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## A Study of the Electrodermal Response as a Measure of Anxiety and Impulsiveness

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A STUDY OF THE ELECTRODERMAL RESPONSE  
AS A MEASURE OF ANXIETY AND  
IMPULSIVENESS

by

Reverend Glenn Francis Williams, S.J.

A Thesis Submitted to the Faculty of the Graduate School  
of Loyola University in Partial Fulfillment of  
the Requirements for the Degree of  
Master of Arts

June

1961

## LIFE OF AUTHOR

Reverend Glenn Francis Williams, S.J., was born in Cleveland, Ohio, April 26, 1924.

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He began his graduate studies in clinical psychology at Loyola University, Chicago, Illinois, in September, 1958.

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## CHAPTER I

### THE PHENOMENON OF THE EDR

Among the electrical phenomena of life which have attracted the attention of scientists and piqued the curiosity of ordinary men there is one which has special interest for psychologists because of its apparent connection with behavior. This phenomenon has borne many different names but today is most frequently called the electrodermal response or EDR, as we shall see later.

Feré published the first article about the EDR in 1888. Even before that time, however, it was known that, when an electrical current is passed through the human body, bodily resistance is high and is subject to large variations. Feré passed a weak current through electrodes on the forearm, having a galvanometer in the circuit, and applied to his subjects such stimuli as a tuning fork, an odor, a colored glass held before the eyes, and so forth. The galvanometer responded with a quick deflection, thus indicating an increased flow of electrical current because of decreased bodily resistance.

In 1890 Tarchanoff reported that any two parts of the skin, connected through a galvanometer, show a difference in electrical potential, as indicated by a weak current which is found to pass through the galvanometer in a certain direction. He was able to

neutralize this current by passing a weak external current in the opposite direction, thus bringing the galvanometer needle to zero. When this had been done, a stimulus applied to the subject often yielded a galvanometer deflection after a latency of one to three seconds. Tarchanoff discovered that he could obtain this response not only with sensory stimuli but also upon inducing shifts in mental activity (Woodworth, 1938, pp. 276-277).

It is generally agreed that these two forms of the EDR--called the Féré effect and the Tarchanoff effect after their respective discoverers--are not two distinct phenomena but rather two aspects of, or two ways of measuring, the same phenomenon. The Tarchanoff effect requires a very sensitive galvanometer to measure the extremely small potentials which this procedure reveals; moreover, correct placement of the electrodes so as to avoid unpredictable shifts in their polarity is a difficult task. For these reasons the Féré effect has been preferred as a research procedure. Nevertheless, the Tarchanoff effect has been the subject of two rather recent studies, one by Hovland and Riesen (1940), the other by Wilcott, Darrow, and Siegel (1957).

The Féré effect consists of an increased flow of impressed current through the body because of the temporary reduction of bodily resistance. The normal resistance of the body is generally considered to be the result of polarization. When an electric current is passed through a mass of living cells, it has to penetrate the cell walls, but these are semipermeable membranes which

are not open to the passage of all ions indiscriminately. The ions which carry the current bank up against the cell walls, thus making each wall a polarization cell with polarity opposite to that of the impressed current. For this reason there arises at the cell wall an electromotive force (emf) which is counter to that of the impressed current but weaker. The impressed voltage is partially neutralized by this counter emf and the current is thereby reduced. The greater the impressed voltage, the greater the polarization. The Féré effect consists, therefore, in a partial and temporary depolarization of the cell walls through which the current is passing. This temporary depolarization is registered on the galvanometer as a temporary decrease in bodily resistance (Woodworth, 1938, pp. 279-280).

That the skin under the electrodes is the locus of this phenomenon is clear from experiments in which the skin under one or both electrodes has been punctured. When direct connection is made with the internal fluids under one electrode, the resistance drops almost to zero. The blood and lymph channels inside the body walls afford such good conduction that it is only in the skin itself that the high apparent resistance of the EDR could occur (Richter, 1926).

What causes the EDR? There have been three principal theories proposed to explain this phenomenon. According to the muscular theory the EDR is the direct display of bioelectric changes in the muscles. The vascular theory holds that the EDR is the elec-

trical activity which attends the vasodilatation or vasoconstriction, while the secretory theory maintains that the EDR is the pre-secretory electrical activity of the sweat glands (McCleary, 1950).

Darrow (1937b) has shown that palmar sweating and the EDR are mediated by the sympathetic nerves and that central control of this secretion involves the dorsal vagal nucleus, the anterior portion of the hypothalamus, the prechiasmatal region, and the premotor cortical region. On the other hand, vasoconstriction has been shown to be associated with increased pulse rate and higher EDR, especially when the subject is confronted with a threatening situation which calls for activity. Nevertheless, after much discussion physiologists are substantially agreed with Darrow and with d'Arsonval, who collaborated with Feré on the original work, that the electrodermal phenomena, both action currents (Tarchanoff) and depolarization (Feré), are due to activity of the sweat gland cells (Richter, Woodruff, & Eaton, 1943; Goadby & Goadby, 1949).

This does not mean that the sweat itself carries the current. The minute amount of sweat usually secreted is insufficient of itself to account for the passage of the current; moreover, the EDR is discernible even before the sweat appears. It seems rather that there is some mechanism in the sweat gland cell which produces both the EDR and the secretion of sweat.

It has already been noted that the electrodermal phenomenon has borne many different names. Veraguth in 1906 called it the psychogalvanic reflex (PGR), but many recent investigators dislike

this term. They claim that the phenomenon is not really a reflex, not necessarily of psychic origin, and not really galvanic. Woodworth (1954) considers galvanic skin response (GSR) a better term and electrodermal response (EDR) still better.

