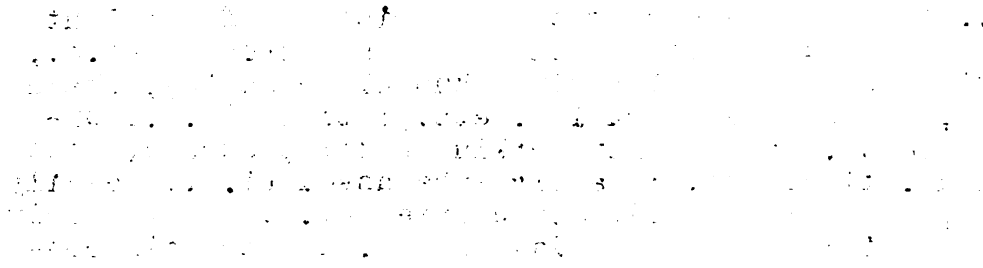
Research accomplished in the measurement of anxiety has resulted primarily from standardized tests designed to elicit

responses which provide some indication of the subject's manifest anxiety level. According to Hoyte and Magoon (1954), manifest anxiety is evident in:

> ...those behaviors or characteristics of a client that would lead you to classify him as nervous: (i.e., mannerisms such as nail biting, knuckle cracking, chain smoking, profuse perspiration, etc.); tense (i.e., unable to relax, continually working under pressure, hand trembling, tics, etc.); easily embarassed (i.e., readily blushes, stammers, etc.); and worried (i.e., apprehensive over what will happen from day to day, doubts self continually.

Repeated reference is made in the literature to the Taylor Manifest Anxiety Scale (TMAS) which appears to be the most common and extensively used of the indicators of anxiety (Dahlstrom, 1962). This test has been repeatedly subjected to extensive research in order to prove or repudiate its content validity, and, although there remain both advocates and criticizers, for various reasons, it appears to be the test most applicable and useful for the present study. Hence, the TMAS should provide the authors with the necessary scores from which to determine the relative level of anxiety in the subjects tested. These scores, in turn, will be correlated with those obtained from pupil measurement, in order to determine whether or not the hypothesized correlation exists.

It is important, therefore, to note that the TMAS has been validated as an instrument capable of distinguishing



between high and low range anxiety levels among normal subjects (Uma and Reddy, 1965). This research was accomplished through the administration of the test to a group of 162 college girls, ages 17-20, in order to establish high and low anxiety groups. A supporting study by Kendell (1954) contrasted the upper and lower percentiles of a group of hospitalized mental patients, and found a significant difference at the .01 level of confidence.

Another study which suggests that the TMAS is applicable to the present research is that conducted by Hoyt and Magoon (1954) who found that thirty of the fifty individual items on the test have validity for college populations. Further, Terwilliger and Fieldler (1958) were able to contrast significantly, at the .05 level, very anxious from less anxious college students. This study compared students asking for help at the counseling center with those of the normal college population.

METHOD

Subjects. The subjects consisted of 104 male and female college students, selected from an undergraduate social work course at Michigan State University. All subjects participated voluntarily in the experiment.

Apparatus. The apparatus (see Figure I, on the following page) was designed and constructed by the experimenters, with technical assistance offered by the Instructional Media Center at Michigan State University. It consisted of a rectangular plywood box, 32" long, 18" high, and 16" wide. At one end a projecting eye piece was mounted, so that when the subject's right eye was in place, it could be photographed by a camera located at the opposite end of the apparatus. Internal illumination of the box was provided by a single 40 watt bulb; external illumination was purposefully minimized, by darkening the room in which the experiment took place. The exterior of the apparatus was painted a flat black; the interior was painted an enamel white, frosted with black primer.

The motion picture camera used was a 16 mm. Eclair 16 II. It was fitted with an Angenioux 12-120 mm. Zoom Lens, with a Number 2 Diopter Close-Up Lens. The lens opening was set at 2.8, allowing the photography at 4 frames per second.

