AN INVESTIGATION OF DIFFERENTIAL PUPILLARY AND GSR REACTIVITY BETWEEN GROUPS DIFFERING IN DEGREE OF EXTRAVERSION

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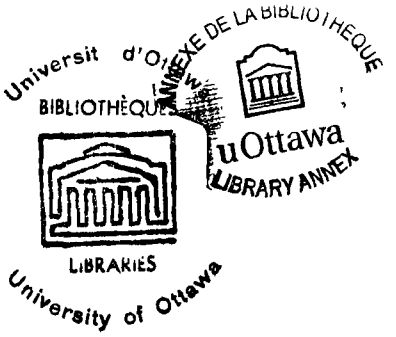
Thesis presented to the Faculty of Psychology of the University of Ottawa as partial fulfilment of the requirements for the degree of Master of Arts



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CURRICULUM STUDIORUM

Nathan Mandelzys was born January 28, 1947, in Montreal, Quebec. He received the Bachelor of Arts degree in Psychology from Loyola College, Montreal, Quebec, in 1969.

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INTRODUCTION

A recent review of the pupillometric research is replete with investigations which indicate that the pupillary response has considerable value as an objective index of an individual's emotional, cognitive and psycho-sensory experience. Although pupillometric research has considerable methodological and procedural problems, it is nevertheless clear that the pupil responds to activating or arousing stimuli. In recent years the concept of arousal, the existence of individual differences in arousal, and the relationship of these differences to personality have been the subject of considerable research and debate. There has, however, been little consideration of the pupillary response as an indicator of these individual differences in arousal in relation to personality.

The aim of this study is to identify the changes in pupillary reactivity, blink rate, ocular movements and Galvanic Skin Response latency and amplitude which accompany psycho-sensory stimulation within the context of Eysenck's theory of extraversion-introversion. An attempt will be made to clarify the nature of Hess's dilation-constriction hypothesis within this context as well.

In order to investigate the problem, subjects classified as Introverts, Ambiverts and Extraverts on the Eysenck Personality Inventory, and therefore assumed to have variable potentials in terms of cortical excitability, and hence arousal capability, will be utilized. In order to elicit the physiological response, neutral, affective and taboo words stimuli will be employed. It is well known that these stimuli elicit individual differences in responsivity as well as reflecting complex cognitive and affective reactions. In order to assess the effects of the stimuli on the subjects over time and to account for the Law of Initial Values with regard to the physiological responses, a pre-stimulus, stimulus and post-stimulus analysis will be undertaken. In addition, an attempt will be made to analyze the individual differences in the physiological responsiveness of the subjects with a view to clarifying the dilation-constriction hypothesis.

The first chapter of this paper is concerned with a review of the various theories and relevant studies which led to the development of the problem. This chapter ends with a statement of the hypotheses. The second chapter gives a description of the sample, tools, procedure and

scoring methodology. The third chapter presents the results. The final chapter involves a discussion of the results in terms of both hypotheses and problem evaluation. The implications and potential research in the area are also considered.

CHAPTER I

REVIEW OF THE LITERATURE

This chapter presents a review of the relevant theoretical and experimental work which were essential to the formulation of the problems to be reported in this paper. The chapter is divided into six sections. A brief review of the neuroanatomical and neurophysiological substrates of the pupillary response is followed by an analysis of the ways in which pupil size has been employed as a dependent variable in psychological research. Section three presents a discussion of the relationship between activation and personality, while the fourth section attempts to assess the relationship between the pupillary response and the concept of activation. Subsequently, there is a review of the relationship between the Galvanic Skin Response and arousal in relation to emotionally laden words. In the final section, a summary and a statement of the hypotheses are presented.