Through 1946 Psychological Abstracts indexed articles about this phenomenon under the heading galvanic reflex, but during 1947 and 1948 changed to psychogalvanic reflex (PGR). From 1949 through 1958 the term galvanic skin response (GSR) was used, but since 1959 this has given way to electrodermal response (EDR). In accord with what seems to be the current trend, the phenomenon will be referred to as the electrodermal response (EDR) in the body of this paper. However, in the reference list at the end of this paper each article will be cited as it appears in the publication from which it has been taken.

## CHAPTER II

### A REVIEW OF THE LITERATURE

The electrodermal response (EDR) has enjoyed considerable popularity as a research topic, being used by many investigators in the study of physiological and psychological dimensions of personality. It has been investigated, for example, as an index of subliminal perception (McCleary & Lazarus, 1949), of frustration (Freeman, 1940a; Jost, 1941; Hulbert, 1957; Schwartz, 1957), and of affective tension (Bloch, 1952; Greenberg & Carpenter, 1957). It has been employed in tests of conditioning and extinction (Grings & O'Donnell, 1956, and many others) and of vision (Wagner, 1950). It has been used to determine the auditory threshold (Girden, 1952; Doerfler & McClure, 1954; Buck, 1958; Hind, Aronson, & Irwin, 1958), especially in cases of deafness of suspected psychogenic origin (Bordley & Hardy, 1949; Knapp & Gold, 1950). It has been used to determine customers' preferences in music (Henkin, 1957) and in advertising (Echstrand & Gilliland, 1948; Golin & Lyerly, 1950) and to explore the autonomic nervous system (Copelman, 1951; Fraisse & Bloch, 1957). Hansel (1951) devised an interesting experiment, potentially important in social psychology, by wiring several subjects into the same electrical circuit and measuring the EDR of the group.

Other investigators have preferred to concentrate on the phenomenon itself, endeavoring to learn what it is and how it works. They have shown that the EDR is associated with massive bodily movements, such as yawning, deep breathing, coughing, and stretching (Starch, 1910). The resistance of the skin rises during sleep but it drops again as soon as a person engages in any sort of wakeful activity (Farmer & Chambers, 1925; Richter, 1926; Ryan & Ranssen, 1944; Levy, Thaler, & Ruff, 1958). Skin resistance has been reported to vary directly with the temperature (Weisgerber, 1951; Behr, Preber, & Silfverskjold, 1955), but Venable (1955) disputes this finding. He claims that only neurotic subjects are affected by temperature changes, whereas changes in humidity affect both neurotics and normals. The resistance level apparently rises toward midday and falls toward evening, and this trend seems to be unaffected by the individual's pattern of eating and sleeping (Essen & Hansen, 1940); however, Conklin (1951) has reported a certain adaptation of this diurnal trend. The EDRs of identical twins are more similar than are those of fraternal twins, and both are much more alike than the responses of unrelated pairs (Ohira, 1956).

The EDR is not correlated with any recognized somatic index (Lacey, Siegel, & Siegel, 1949), but it does seem to indicate something about a person's mental state. It is higher among hysterics than among neurasthenics (Shirokov, 1937), and it is almost entirely missing among organic defectives (Redlich, 1945; Ellis & Sloan,

1958). It can be extinguished under hypnosis (West, Niell, & Hardy, 1952). Hoch, Kubis, and Rouke (1944) found a distinctive pattern among psychotic patients, which led these investigators to question the validity of using physiological indexes, such as the so-called "lie detector," in the testing of suspected criminals, many of whom are at least borderline psychotics.

The EDR is not subject to voluntary control (Kehres, 1956), and experiments in which the subject has attempted to inhibit or to exaggerate his EDR have given negative results. There seems also to be an inverse correlation between the magnitude of the EDR and the intensity of the subject's external reaction to an apparently threatening situation, but this relationship needs further study (Freeman, 1940b; Conklin, 1951).

The literature reveals a persistent effort to correlate the EDR with particular emotions or, failing that, with emotional life in general. For instance, Marinescu, Copelman, and Stanescu (1937) claim that the EDR is so successful in revealing one's emotional life that the "criminal type" of person can be successfully discriminated in this way. Hsü (1951) claims that he can draw the personality profiles of his subjects from their EDR records when they associate some past experience of their own with the emotion-charged verbs which he gives them. A few other investigators have assumed a connection between the EDR and emotionality (e.g., Golla, 1948; Cardu, 1954), but most have preferred to study this connection without prior assumptions.



Bayley (1928) and Patterson (1930) used stimuli which were intended to elicit largely fear and surprise. When they asked their subjects to report not only the intensity of their emotions but the kind of emotion as well, they found that the largest EDR deflections were associated with emotions reported as startle, while the least were for those reported as relief and indifference. Davis (1930) found that any sort of mental work yields large EDR deflections, the more so when the surrounding atmosphere is full of distractions. Sears (1933) found a positive correlation between the EDR and demands for speedy or difficult work. Thiesen and Meister (1949) found that the EDR was a good measure of children's frustration, while Küppers (1954) found the horizontal wavy EDR curve to be characteristic of heightened emotional involvement in attempted problem solving. Moreover, Freeman (1940b) has shown that these EDR deflections are related to subjective effort rather than to the performance level of the task itself.

Increased tension, measured operationally in the performance of a task, is related to an increase in EDR conductance (Staudt & Kubis, 1948; Venables, 1956), whereas failure tends to decrease conductance, perhaps as the result of depression and disappointment (Mizushima, 1954). Large EDR deflections have been found associated with strong attitudes of any sort (Cooper & Singer, 1956), but especially with strong racial or national bias (Cooper & Siegel, 1956), with hostility (Burdick & Burnes, 1958), and with

fear and embarrassment, particularly over sexual problems (Dittes, 1957a).