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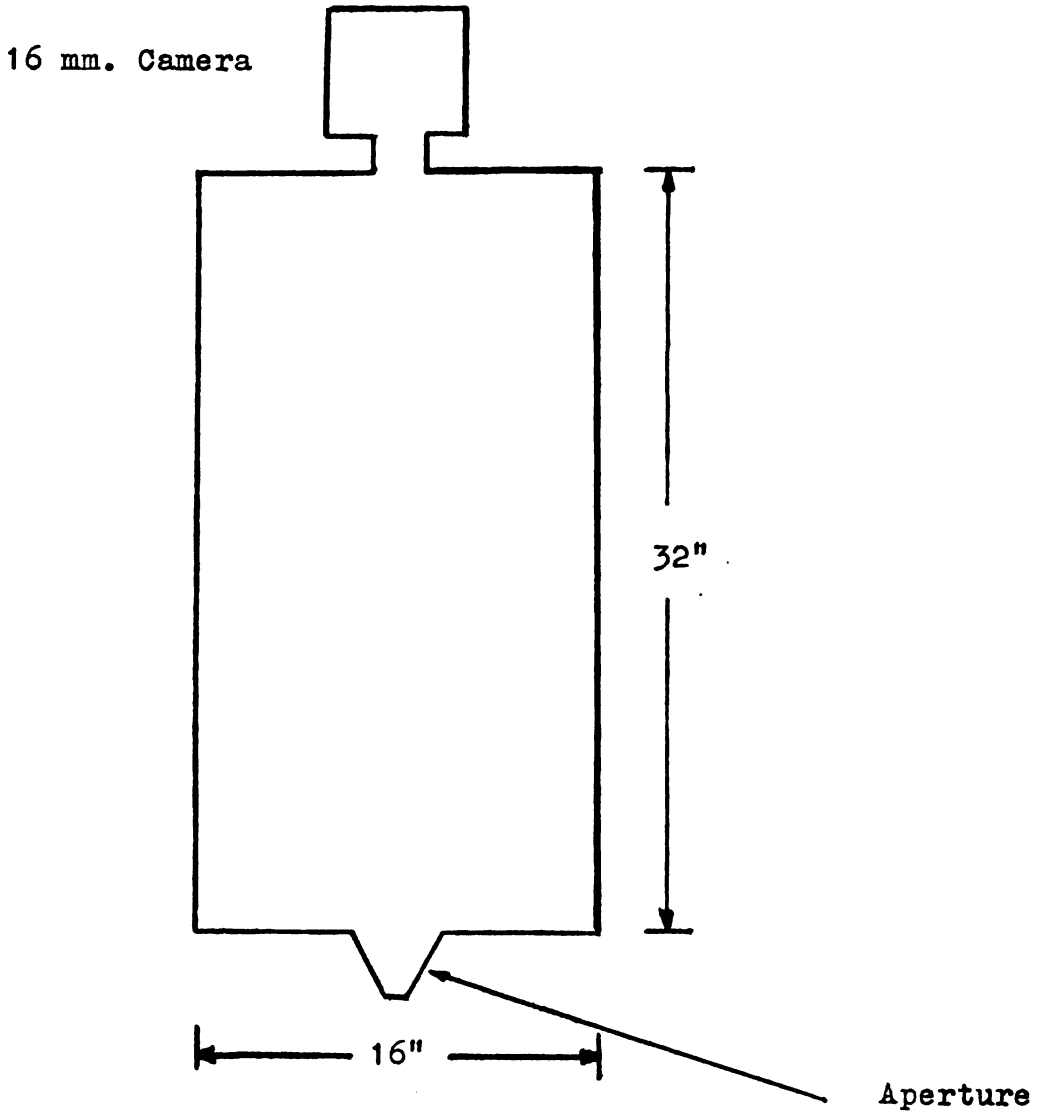
FIGURE I

Experimental Apparatus*



*Top View. Scale: 1/8" = 1".

The projecting eyepiece was constructed on the exterior of the apparatus for the purpose of maintaining the visual axis at 36" for all subjects. The aperture was large enough in circumference to permit the exposure of the entire eye, yet sufficiently constricted to inhibit distraction by possible external stimuli.

Procedure. All subjects were introduced to the research situation through a prepared oral presentation, which was read by one of the experimenters, as follows:

> Today you will be involved in a research project conducted by a group of second year graduate students, in partial fulfillment of their requirements for the Degree of Master of Social Work. This project will involve approximately twenty minutes of your time. There is nothing difficult to do. Your eye will be photographed, and you will be asked to answer some simple questions. These are statements of fact -- there are no right or wrong answers. Please answer according to your best judgement.
>
> All participants will remain anonymous; no identifying information will be requested. You will be identified only by a number to which you will be assigned. Those of you who wish to participate will be called according to the rows in which you are seated. When you are finished, please return to your classroom quietly -- class will continue to be in session while the experiment is in progress.
>
> At the end of this term the results of the experiment will be reported to you. Your cooperation will be greatly appreciated.

The subjects were called according to the classroom rows, and escorted to the photographing room, where they were introduced to the apparatus and received further instructions.