1. Neuroanatomical and Neurophysiological Substrates of the Pupillary Response.

In order to better understand the possible uses of pupillometry in assaying psychological conditions, a brief review of the neuroanatomical and neurophysiological substrates

of the pupil response is neccessary. Both the constriction and the dilation of the pupils are autonomic responses, with both sympathetic and parasympathetic and excitatory and inhibitory factors playing a role. Loewenfeld,[1] and Lowenstein and Loewenfeld,[2] have attributed psycho-sensory pupil dilation to four mechanisms: active sympathetic pathways to the dilator muscle; an inhibitory mechanism acting upon the Edinger-Westphal nucleus---the reflex center for constriction; and two adrenergic humoral mechanisms, adrenal epinephrine and another nonadrenal adrenergic substance. The same authors have attributed psycho-sensory pupil constriction to parasympathetic impulses, to a loss of sympathetic innervation, to a decrease of central inhibitions of the Edinger-Westphal nucleus either functionally or organically, or to cholinergic substances. Schaeppi and Koella,[3] however, have cited other evidence which suggests that the physiological basis of

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1 I.E. Loewenfeld, "Mechanisms of Reflex Dilatation of the Pupil", Documenta Ophthalmologica, 1958, 12, 185-448.

2 O. Lowenstein and I.E. Loewenfeld, "The Pupil", in H. Davson, (Ed.), The Eye, Vol. 3, N.Y., Academic Press, 1969, p. 256-329.

3 V. Schaeppi and W.P. Koella, "Adrenergic Innervation of Cat Iris Sphincter", American Journal of Physiology, 1964, 207, 273-278 (a).

pupillary phenomena may be more complex than this.

There is a growing volume of literature which points to higher cortical control of pupil size during some psychosensory reactions. Lowenstein and Loewenfeld[4] consider changes in pupil size of this type to be due to changes in the degree of cortico-thalamo-hypothalamic activity. Such activity is increased by sensory or emotional stimulation, or by spontaneous thoughts and emotions. The importance of thalamic and hypothalamic functioning upon the pupil of the eye is attested to by Gellhorn[5] who says that "pupillary dilation is one of the most constant symptoms observed on electrical stimulation of the hypothalamus." Also, as Lowenstein and Loewenfeld[6] have reported, destruction of the thalamus or hypothalamus in cats results in a significant reduction of pupil dilation.

The intimate relationship between the activities of the pupil and neurophysiological brain activities is further emphasized by the fact that the eye and the brain develop from

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4 O. Lowenstein and I.E. Loewenfeld, op. cit., 1969, p.315.

5 E. Gellhorn, "Autonomic Regulations, their Significance for Physiology, Psychology, and Neuropsychiatry," N.Y., Interscience, 1943.

6 O. Lowenstein and I.E. Loewenfeld, op. cit., 1969, p.307.

the same embryological neuroectodermal tissue.[7] The pupil acts as a collatoral tool of the brain in gathering and transmitting sensory data. This transmission of sensory data is a feature of pupillary behavior that generally operates at a nonverbal level and without conscious awareness.

Finally, it should be emphasized that the pupil is constantly influenced by sympathetic, parasympathetic and supranucleur cortical mechanisms. These are all simultaneously active to different degrees and on these structures various complex reflexes and reactions are superimposed.

2. The Use of Pupil Size as a Dependent Variable in Psychological Research.

Current pupillometric investigations began with a series of studies by Hess and his co-workers at the University of Chicago. Hess and his associates have suggested that dilation and constriction of the pupils reflect changes in ongoing mental activity and that the degree of pupillary activity reflects the degree of mental activity occurring.[8] They have also proposed that the pupillary response is a consistent indicator of interests, emotions, thought processes

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7 B.M. Patten, Human Embryology, Third Edition, N.Y., McGraw-Hill, 1968.

8 E.H. Hess and J.M. Polt, "Pupil Size in Relation to Mental Activity During Simple Problem Solving", Science, 1964, 143, 1190-1192.

and attitudes.[9,10,11] Hess has argued that stimuli which are liked, pleasant, or of positive interest value produce a dilation response; while stimuli which are disliked, unpleasant, or of negative interest value produce a constriction response.[12] The bi-directional nature of the pupillary response has met with considerable debate and has yet to be resolved.[13] The notion of pupillary constriction to aversive stimuli contradicts the prevailing opinion that emotional reactions, regardless of their affective quality, tend to elicit predominently sympathetic activity, and therefore, pupil dilation. Loewenfeld,[14] has asserted that "all physiologic and sensory stimuli, with the exception of light, dilate the pupil and none of them contract it." In another study,

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9 E.H. Hess and J.M. Polt, "Pupil Size as Related to the Interest Value of Visual Stimuli", Science, 1960, 132, 349-350.