In addition to these studies which have sought to link the EDR with emotionality in general, there have been several which have directly investigated its connection with anxiety. Patients diagnosed as suffering from neurotic anxiety tend to acquire EDR conditioning more readily (Welch & Kubis, 1947) and extinction less readily (Bitterman & Holtzman, 1952) than normal subjects. Dittes (1957b) found that large EDRs indicated the patient's anxiety or his "mobilization" against any cue which threatened punishment by the therapist, such as a cue which he had learned to perceive as evidence of low esteem. Martin (1956) found that subjects who had attained high anxiety scores on the Taylor Manifest Anxiety Scale (MAS) tend to lose their anxiety as a function of repeated sessions with the same therapist, who presumably became less threatening as they came to know him better. Grant and Patel (1957) have found that the conceptual behavior of subjects who score high on the MAS is somewhat more vulnerable to anxiety-producing stimuli than is the conceptual behavior of subjects who score low on this scale.

Of the many different stimuli which have been used to elicit the EDR one of those used most frequently has been the presentation of emotionally-charged words. Some investigators have asked their subjects to free associate to these words, while others have been content to measure the EDR associated with the mere percep-

tion of such a stimulus. Peterson and Jung (1907) were apparently the first to use emotional words for this purpose. They believed that the EDR was an index, not entirely of conscious emotion, but often of an unconscious emotion, the stirring of which by a stimulus word would elicit the EDR as a physiological expression of emotion. Using the EDR as part of a free association test with verbal stimuli, they concluded that the response must be caused by the meaning which the subject attaches to the individual words, since there is a differential response to the various words.

Wells and Forbes (1911) asked their subjects to estimate the intensity of their emotional response to each of a series of stimulus words. They found that the average magnitude of the EDR corresponded to the reported magnitude of the emotional experience, but that there were many exceptions. Smith (1922) presented a list of emotionally-toned words to a group of well-educated subjects and concluded from their reactions that the EDR was a good measure of emotion. Syz (1926) read a list of words to his subjects, then asked each one to report which words had most aroused his emotions. He found many discrepancies between the reported emotional level and the EDR, but concluded from this that the EDR is a better index of emotion than is the verbal report. Dysinger (1931) found EDR deflections greatest for words reported as being very unpleasant, almost as great for those reported as being very pleasant, and least for those reported as being indifferent. McGinnies (1949) reported large EDRs from emotionally-toned words,

as did Johnson (1951), who used words with psychosexual import. Herr and Kobler (1953) designed a list of sixteen emotionally-toned words which were thought to distinguish neurotics from normals, and Cabanski later (1958) used the same list in his comparison of the EDR with certain categories of the MMPI. Jacobs (1955) found that the degree of difficulty which the subject experienced in forming new associations to previously associated words reflected inversely the amount of emotionality which was attached to these words.

Several investigators have also studied the EDRs produced during administration of the Rorschach test (Kubis, Rockwell, & Fisichelli, 1946). They reported that cards VI through X elicited larger EDRs than the earlier cards, especially when psychotic patients were used as subjects (Niimi, Hashimoto, Mochizuki, & Ohno, 1956). Card VIII evoked the largest EDR of all (Levy, 1950).

Some of these studies seem to have fallen into the error of which Landis and Hunt (1935) warned all EDR investigators. "The EDR," they wrote, "is associated with such a variety of mental states that, by employing stimuli suited to produce only one mental state, as many investigators have done, a fallacious case can be constructed for its connection with that one state." To avoid this pitfall themselves, Landis and Hunt presented their subjects with a variety of stimuli calculated to arouse fear, amusement, sex emotion, pleasantness, unpleasantness, and other states. They concluded that the EDR is "more nearly related to startle or to

tension than to anything else." Jones (1950) engaged in a similar study and concluded from his findings that the EDR gives a clue to the strength of the provocative stimulus, but does not reveal the specific emotion elicited.

Abel (1930) claims that the EDR is an index, not so much of feeling or emotion, as of an attitude of the organism directed toward overcoming a difficulty. In this he seems to second Thouless' opinion (1925) that the EDR is a sign of bodily preparedness to react to a threatening stimulus. For a long time Woodworth left open the question of whether or not the EDR measures emotion, but he finally decided (1954) that it should be considered an index of the level of activation, not necessarily identified with emotion. He described it as a "transient burst that anticipates increased demands on the subject." At the present time, therefore, it seems that the EDR should not be considered an index of emotionality but rather of the level of activation, "more nearly related to startle or to tension than to anything else." (Landis & Hunt, 1935).

Another topic which has enjoyed wide discussion in the literature is the unit of measurement which should be used for analyzing the data of the EDR. Darrow (1937a) found that, when resistance scores are analyzed without reference to the basic resistance level of the subject, the distribution of scores is markedly skewed. This is not surprising, since the EDR is generally acknowledged to indicate a deviation from normal homeostatic conditions within the organism. Several investigators have suggested using conductance

scores (Lacey, 1947, and others), but these are not notably better than resistance scores, since conductance is merely the reciprocal of resistance.

In 1940 Hovgland and Riesen suggested from Copenhagen that logarithmic conductance scores be used, but their suggestion was not heeded at once. Sherman and Jost (1942) preferred to use the percentage change of resistance, while Freeman and Katzoff (1942) preferred the percentage change of conductance. Haggard (1945) showed that unconverted resistance or conductance scores are inadequate measures and later proposed (1946) a logarithmic transformation, which has come to be known as the "Haggard transformation." This transformation involves the addition of an empirically-determined constant to the logarithm of the resistance change before dividing the sum by the basic level of resistance. For ease of calculation the quotient is multiplied by a constant large enough to remove decimals throughout. The Haggard score is computed as follows:

$$\text{Score} = \frac{\log \text{ resistance change} + K}{\text{basic resistance level}} \times 10^b$$

But Haggard's transformation has not won universal acceptance. In 1947 Lacey still preferred untransformed conductance scores. In another article (1949) Haggard discussed resistance change, conductance change, logarithmic resistance change, and logarithmic conductance change. He decided once again that the modified logarithmic resistance change, the so-called "Haggard transformation,"

was the most appropriate unit, because it best satisfied the criteria of additivity, normality, homogeneity of variances, randomness, independence of means and variances, and maximal precision. Lacey (1949) acknowledged that either conductance scores or logarithmic conductance scores were acceptable units.