Those who wore eyeglasses were asked to remove them. Each subject was then asked to place his left hand over his left eye, step up close to the apparatus, and place his right eye closely against the projecting eyepiece. Five preliminary seconds were allowed at this point, in order for the subject's pupil to adjust itself to the interior illumination of the apparatus. He was then instructed to look directly at the small opening located at the opposite end of the box, in which the camera lens was located, to keep his eye as open and as steady as possible, until informed that photography was completed. The photographing, itself, was maintained at an average of 12 seconds for each subject's eye, in order to obtain a series of frames by which the mean pupil size of each individual could be determined.

Following the completion of the photographing, the subjects were escorted immediately to the testing room, where the Taylor Manifest Anxiety Scale (see Appendix A) was administered, according to instructions printed on the board. The subjects were in no way made aware of the nature of the test which they were taking. A standard IBM scoring sheet was used to facilitate grading.

The eye photographs were examined by use of a Bell and Howell Analyst movie projector, selected because it permitted the viewing of individual frames from the film. This

apparatus projected the images of the pupils, at a magnification of 5½ times, onto a screen from which they were accurately measured with a caliper and a millimeter ruler. Four frames per subject, selected at intervals of 12, were measured, in order to further standardize the data gathered.

Measures were not obtainable on three subjects, either because the boundaries of the pupil were rather indefinable, or because the eye was closed during photography. Thus, analysis of the data was based upon pupil measurements of 101 subjects.

RESULTS

The ratings of each of the 101 subjects was determined on the Taylor Manifest Anxiety Scale, and a mean score was computed for the population. A mean was also determined from the individual scores obtained by pupil measurement. The ratings of each subject on both tests were identified by the number to which he had been assigned.

The Pearson Product Moment Correlation was computed to determine whether or not a positive correlation existed between the scores from the TMAS and those obtained from pupil measurement. The resultant correlation was .0599, obviously of a magnitude too low to be of consequence. Hence, it can not be concluded that anxiety and pupil size are positively correlated, at least by either instrument used in the present study.

In order to determine whether or not any other relationship might exist, a scatter-gram was constructed from the data obtained from the two tests administered. This device provided no evidence of the existence of a curvilinear relationship between the variables, nor did it indicate the possibility of any unconsidered relationships. Therefore, in view of the results of statistical analysis, and of the graphic representations, the hypothesis of relationship between pupil size and anxiety must be rejected.

The relines of each of the 101 subjects was determined on the Taylor Manifest Anxiety Scale, and a mean score was computed for the entire population.

DISCUSSION

Although the stated hypothesis of the present study was not supported, this does not invalidate the basic premises upon which it was constructed. Some indication exists to support the reasoning that the hypothesis was not borne out in the results because of the presence of a fundamental difference between the type of anxiety measured by the TMAS, and that manifested in pupil reactivity.

The Taylor Manifest Anxiety Scale may be an instrument which only measures somatic manifestations of anxiety, modes in which the affective state is bound in bodily activity, discharged and, hence, perhaps to an extent alleviated. It is possible that the test, itself, may actually provide little or no indication in regard to the degree to which the individual is experiencing anxiety, but may merely indicate his particular mode of channeling it. Theoretically, then, there may justifiably be some question as to whether or not there continues to exist a measurable degree of anxiety from the pupils of subjects representing a normal population, regardless of the fact that they may have scored within the "anxious range" on the TMAS. The fact that such individuals did, in fact, achieve higher scores on this test may merely provide some indication that they have effectively channeled off

existing anxiety, through manifest symptomatology, to the extent that its presence may be imperceptible in pupillary reactivity.

As indicated earlier, however, although criticized for just such limitations, the TMAS continues to be the most widely used test of manifest anxiety, and was chosen for the present study on that basis. The preceding discussion, of course, neither supports or rejects the test's validity for its function in providing a relative measure of manifest anxiety. What it does imply, though, is that because anxiety may be channeled off into manifest symptomatology such as that to which the TMAS refers, a decreased degree is available to stimulate physiological processes which might produce a measurable pupillary response.

In the present study, the authors employed the term "free anxiety" as an operational concept. It was hypothesized that, at any given moment in time, such anxiety was measurable in any individual, as evidenced by differential degrees of pupil reactivity. In theory, it was assumed that free anxiety was capable of producing a resultant stimulus effect upon the bodily functions, one of which would be the release, by the adrenal glands, of the activating hormone, epinephrine. Hence, there was reason to believe that persons from any normal population who had a higher level of free

anxiety than others would secrete greater quantities of epinephrine into the blood stream, eventually arriving at the eye, and ultimately determining the degree of pupil dilation, as part of the individual's autonomic response in preparation for the resolution of the anxious state.