10 ----------, "Changes in Pupil Size as a Measure of Taste Preference", Perceptual and Motor Skills, 1966, 23, 451-455.

11 E.H. Hess, A.C. Seltzer and J.M. Shlein, "Pupil Responses of Hetero- and Homosexual Males to Pictures of Men and Women: A Pilot Study", Journal of Abnormal Psychology, 1965, 70, 165-168.

12 E.H. Hess, "Attitude and Pupil Size", Scientific American, 1965, 212, 46-54.

13 B.C. Goldwater, "Psychological Significance of Pupillary Movements", Psychological Bulletin, 1972, 77, 340-355.

14 I.E. Loewenfeld, "Comment on Hess's Findings", Survey of Ophthalmology, 1966, 11, p. 293.

Woodmansee[15] failed to show evidence of the constriction response in repeated attempts. Peavler and McLaughlin[16] have attributed the constriction response to artifactual phenomena. Nunnally and his co-workers[17] examined pupillary changes in anticipation of a previously experienced loud gunshot. The threat of a gunshot was paired to the third of a series of five numbered slides. The pupil dilated as the critical third slide was approached, followed by a return to baseline. This finding is in direct contradiction to Hess's hypothesized relationship. In a recent paper, Libby, Lacey and Lacey state that:

> .....our data do not agree with the hypothesis advanced by Hess that aversive or unpleasant stimuli lead to pupillary constriction, while pleasant stimuli lead to dilation. While we did find, in fact, that the characteristic response was a pupillary constriction for a few stimuli and a few individuals, we could not define the effective characteristics of those stimuli that produced constriction.[18]

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15 J.J. Woodmansee, "Pupil Reaction as an Index of Positive and Negative Affect", Paper presented at the Pupil Symposium, APA Convention, Washington, 1967.

16 W.S. Peavler and J.P. McLaughlin, "The Question of Stimulus Content and Pupil Size", Psychonomic Science, 1967, 8, 505-506.

17 J.C. Nunnally, P.D. Knott, A. Duchnowski and R. Parker, " Pupillary Response as a General Measure of Activation", Perception and Psychophysics, 1967, 2, 149-155.

18 W.L. Libby, B.C. Lacey and J.I. Lacey, "Pupillary and Cardiac Activity During Visual Attention", Psychophysiology, 1973, 10, p. 288.

On the other hand, Fredericks and Groves[19] support the hypothesis that pleasant pictorial stimuli elicit dilation responses and unpleasant pictorial stimuli elicit constriction responses. These authors claim that failure to control for modal level of illumination probably accounts, in part, for the lack of substantiation of Hess's hypothesized relationship in previous research. As well, Hess's prediction has received support from a study by Hutt and Anderson[20] who obtained a significant negative correlation (r= -.189) between pupil size and the recognition threshold of taboo words. Barlow[21] found highly significant correlations between rank order of pupil size and rank order of stimulus pleasantness. Though no percentage changes were reported, the author states that, in general, dilation was found for the most pleasant stimuli and constriction for the most unpleasant stimuli. An experiment by Bergum and

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19 R.S. Fredericks and M. Groves, "Pupil Change and Stimulus Pleasantness", Proceedings of the 79th American Psychological Association Convention, 1971, 371-372.

20 L.D. Hutt and J.P. Anderson, "The Relationship Between Pupil Size and Recognition Threshold", Psychonomic Science, 1967, 9, 477-478.

21 J.D. Barlow, "Pupillary Size as an Index of Preference", Perceptual and Motor Skills, 1970, 31, 331-336.

Lehr[22] appears to have confirmed that dilation and constriction responses can occur upon the presentation of pictorial stimuli with positive and negative affect, respectively.