Paintal (1951) suggested that the proper unit was the ratio of the resistance change to the maximum resistance change obtained for each subject, arguing that these ratios should be preferred to any transformation scores in which the individuality of the subject was lost. Elliott and Singer (1953) have supported Paintal's findings, but Niimi and Hashimoto (1953) have continued to use the percentage change of conductance, while Schlosberg and Stanley (1953) have preferred the square root of the conductance.

Grant (1956) used analysis of variance tests but found that even these did not constitute a universally acceptable method of analyzing and comparing trends in his EDR data. He concluded that "no such method can exist and no routine can substitute for an experimenter's insight and ingenuity."

Haggard's transformation has not won universal acceptance but it seems to be used more frequently in the published research than any other single unit of EDR measurement. However, it may yet turn out that each different set of stimulus conditions requires a different kind of transformation, if the resulting scores are to be manipulated by means of parametric statistics.

## CHAPTER III

### INVESTIGATION OF THE PROBLEM

Anxiety is a state of emotional tension characterized by apprehension and fearfulness (Coleman, 1956, p. 641). Though it is similar to fear, it can be distinguished in this way. Fear is a response to an actual, present, external danger. This response does not persist, since the danger is soon eliminated either through conquest or escape. Anxiety, on the other hand, is a response which is not referable to specific objects or events. It often arises from frustrations, dissatisfactions, insecurity, hostility, or other interpersonal issues, and is one of the most distressing and intolerable of mental states (Noyes & Kolb, 1958, p. 117).

Is it possible to detect an anxious person from the record of his EDR? Put another way, is there a correlation between a person's EDR and his state of anxious tension? This is the question which has led to the present investigation.

It may seem that the work reviewed in the previous chapter should have discouraged further efforts to correlate the EDR with any form of emotionality. However, closer scrutiny of that review will show that, while the EDR is apparently not correlated with any specific emotion, apparently it is related to tension (Landis



& Hunt, 1935) and is a sign of bodily preparedness to react to a threatening stimulus (Thouless, 1925) or to overcome a difficulty (Abel, 1930).

According to Woodworth (1954, p. 159) the biggest problem in attempting to correlate the EDR with emotion has been caused by the prevalence of a wrong concept of emotion. He suggested that we stop thinking of emotion as being a special sort of mental or behavioral state and begin to use emotion to describe the individual who is highly energized, active, tense, or activated. "For emotion in this sense both the basic level of conductance and the EDR are pretty good measures, since they reflect various degrees of activation and of readiness for action, ranging from sleep to rage." He feels that, while the EDR may not be measuring traditional emotion in these instances, it is measuring a much more fundamental dimension of behavior.

If the EDR is indeed a sign of bodily preparedness to react to a threatening stimulus or to overcome a difficulty, then it seems reasonable to investigate the possible correlation of the EDR with other instruments which purport to measure similar psychological dimensions. One such instrument is the MAS, which Taylor constructed according to the description of anxiety reaction given by Cameron. "Anxiety," writes Cameron, "is the predominantly

covert skeletal and visceral reaction which for an unhampered and uninhibited person constitutes the normal preliminary phase of emotional flight, but which for some reason is prevented from going on into its consummatory phase. The pulse, blood-pressure, and respiratory rate increase, gastrointestinal functions alter

characteristically, kidneys are overactive, tremors and other signs of skeletal tensions appear, the pupils dilate, sweating is present, and the mouth goes dry. (Cameron, 1947, p. 147).

As several references in the previous chapter have shown, the testing of known or suspected anxiety neurotics with the EDR is not a new procedure. Neither is this the first time that a correlation of the EDR with the MAS has been attempted.

Schiff, Dougan, and Welch (1949) reported a correlation of .52 between clinically-diagnosed anxiety and the EDR. A few years later when Herr and Kobler (1953) published their study of the discrimination between neurotics and normals by means of emotionally-toned words, they reported their suspicion that a general anxiety factor seemed to run through the entire list of words. Then Caban-  
ski (1958) used the same words in attempting a correlation with the anxiety index originally reported by Welch (1952).<sup>1</sup>

Raphelson (1957) attempted a multiple correlation of the MAS, the EDR, the Need Achievement Test, and the Mandler-Saranson Test Anxiety Questionnaire. He found that the MAS and the Test Anxiety Questionnaire were positively correlated (.53), but that the Need Achievement Test was not correlated with either of them. The EDR, on the other hand, yielded positive correlations with the Need Achievement Test and with the Mandler-Saranson Questionnaire but

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<sup>1</sup>The "anxiety index" developed by Welch (1952) employs several categories of the MMPI. It is calculated as follows:

$$\text{Anxiety Index} = \frac{Hs + D + Hy}{3} (D + Pt) - (Hs + Hy)$$

not with the MAS. This seemed like an invitation to further research; thus, it was decided to investigate the correlation of the EDR with the MAS.

While the details of this project were still being worked out, Barratt (1959) reported his new Impulsiveness Scale (IS) and his efforts at correlating it with the MAS. He claimed that his results indicated a need for the IS, since it measured a dimension different from that measured by the MAS. A search of the literature failed to reveal any previous attempt to correlate either the EDR or the MAS with the IS, and so it was decided to incorporate this attempt into the design of the present experiment.