Again, however, the results of the present research did not indicate the existence of any such physiological effect. At least a portion of the explanation for this fact may be derived from some basic premises of psychoanalytic theory, which provide some insight into the dynamics of libidinal energy and the psychodynamic structure. Psychoanalytic theory indicates that libidinal energy, which presents itself as undesirable and unacceptable to the ego, is bound and repressed by the secondary processes of that structure, and thereby retained from conscious expression. In normal individuals, this process effectively inhibits the conscious experiencing of overwhelming quantities of free anxiety, and its resultant disintegrative effect upon adequate psychological functioning.

In view of the implications of this theory, it would follow, then, that, because the subjects employed in the present research were, as college students, in all probability, mature individuals, with differentiated and supposedly adequately functioning egos, there would exist in their

intrapsychic structures little or no mobile libidinal energy to cause the degree of free anxiety, which may be associated with grosser forms of psychopathology, in that the adequately functioning secondary processes had effectively bound and discharged it through precisely those somatic structures to which the TMAS refers in its measurement of manifest anxiety.

It is not inconceivable, therefore, that the adequately functioning psychodynamic system is able to bind and discharge the resulting tension arising from normal degrees of free anxiety through such manifest bodily activity as measured by the TMAS. Pupillary responsivity, however, may be manifested at a point in which the normally functioning psychodynamic system is taxed beyond its capacity to bind and discharge anxiety through already existing psycho-physiological patterns and coping mechanisms. Such a situation might occur with the increased anxiety reaction usually experienced with the advent of a specific situational threat. This assumption is supported, to an extent, by the studies of Bender (1933), Hess, et al. (1965), Guinan (1966) and Miller (1966), who have dealt with correlations between specific emotional stimuli and pupillary response, as well as by the work of Lowenstein and Lowenfeld (1962) who have indicated that the adrenal hormone, epinephrine, is secreted as part of the organism's total response to the stimulus of a threat. Although not

mentioned in the studies of these authors, the threat to which they were referring was perhaps not of the type experienced by normal individuals in their attempts to bind and discharge normal free anxiety, arising from the existence of unresolved internal conflicts and tensions, but of the kind of anxiety experienced as a result of an external situational threat, requiring the fight or flight reaction, as prepared for by adrenal activity. Hence, it may be that normal, continuing, free anxiety from internal tension does not stimulate the adrenal secretion of epinephrine to the extent of that experienced with the immediate advent of an external situational threat, and, therefore, to the extent which would result in a measurable degree of pupillary responsivity.

Certainly, the notion that biochemical systems function within homeostatic boundaries is not a novel one, and it may be that this principle is in operation in relation to hormonal activity accompanying the anxiety reaction, as well. Perhaps as long as the individual is able to absorb the effects of anxiety, either physiologically, through other manifest symptomatology, or psychologically, through the repressive function of the ego, the homeostatic balance of the biochemical system may receive insufficient stimuli to elicit the degree of epinephrine secretion to evoke pupillary response. Such hormonal activity may not accompany normal

free anxiety at all, but may only be present in sufficient quantity in anxiety of the type aroused in situational threats, when the biochemical system may be forced beyond its continuing homeostatic level, in preparing the body both physiologically and psychologically for either fight or flight.

IMPLICATIONS

Anxiety has been shown to be a multidimentional problem, and the present research has attempted to deal with but one facet of it. Certainly, an implication for further research should involve the determination of whether or not a correlation exists between the degree of pupil dilation, and anxiety evoked as a result of a specific situational threat. Again, such a threat might arouse sufficient situational anxiety to stimulate adrenal activity of the magnitude necessary to elicit pupillary response. Here, of course -- at least in theory -- a form of noxious stimuli would have to be introduced in order to activate the needed psychological and resulting physiological mechanisms associated with attempts at resolution of the anxious state.

Further, a test other than the TMAS which, as has been indicated, may simply measure somatic modes of channeling anxiety, rather than the degree to which the affective state is experienced by the individual, may either have to be located or developed. To the authors' knowledge, however, no such test is currently in existence.

Other variables which may be introduced on a procedural level might involve the administration of the test for anxiety prior to the actual photographing of the eye. The

written test situation, in itself, could conceivably provide sufficient situational anxiety -- especially for college students -- to elicit a measurable degree of pupillary response.

It may be that the use of a population, in which was present grosser forms of psychopathology, would tend to produce a degree of anxiety sufficiently potent to be measurable without the introduction of noxious stimuli needed for more normal populations. Such a population could conceivably offer a more dramatic representation of the relationship between free anxiety and pupillary reactivity. The results of such a study might do much to resolve the current theoretical dilemma which exists between those theorists who believe that psychotics are extremely anxious, and those who believe that they are relatively anxiety free. An experiment of this sort with psychotics might also provide some insight into the varying degrees of anxiety prevalent in individuals classified under different diagnostic categories.