Hess[23] has reported an unpublished experiment conducted at the Pupil Research Center of the University of Michigan which supports his claim with regard to the bi-directional nature of the pupillary response. Subjects were hypnotized and then told that they were going to be shown some slides in a projection apparatus. However, the projected slides that the subjects viewed were blank. The subjects were told that one of these slides was an extremely pleasant picture; its content was unspecified. For another blank slide the subjects were told that they were seeing an unpleasant and distasteful picture. Again, the actual content was unspecified. As hypothesized, the pleasant pictures resulted in pupillary dilation and the unpleasant pictures resulted in pupillary constriction.

In addition to the types of studies just described, some work has been done in an attempt to relate pupillary reactivity to other autonomic indices. In animal studies there is some evidence for correlations of pupillary dilation

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22 O. Bergum and J. Lehr, "Prediction of Stimulus Approach: Core Measures Experiment I." Research Reports R66-8 and R66-36, Rochester, N.Y., Xerox Corporation, 1966.

23 E.H. Hess, "Pupillometrics", in N.S. Greenfield and R.A. Sternbach, (Ed.), Handbook of Psychophysiology, N.Y., Holt, Rinehart and Winston, 1972, p. 490-531.

with respiration under hypothalamic stimulation,[24] with cardiac acceleration in response to voluntary breathing changes,[25] and with heart rate and skin potential during voluntary pilomotor activity.[26] Using human subjects, Kahneman and his associates[27] found similar changes in GSR, heart rate and pupil size during a digit-transformation task. The results of a study by Colman and Paivio[28] suggested that the pupillary response, especially its latency, may be a more sensitive peripheral response than GSR during cognitive tasks. A study by Bernick, Kling and Borowitz[29] and another

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24 J.W. Ranson and H.W. Magoun, "Respiratory and Pupillary Reactions Induced by Electrical Stimulation of the Hypothalamus", Archives of Neurology and Psychiatry, 1933, 29, 1179-1194.

25 C.M. Harsh, J.G. Beebe-Center and S.S. Stevens, "The Relation of Pilomotor, Pupillary, Cardiac and Respiratory Responses", Psychological Bulletin, 1939, 36, 537.

26 D.B. Lindsley and W.H. Sassaman, "Autonomic Activity and Brain Potentials Associated with Voluntary Control of the Pilomotors", Journal of Neurophysiology, 1938, 1, 342-349.

27 D. Kahneman, B. Tursky, D. Shapiro and A. Crider, "Pupillary, Heart Rate and Skin Resistance Changes During a Mental Task", Journal of Experimental Psychology, 1969, 79, 164-167

28 F. Colman and A. Paivio, "Pupillary Response and Galvanic Skin Response During an Imagery Task", Psychonomic Science, 1969, 16, 296-297.

29 N. Bernick, G. Kling and A. Borowitz, "Physiologic Differentiation of Sexual Arousal and Anxiety", Psychosomatic Medicine, 1971, 33, 341-352.

by Gibney[30] have both suggested a possible superiority of pupil size as a measure of activation over corticosteroid levels and heart rate. In a study that monitored pupillary response, heart rate, and blood pressure, Libby, Lacey and Lacey[31] reported results that showed directional fractionation of the cardiac and pupillary responses.

3. Activation and Personality.

Duffy has presented considerable evidence to support the conclusion that:

> .....individuals differ to a marked degree in the extent of activation in the same situation; these differences in activation tend to persist and to characterize the individual; and, in general, the individual who responds with a high degree of activation in one situation is likely, as compared with other individuals, to respond with a high degree of activation in other situations also.[32]

Her conclusion was based upon extensive reviews of research utilizing metabolic patterns, EMG data, muscle tension, cardio-

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30 T.K. Gibney, Vigilance Performance and Autonomic Nervous System Activity, unpublished Master's thesis presented to Purdue University, 1966. (Abstract).

31 W.L. Libby, B.C. Lacey and J.I. Lacey, "Pupillary and Cardiac Activity During Visual Attention", Psychophysiology, 1973, 10, 270-294.