A word about the reliability and validity characteristics of these test measures is in order. In constructing the MAS, Taylor asked five clinicians to choose from among 200 selected MMPI items those which they considered most indicative of chronic anxiety reaction, as that syndrome has been described by Cameron. The 65 items which they agreed upon were combined with 135 buffer items and tested on 352 student subjects. Scores ranged from 1 to 36, with a median score of 14. The revised version of the MAS uses only 50 of these 65 items, but includes 41 items taken from a scale of rigidity developed by Wesley and includes also most of the L-, K-, and F-scale items of the MMPI. This version was standardized on 1,971 subjects and yielded a median score of 14.56. It has a retest reliability of .89 after three weeks (N:59), of .88 after four weeks (N: 179), of .82 after five months (N: 113), and of

.81 after 9-17 months (N: 50). With the anxiety scale of the MMPI used as a criterion, the MAS shows a validity coefficient of .68. In addition, the test author reports a "high correlation" of her scale with clinical diagnosis of neurotics and psychotics (N: 103) from which she concludes that there "seems to be some relationship between the anxiety-scale scores and the clinical observation of manifest anxiety." (Taylor, 1953, p. 290).

In constructing the IS, Barratt employed operational definitions of anxiety and impulsiveness, defining these as the dimensions measured by the MAS and the IS, respectively. He based his IS scale on the Impulsiveness Scale of the Thurstone Temperament Schedule but included several new items and some rewritten from other scales. The IS has a retest reliability of .87 after an interval of one month (N: 300). No validity coefficients have been reported and the test author admits that the construct validity of the scale is in need of clarification. Barratt's work showed that the MAS and the IS are not significantly related ( $R: -.075$ ; N: 240). Nevertheless, he claims that both are significantly related to emotional instability, with the MAS showing a much higher relationship to emotional instability than does the IS.

## CHAPTER IV

### DESCRIPTION OF SUBJECTS, APPARATUS, AND PROCEDURE

Subjects. The subjects used in this experiment were white male college students who had volunteered their cooperation. They ranged in age from 22.3 years to 32.3 years, with a median age of 24.3 years. All had completed at least three years of liberal arts course in college. Most were currently engaged in graduate studies at the Loyola University Summer School.

Apparatus. A Leeds and Northrup moving-coil type of galvanometer with mirror attachment was used in this experiment. The galvanometer was arranged in the form of a Wheatstone bridge. When the galvanometer is arranged in this way, three arms of the bridge contain known constant resistances, while the fourth arm consists of a large, adjustable resistance in series with the subject. When the level of the subject's resistance changes—it usually declines in the course of an experimental sitting—the resistance in series with him is adjusted so as to compensate for his changed resistance. In this way the total resistance in the subject's arm of the bridge is kept constant. Since the resistance in the circuit and the impressed voltage are also constant, a constant current—in this experiment, 160 microamperes—is maintained and

measurement in absolute units is possible.

A light was focused on the galvanometer mirror in such a way that, when the galvanometer was balanced, the reflected beam fell at or near the zero mark on a visual scale, which was calibrated in millimeters. Any change in the subject's skin resistance caused the galvanometer mirror to shift and the beam of light to move across this visual scale. Placed directly behind this scale was the camera box which contained a roll of photosensitive electrocardiograph paper—Kodak #554, 70 mm wide and 30.5 mm long. This paper was drawn past a slit in the box at the rate of 73 mm per minute by a synchronous motor connected to the galvanometer mechanism. Another light, mounted so as to shine at the extreme left of the visual scale and thus recorded at the extreme left of the photographic record, flashed on and off at intervals of one second, thereby giving a photographic record of the overall timing of the experimentation. Wired into circuit with this flashing light was a telegraphic key, which allowed the experimenter to record the instant at which the stimulus word was presented and the instant at which the subject responded, thus providing a permanent record of the latency of the EDR and of the verbal response.

Two copper electrodes, 60 mm long and 12 mm wide, were connected to the galvanometer circuit and immersed, one each in a small glass cup containing 0.1 N sodium chloride solution. The subject was "wired" into the circuit by placing his first finger of his right hand in one of these cups and the third finger of the same

hand in the other.

The room in which this experimentation took place was a booth in the Loyola Lake Shore Campus perception laboratory, 11 feet long, 6 feet wide, and 7.5 feet high. Ceiling and sound-proofed walls were painted battleship grey. The floor was covered with grey linoleum tile. An exhaust fan in the ceiling provided for the circulation of fresh air.

Procedure. Each subject was met by the experimenter, asked to wash his hands thoroughly, so as to remove all dirt and perspiration, then ushered into the booth just described. As soon as it was judged that rapport had been established, the subject was given the following instructions:

You have probably heard of free association tests already. This is a similar sort of test. I am going to read you a list of words, one at a time, and I want you to tell me as quickly as possible the first word which each of these words brings to mind. May I emphasize this point, that I want you to answer with the first word which comes to mind, no matter what that word is. And I want you to answer as quickly as possible. Do you understand? (pause)

Now would you please put the first and third fingers of your right hand into these cups, one finger into each cup. (adjust the arm rest) Is that comfortable now?

Occasionally I will have to make a few adjustments on this gadget here. This may take a few minutes, so please do not become disturbed or think that anything has gone wrong. I shall tell you when we are finished with the test. Now may I ask you to close your eyes gently and to keep them closed until the test is finished. (pause) Please take a good deep breath. (pause) Another good deep breath, please. All right now, here is the first word.

The deep breaths were intended to help the subject relax. While he was taking these breaths, the machine was turned on and the galvanometer engaged, but the protective shunt was still operative. Gross adjustments of the variable resistance were made until the beam of light reflected from the galvanometer mirror was near the zero point on the visual gauge. Then the shunt was disengaged and a fine adjustment of the variable resistance was made. The synchronous motor used to draw the photosensitive paper past the slit in the camera box was not yet engaged, nor was the timing device in use.