Finally, color film of the eye might prove extremely useful, not only in more accurately determining pupil diameter, but through the introduction of data enabling the comparison of pupillary response as it is related to persons with different eye color.

These implications certainly warrant a replication of an investigation similar to the present one, with corrections

in those areas mentioned. Such studies would continue to have specific value both in psychosocial diagnosis and in therapy for psychiatric social work. Admittedly, however, implications are somewhat more limited due to the apparent need for anxiety provoking stimuli to produce sufficient situational anxiety to elicit measurable pupillary response. Yet, here too, there exists, in theory, some applicability for the use of the phenomenon of pupil reactivity in the interview situation. For example, a series of stimuli representative of specifiable conflict situations could be devised, and then an individual's pupil response to those situations could be recorded. Larger pupil dilation would hypothetically be related to stimuli indicative of that person's problem area. Further, alterations in emotional responsivity to conflict situations may be utilized as a measure of movement in casework.

SUMMARY

A series of recent investigations have provided data to support the existence of a relationship between pupil size and emotional excitation. The present research was an attempt to validate the pupillary response as an objective physiological measure of the generalized response by the organism to free anxiety.

It was hypothesized for the present study that the degree of pupil dilation should provide a relative measure of the degree of anxiety present in a subject during any given moment in time; a positive correlation should exist between pupil size and anxiety level.

In order to test the hypothesis, 104 male and female subjects, from an undergraduate social work course at Michigan State University, were asked to place their eyes against the aperture of a specially constructed, light-tight apparatus, upon which was mounted a 16 mm. camera that photographed the pupils at a rate of four frames per second. Immediately following this procedure, all subjects were administered the Taylor Manifest Anxiety Scale.

The Pearson Product Moment Correlation was computed to determine whether or not a positive correlation existed between the scores obtained from the TMAS and those obtained

from pupil measurement. The resultant correlation was .0599, obviously of a magnitude too low to be of consequence. Hence, it could not be concluded that anxiety level and pupillary response were positively correlated, at least by either measurement used in the present study. Implications of these results were discussed, and suggestions were made for further research.

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APPENDICES

QUESTIONS

1. I am often sick to my stomach.
2. I do not tire quickly.
3. I am about as nervous as other people.
4. I have very few headaches.
5. I work under a great deal of strain.
6. I cannot keep my mind on one thing.
7. I worry over money and business.
8/ I have diarrhea ("the runs") once a month or more.
9. I frequently notice my hand shakes when I try to do something.
10. I blush as often as others.
11. I have nightmares every few nights.
12. I worry quite a bit over possible troubles.
13. I practically never blush.
14. I am often afraid that I am going to blush.
15. My hands and feet are usually warm enough.
16. I sweat very easily even on cool days.
17. When embarrassed I often break out in a sweat which is very annoying.
18. I do not often notice my heart pounding and I am seldom short of breath.
19. I feel hungry almost all the time.
20. Often my bowels don't move for several days at a time.
21. I have a great deal of stomach trouble.
22. At times I lose sleep over worry.
23. My sleep is restless and disturbed.
24. I often dream about things I don't like to tell other people.
25. I am easily embarrassed.
26. My feelings are hurt easier than most people.
27. I often find myself worrying about something.
28. I wish I could be as happy as others.
29. I am usually calm and not easily upset.
30. I cry easily.
31. I feel anxious about something or someone almost all of the time.
32. I am happy most of the time.
33. It makes me nervous to have to wait
34. At times I am so restless that I cannot sit in a chair very long.
35. Sometimes I become so excited that I find it hard to get to sleep.
36. I have often felt that I faced so many difficulties I could not overcome them.
37. At times I have been worried beyond reason about something that really did not matter.
38. I do not have as many fears as my friends.
39. I have been afraid of things or people that I knew could not hurt me.
40. I certainly feel useless at times.
41. I find it hard to keep my mind on a task or job.
42. I am more self-conscious than most people.

43. I am the kind of person who takes things hard.
44. I am a very nervous person.
45. Life is often a strain for me.
46. At times I think I am no good at all.
47. I am not at all confident of myself.
48. At times I feel that I am going to crack up.
49. I don't like to face a difficulty or make an important decision.
50. I am very confident of myself.
51. Something unusual happened to me today which caused me to be particularly anxious.
52. Generally I am an anxious person.
53. I have an optical problem.
54. I wear glasses.
55. I wear contacts.

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