32 E. Duffy, Activation and Personality, N.Y. Wiley, 1962, p. 227.

vascular measures, and various EEG variables. Although the intercorrelations between the various forms of activation were sometimes quite low, they were large enough to justify her position with regard to individual differences in physiological responsivity. Furthermore, individuals who physiologically are more responsive to the environment are more likely to exhibit modes of behavior different from those individuals who are less responsive. These modes of behavior, according to Duffy,[33] can be regarded as personality traits.

Parallel to Duffy has been the work of Eysenck, who has accelerated the analysis and explanation of the biological basis of personality.[34] After extensive research he proposed two pervasive, independent, orthogonal personality dimensions of extraversion-introversion (E) and neuroticism-stability (N).[35] Extraversion-introversion is a concept modified from the Hullian notion of reactive inhibition and linked to the Russian dimension of strength of the nervous system. The basis for this theoretical linkage is the concept

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33 Ibid. p. 271

34 C.S. Hall and G. Lindzey, Theories of Personality, Wiley, N.Y., 1967, p. 388.

35 H.J. Eysenck, "A Dynamic Theory of Anxiety and Hysteria", Journal of Mental Science, 1955, 101, 28-51.

of cortical excitation as opposed to cortical inhibition. It is hypothesized that the Introvert in whom cortical excitatory processes presumably dominate, is quite similar to the Russian weak nervous system individual, and the Extravert in whom cortical inhibitory processes dominate is similar to the strong nervous system individual.[36] Moreover, persons who show weak nervous system activity, such as Introverts, display characteristics at the physiological level such as low sensory thresholds, low thresholds of transmarginal inhibition and maximum capacity reached at lower levels of stimulus input.[37] Conversely, Extraverts are presumed to manifest the opposite.

When confronted with a potentially threatening stimulus, one would expect differential reactivity within the Eysenckian framework for Introverts and Extraverts. Consistent with Gray's[38] modifications of Eysenck's position, one would expect a higher level of arousal to be maintained in Introverts leading to sensory sensitization in contrast to sensory repression in Extraverts.

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36 H.J. Eysenck, The Biological Basis of Personality, Springfield, Illinois, Charles C. Thomas, 1970, p. 80.

37 J.A. Gray, "Strength of the Nervous System, Introversion-Extraversion, Conditionability and Arousal", Behavior Research and Therapy, 1967, 5, 151-169.

38 J.A. Gray, "The Physiological Basis of Introversion-Extraversion", Behavior Research and Therapy, 8, 1970, 249-266.

There is some evidence that Introverts do experience any degree of stimulation, whether aversive or otherwise, as affectively greater. Corcoran[39] found Introverts to salivate significantly more to taste stimuli and Eysenck and Eysenck[40] have shown that Introverts are governed by greater autonomic lability as shown by their 'lemon juice test' for the extensiveness of the salivary response. In a related study, Fisher, Marks, Hill and Rockey[41] found a significant correlation between high taste sensitivity and introversion. Haslam[42] found significantly lower pain thresholds in Introverts, and Holmes[43] found that high levels of acetylcholine, as inferred from rapid pupillary constriction to light, were significantly related to superior verbal conditioning and Introversion as assessed by the EPI and peer

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39 D.W.J. Corcoran, "The Relation Between Introversion and Salivation", American Journal of Psychology, 1964, 77, 298-300.

40 S.B.G. Eysenck and H.J. Eysenck, "Salivary Response to Lemon Juice as a Measure of Introversion", Perceptual and Motor Skills, 1967, 24, 1047-1053.

41 R. Fisher, P.A. Marks, R.M. Hill and M.A. Rockey, "Personality Structure as the Main Determinent of Drug Induced (Model) Psychosis", Nature, 1968, 218, 296-298.

42 D.R. Haslam, "Individual Differences in Pain Threshold Level of Arousal", British Journal of Psychology, 1969, 58, 139-142.