When the galvanometer beam was steady and approximately at the zero point of the scale, the first buffer word was presented to the subject. While these neutral words were being given, the galvanometer sweeps were observed visually but not recorded photographically. When it seemed that the subject was relaxed and ready for the test proper, the switch controlling the synchronous motor and the illuminated timing device was thrown and the first stimulus word was presented.

In the list of stimulus words which follows those words which are printed in capitals are the words of supposed emotional tone. Those in lower case are the neutral buffer words.

chair - house - floor - table - tree - SICK - clock -  
HIGH - glass - LOVE - bell - AFRAID - chair - SIN -  
flower - CLOSED - noise - HOSPITAL - sand - ASHAMED -  
subway - SEX - white - OPEN - horse - PAIN - country -



GOD - shoe - SWEETHEART - window - TROUBLE - far -  
CHURCH - cloud - BREAST

At the start of the experimentation as many buffer words were given as were needed to bring the subject to a state of apparent relaxation. Once the first emotionally-toned word had been given, however, the rest of the list was presented without interruption or variation.

After all the subjects had finished their sessions with the psychogalvanometer, each one was asked to complete the MAS and the IS. Finally, introspections and comments upon the whole scheme of the experimentation were invited and recorded.<sup>1</sup>

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<sup>1</sup>The significant items of the MAS are listed in Appendix I; the significant items of the IS are listed in Appendix II.

## CHAPTER V

### RESULTS AND CONCLUSIONS

Since there is an interval of several seconds between the presentation of the stimulus and the beginning of the EDR deflection, it is quite easy to measure the size of the deflection visually. For this reason the only data recorded during the experimental sessions were the subject's verbalizations and the experimenter's estimate of the subject's basic resistance level (expressed in ohms) and the size of his EDR (expressed in millimeters). Examination of the photographic record at a later time yielded a measure of the latency of the subject's verbal and electrodermal responses and an accurate measure of his basic resistance level and of his EDR.

Calibration of the galvanometer showed that each millimeter of deflection represented a change of 20 ohms in the subject's skin resistance. When the deflection measurements had been converted in this way into measures of resistance change, the Haggard transformation (discussed on pages 14 and 15 of this paper) was used to calculate the EDR "score" for each presentation of each stimulus word.

Several reasons prompted the use of the Haggard transformation in preference to one of the other measures discussed in Chap-

ter II of this paper. First, Herr and Kobler (1953) found that the simple Paintal ratio was inadequate, while Paintal himself (1951) found that the results obtained by using his formula were closely correlated with those obtained by using the Haggard transformation. Second, use of the Haggard transformation makes it possible for the results of the present investigation to be compared with the results obtained by Herr and Kobler (1953, 1957) and by Cabanski (1958), all of whom used the Haggard scores.

It was determined that the empirical constant which is to be algebraically added to the logarithmic resistance change in the Haggard formula for these data is  $-2.45$  and that each score became most manageable when all scores had been multiplied by  $10^7$ . Thus, the transformation actually used in analyzing these data is computed as follows:

$$\text{Score} = \frac{\log \text{resistance change} - 2.45}{\text{basic resistance level}} \times 10^7$$

Forty-three students had originally volunteered for this project, but the records of three of them were excluded because they had not completed all the phases of the experimentation. Two others were excluded because the photographic records of their EDR deflections were defective. The results reported in this paper have been obtained from the records of the remaining 38.

The 16 scores for each subject were calculated in accordance with the formula given above, then averaged so as to yield a mean EDR value for each subject. The MAS and the IS were scored accor-

ding to the directions given by the test authors. These results are given in Table 1.

Since preliminary trials indicated that the EDR scores and the results of the MAS were homoscedastic and approximated a normal distribution, it was decided to calculate a Pearson product-moment coefficient of correlation for these data. This calculation revealed a correlation of .14 between the EDR and the MAS, a correlation of .14 between the EDR and the IS, and a correlation of .07 between the MAS and the IS. None of these correlations is statistically significant.

The chi-square test for normality of distribution, however, had shown that the data of the IS did not approximate a normal distribution as closely as the other data did. For this reason it was decided to compute the non-parametric Spearman rank-order coefficient of correlation also. This revealed a correlation of .14 between the EDR and the MAS, a correlation of .19 between the EDR and the IS, and a correlation of .09 between the MAS and the IS. None of these correlations is statistically significant.

Low-order correlations of this sort do not warrant apodictic assertions. However, it seems reasonable to conclude that the EDR is not a significant index of anxiety or of impulsiveness, as these dimensions are measured by the MAS and the IS. Barratt's claim that his IS measures a dimension which is not measured by the MAS seems to be supported. Whether his scale is a valid measure of this other dimension, however, remains open to question.

Table 1  
Results of the EDR, the MAS, the IS,  
and the Herr-Kobler Neurotic Ratio  
for 38 Male College Students

Subject Number	Mean EDR	MAS	IS	Herr-Kobler Ratio
1	474	14	25	1.033
2	364	12	15	1.179
3	454	5	18	1.033
4	275	10	19	.686
5	282	13	15	1.482
6	271	12	30	.894
7	395	9	24	.854
8	212	19	24	.705
9	117	26	20	.604
10	357	9	9	.895
11	506	24	19	1.245
12	343	10	25	1.019
13	330	9	18	1.061
14	387	9	30	1.094
15	192	0	16	.478
16	182	19	15	.372
17	487	3	16	.903
18	365	13	11	.879
19	336	18	25	1.029

Table 1 (cont'd)

Subject Number	Mean EDR	MAS	IS	Herr-Kobler Ratio
20	369	19	20	.729
21	324	17	15	1.007
22	278	3	14	.925
23	138	3	17	.612
24	471	8	27	.924
25	272	15	11	.893
26	259	5	30	.920
27	383	14	21	.798
28	343	19	27	1.016
29	475	13	19	.941
30	215	14	14	.628
31	236	7	19	.915
32	315	8	21	.559
33	376	7	29	.976
34	359	17	31	.823
35	568	21	11	.805
36	219	3	14	.966
37	597	17	23	.930
38	421	17	28	.912
Mean	340.72	12.13	20.13	.887
S.D.	111.70	6.22	6.09	.210

Cabanski found "no correlation even approaching significance between the EDR and the anxiety index" developed by Welch in 1952. (Cabanski, 1958, p. 23) Raphelson (1957) found no significant correlation of the EDR with the MAS. Thus, if Welch's index and the MAS actually measure anxiety and if the investigations by Raphelson and Cabanski are reliable, it is not surprising that the correlation of the EDR with the MAS which is reported in this paper is so low. In fact, this result can be interpreted as confirming the results of all four earlier investigators, namely, Welch, Taylor, Raphelson, and Cabanski.

The questions which originally prompted this study have now been answered, but there are many other ways in which these data can be used. Since the list of stimulus words was the same as that administered by Herr and Kobler (1953, 1957) and by Cabanski (1958), the mean EDR for each word was calculated and compared with the mean EDRs found in the earlier investigations. These results are given in Table 2.

A comparison of the mean values for each stimulus word, as found in the three studies, reveals striking similarities. For instance, open elicited the smallest EDRs in all three studies. Church, high, trouble, afraid, and sweetheart occupied very nearly the same relative positions on each list, whereas four words—sex, sin, love, breast—caused the largest EDRs in all three studies, though not always in exactly the same rank order. The ranks for all 16 stimulus words are given in Table 3.

Table 2

Comparison of Mean EDR Values for 16 Stimulus Words  
as Reported in Three Different Studies

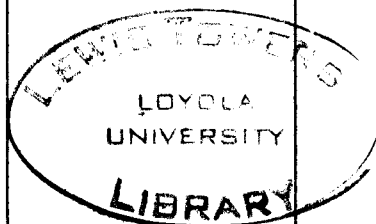
Stimulus Word	Herr-Kobler		Cabanski		Williams	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
sick	338	151	393	132	338	155
high	258	137	408	114	307	135
love	468	178	507	126	409	113
afraid	348	133	443	163	349	139
sin	386	158	503	190	403	121
closed	214	124	434	254	306	149
hospital	240	132	419	233	283	117
ashamed	317	193	493	247	391	156
sex	403	173	501	202	426	119
open	126	94	293	183	240	151
pain	218	137	420	287	291	158
God	258	178	467	227	347	143
sweetheart	360	209	466	191	398	123
trouble	308	202	441	211	313	148
church	231	155	393	253	283	101
breast	394	198	516	189	429	129
Mean	303		443		342	



Table 3

Rank-Order of 16 Stimulus Words, as Measured by EDRs  
and Reported in Three Different Studies

Rank	Herr-Kobler	Cabanski	Williams	Rank
1	breast	love	breast	1
2	love	sex	sex	2
3	sin	breast	love	3
4	sex	sin	sin	4
5	ashamed	sweetheart	sweetheart	5
6	God	afraid	ashamed	6
7	sweetheart	sick	afraid	7
8	afraid	ashamed	God	8
9	trouble	trouble	sick	9
10	closed	God	trouble	10
11	pain	high	high	11
12	hospital	hospital	closed	12
13	high	church	pain	13
14	sick	pain	church	14
15	church	closed	hospital	15
16	open	open	open	16



That the similarity of results in these three studies is not merely an apparent one was determined by calculating the Spearman rank-order coefficients of correlation for the several pairs of studies. The present study yielded a correlation of .90 with the Herr-Kobler results and a correlation of .94 with the Cabanski results, while the Herr-Kobler and the Cabanski results had a correlation of .80 with each other. All of these correlations are significant beyond the .01 level of confidence.

Two other investigators whose work has not been published have also found highly significant rank-order correlations with the Herr-Kobler rankings of the stimulus words.<sup>1</sup>

The Herr-Kobler study (1953) involved the calculation of a "neurotic ratio," with which it was hoped that neurotic patients could be distinguished from normals. This ratio is obtained by dividing the mean EDR elicited by five words—high, closed, open, pain, God—by the mean EDR elicited by four other words—sick, sweetheart, trouble, church. Herr and Kobler reported a mean neurotic ratio of .80 for normals, with a standard deviation of .09, whereas diagnosed neurotics had a mean neurotic ratio of 1.19, with a standard deviation of .12.

The neurotic ratios for the subjects used in the present study have been given in Table 1. The mean neurotic ratio for

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<sup>1</sup>Private communication from the Reverend Vincent V. Herr, S.J., chairman of the department of psychology, Loyola University, Chicago, Illinois. The data to substantiate these correlations are in his possession.

this group (.89) compares favorably with the Herr-Kobler index of normality. However, the large standard deviation of the present group (.21) indicates that there are several high-ratio subjects included in the group. Inspection of the individual ratios reveals that two subjects have neurotic ratios higher than the neurotic mean reported by Herr and Kobler, whereas one subject—#5—exceeds that mean by more than two standard deviations.

Ranking each subject according to his neurotic ratio gave a Spearman rank-order correlation coefficient of .14 with the IS, exactly the same value as the Pearson product-moment correlation of the IS with the mean EDR. The Spearman correlation of the neurotic ratio with the MAS, however, was  $-.06$ . Neither of these correlations is statistically significant.