43 D.S. Holmes, "Pupillary Response, Conditioning and Personality", Journal of Personality and Social Psychology, 1967, 5, 98-103.

ratings. Holmes interpreted his results in terms of the hypothesized role of acetylcholine in learning, with the speed of constriction presumed to reflect the amount of acetylcholine. He theorized that an individual who conditions rapidly tends to be highly sensitive to his environment, inhibited and introspective. Finally, Siddle, Morrish, White and Mangan[44] found a moderate relationship between visual sensitivity and introversion. Neuroticism appeared to be a confounding variable in this study since significant correlations were found only for samples from which highly neurotic subjects were excluded.

It appears, therefore, that the dimension of extraversion has some features in common with the concept of physiological activation. Eysenck, commenting on this point has stated that:

> .....it will have been noted that in terms of our excitation-inhibition theory, most stress in accounting for extravert-introvert differences has been laid on inhibition (reactive inhibition or internal inhibition); in linking up this theory with neurophysiology, stress seems to have shifted to arousal, differences in arousal level, and high arousal thresholds.[45]

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44 D.A. Siddle, R.B. Morrish, K.D. White and G.L. Mangan, "Relation of Visual Sensitivity to Extraversion", Journal of Experimental Research in Personality, 1969, 3, 264-267.

45 H.J. Eysenck, op. cit., p. 238.

4. Activation and the Pupillary Response.

Stimuli that are judged to have arousing properties have been found to generally produce a pupillary response. This has been coroborated for stimuli relating to sexual arousal,[46,47] social familiarity,[48,49] social and political attitudes,[50,51] drug related stimuli,[52] as well as sensory stimuli such as music[53] and taste.[54] Nunnally, Knott, Duchnowski and Parker[55] have proposed that the pupillary response is a general measure of all types of activation.

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46 Hess, Seltzer and Shlein, op.cit., 1965, p. 165.

47 Bernick, Kling and Borowitz, op. cit., 1971, p. 341.

48 H.E. Fitzgerald, "Autonomic Reflex Pupillary Activity During Early Infancy and its Relation to Social and Nonsocial Visual Stimuli", Journal of Experimental Child Psychology, 1968, 6, 470-482.

49 R.F. Boddicker, Pupillary Response as a Function of Interpersonal Attraction. Unpublished Master's thesis presented to the Faculty of Purdue University, 1969.

50 Hess, op. cit., 1965, p. 50.

51 Woodmansee, op. cit., 1967.

52 F. Altman, N. Bernick and D. Mintz, "Pupil Responses of Addicts in Treatment to Drug Culture Argot: I. Auditory Presentation of Double Entendre Words", Psychonomic Science, 1972, 28, 79-80.

53 Hess, op. cit., 1965, p. 53.

54 Hess and Polt, op. cit., 1966, p. 451.

55 J.C. Nunnally et al., op. cit., 1967, p. 149.

They tested the sensitivity of the pupillary response to five different types of stimulation representing a wide spectrum of situations that other author's have referred to as activating and which represented varying response systems. The stimuli included muscle tension, fear of a gunshot, intense tones, orienting responses from viewing novel pictures, and pleasant and unpleasant pictures. Significant effects on pupil size were found for all five types of stimulation.

In many other studies, however, group differences to arousing stimuli have been eroded by highly individualistic pupillary reactions. Polt and Hess[56] found highly individualistic responses to affective words, as did Kahneman and Beatty,[57] Paivio and Simpson,[58] and Schaefer, Fergenson, Klein and Rawson.[59] Finally, Libby, Lacey and Lacey,[60]

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56 J.M. Polt and E.H. Hess, "Changes in Pupil Size to Visually Presented Words", Psychonomic Science, 1968, 12, 389-390.

57 D. Kahneman and J. Beatty, "Pupillary Responses in a Pitch Discrimination Task", Perception and Psychophysics, 1967, 2, 101-105.

58 A. Paivio and H. Simpson, "The Effect of word Abstractness and Pleasantness on Pupil Size During an Imagery Task", Psychonomic Science, 1966, 5, 55-56.