## CHAPTER VI

### SUMMARY

The EDRs of 43 male college students were recorded photographically as these subjects gave free-association type responses to the list of 16 emotionally-toned words standardized by Herr and Kobler (1953). Each subject also completed the Taylor Manifest Anxiety Scale (1953) and the Barratt Impulsiveness Scale (1959). The results of the 38 records used in this study indicate no significant correlations of the EDR with either of these scales nor of these two scales with each other.

The neurotic ratio reported by Herr and Kobler (1953) was calculated for these same subjects, but gave no significant correlations with either of the scales. However, the rank order of the emotionally-toned stimuli, reported by Herr and Kobler (1953) and confirmed by Cabanski (1958) and others, was reconfirmed.

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## APPENDIX I

### SIGNIFICANT ITEMS OF THE TAYLOR

#### MANIFEST ANXIETY SCALE

Note: After each item is given the score—either "T" for true or "F" for false—which according to the test author is indicative of manifest anxiety.

1. I do not tire quickly. (F)
2. I am troubled by attacks of nausea. (T)
3. I believe that I am no more nervous than most others. (F)
4. I have very few headaches. (F)
5. I work under a great deal of tension. (T)
6. I cannot keep my mind on one thing. (T)
7. I worry over money and business. (T)
8. I frequently notice that my hand shakes when I try to do something. (T)
9. I blush no more than others. (F)
10. I have diarrhea once a month or more. (T)
11. I worry quite a bit over possible misfortunes. (T)
12. I practically never blush. (F)
13. I am often afraid that I am going to blush. (T)
14. I have nightmares every few nights. (T)
15. My hands and feet are usually warm enough. (F)
16. I sweat every easily even on cool days. (T)

17. Sometimes, when embarrassed, I break out in a sweat which annoys me greatly. (T)

18. I hardly ever notice my heart pounding and I am seldom short of breath. (F)

19. I feel hungry almost all the time. (T)

20. I am very seldom troubled by constipation. (T)

21. I have a great deal of stomach trouble. (T)

22. I have had periods in which I lost sleep over worry. (T)

23. My sleep is fitful and disturbed. (T)

24. I dream frequently about things that are best kept to myself. (T)

25. I am easily embarrassed. (T)

26. I am more sensitive than most other people. (T)

27. I frequently find myself worrying about something. (T)

28. I wish I could be as happy as others seem to be. (T)

29. I am usually calm and not easily upset. (F)

30. I cry easily. (T)

31. I feel anxiety about something or someone almost all the time. (T)

32. I am happy most of the time. (F)

33. I have periods of such great restlessness that I cannot sit long in a chair. (T)

34. Sometimes I become so excited that I find it hard to get to sleep. (T)

35. It makes me nervous to have to wait. (T)

36. I have sometimes felt that difficulties were piling up so high that I could not overcome them. (T)

37. I must admit that I have at times been worried beyond reason over something that really did not matter. (T)

38. I have very few fears compared to my friends. (F)

39. I have been afraid of things or people that I know could not hurt me. (T)

40. I certainly feel useless at times. (T)

41. I find it hard to keep my mind on a task or job. (T)

42. I am unusually self-conscious. (T)

43. I am inclined to take things hard. (T)

44. I am a high-strung person. (T)

45. Life is a strain for me much of the time. (T)

46. At times I think that I am no good at all. (T)

47. I am certainly lacking in self-confidence. (T)

48. I sometimes feel that I am about to go to pieces. (T)

49. I shrink from facing a crisis or difficulty. (T)

50. I am entirely self-confident. (F)



## APPENDIX II

### SIGNIFICANT ITEMS OF THE BARRATT IMPULSIVENESS SCALE

Note: After each item is given the score—either "T" for true or "F" for false—which according to the test author is indicative of impulsiveness.

1. I like to be where there is something going on all the time. (T)
2. I remember the names of the people I meet. (T)
3. I like work in which I must change often from one task to another. (T)
4. I like to do things on the spur of the moment. (T)
5. I spend much of my leisure time out of doors. (T)
6. I like to play chess. (F)
7. I often make people laugh. (T)
8. I frequently forget things. (T)
9. I like detailed work. (F)
10. I make up my mind quickly. (T)
11. I like a great deal of variety in my work. (T)
12. I change my plans often. (T)
13. I easily become impatient with people. (T)
14. I don't like changes. (F)
15. I answer questions quickly. (T)

16. I don't like to wait for traffic lights to change. (T)
17. My friends consider me to be happy-go-lucky. (T)
18. I like mathematics. (F)
19. I consider myself always careful. (F)
20. I am always on time for social events. (F)
21. I don't like having my plans changed. (F)
22. I don't like to work with slow people. (T)
23. As a youngster I enjoyed taking part in reckless stunts.

(T)

24. I let myself "go" at a party. (T)
25. I frequently feel "on top of the world." (T)
26. I usually think before I leap. (F)
27. I like to solve complex problems. (F)
28. I like to work crossword puzzles. (F)
29. I like prompt people. (T)
30. I scan newspapers rather than read them carefully. (T)
31. I like to work at things requiring patience and careful-

ness. (F)

32. I usually have a ready answer. (T)
33. I keep a diary regularly. (F)
34. My interests tend to change quickly. (T)
35. I like new situations. (T)
36. When I see a train, I wish I were on it. (T)
37. I like work involving competition. (T)
38. I make up my mind easily. (T)

39. I change my plans often. (T)

40. I like to take a chance just for the excitement. (T)

41. I like work that has lots of excitement. (T)

42. I have more trouble concentrating than other people seem to have. (T)

43. In watching games I often yell along with the others. (T)

44. I usually notice the furniture arrangements in a strange house. (F)

45. In the morning I usually bound out of bed energetically.  
(T)

APPROVAL SHEET

The thesis submitted by Reverend Glenn Francis Williams, S.J. has been read and approved by a board of three members of the Department of Psychology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Arts.

2/2/61  
Date

Vincent V. Herr SJ  
Signature of Adviser