59 T.J. Schaefer et al., "Pupillary Responses During Mental Activities", Psychonomic Science, 1968, 12, 137-138.

60 Libby, Lacey and Lacey, op. cit., 1973, p. 286.

using visual stimuli, found that the pupillary responses for any subject or to any stimulus were very variable, with standard deviations that typically were several times greater than the averages.

It appears possible that individual differences in activation or arousal are contributing to the inconsistent and contradictory results contained in the literature. While some of the cited studies have implications for individual differences in arousal or pupillary response, "none have specifically investigated individual differences or related pupillary responsiveness to objective personality measures. Only very few studies have even tangentially investigated individual differences in pupil response or the relationship between pupillary responsiveness and objective personality measures."[61]

Several studies by Rubin[62,63] have attempted to assess the role of individual differences with regard to the pupillary response. In his studies Rubin employed measures of

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61 R.F. Boddicker, Neuroticism-Stability, Extraversion-Introversion and the Pupillary Response. Unpublished Doctoral thesis presented to the Faculty of Purdue University, 1972, p. 8.

62 L.S. Rubin, "Autonomic Dysfunction as a Concomitant of Neurotic Behavior", Journal of Nervous and Mental Disorder, 1964, 138, 558-574.

63 L.S. Rubin, "Autonomic Dysfunction in Neurotic Behavior", Archives of General Psychiatry, 1965, 12, 572-585.

pupillary dilation and constriction to the presence or absence of lights as indices of adrenergic and cholinergic outflow in both neurotics and normals. He found that the pupillary return to normal after the cold pressor test was significantly slower in neurotics than in normal control adults even though the pupillary reactions during dark and light adaptation periods was the same for both groups.

Adams[64] differentiated people as either high anxious or low anxious on the basis of their scores on the IPAT Anxiety Scale. She found no significant group differences although significant individual differences were found. Crough[65] dichotomized subjects as being either high or low in reasoning ability and found that low ability subjects showed greater pupillary dilation than high ability subjects to items chosen from the Raven Progressive Matrices.

Two studies employing the Eysenck Personality Inventory as a concommitant variable have also been reported in the literature. Francis[66] differentiated subjects on the neur-

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64 N.M. Adams, Changes in Pupil Size Under Conditions of Anxiety and Stress. Unpublished Doctoral thesis presented to the Graduate School of the George Washington University, Washington, D.C., 1968, iii-69 p.

65 D.G. Crough, An Investigation of Differential Pupillary Response Between Groups Differing in Reasoning Ability. Unpublished Doctoral thesis presented to the Graduate School of the Catholic University of America, Washington, D.C., 1971, 1-58 p.

66 R.D. Francis, "Neuroticism and Optical Pupil Changes in Response to Auditory Stimuli", British Journal of Social and Clinical Psychology, 1969, 8, 344-349.

oticism dimension of the EPI and concluded that the tendency to make optical responses involving a change in pupil size was related to neuroticism. He interpreted his results as lending support to Eysenck's position that neurotics are characterized by greater autonomic lability. Unfortunately, the methodology for recording the pupillary changes was crude. The experimenter simply monitored the pupil on a television screen and checked for clear and unambiguous changes in size.

Boddicker[67] utilized forty subjects with neuroticism and extraversion scores in the extremes of each of the four EPI quadrants. The results indicated that neither the neuroticism nor the extraversion dimensions of the EPI were related significantly to the pupillary response although the trend of the results indicated that high pupillary reactivity was associated with low neuroticism and low extraversion scores.

5. GSR and Arousal in Relation to Emotionally Laden Words.

A second concern of this study was to analyze the effects of emotionally laden word stimuli in producing changes in more than one autonomic response, and, as well, to

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67 R.F. Boddicker, op. cit., 1972, p. viii.

corroborate and refine the interpretation of pupil reactivity.

Galvanic skin response measures have been shown to be associated with the emotional or affective connotation of words. McGinnies[68] showed that emotionality as measured by GSR was significantly greater for selected 'critical' words when compared with neutral words. Noble[69] utilized the GSR to assign weights to words that had been judged as neutral, pleasant or unpleasant. Cohen, Silverman and Barch[70] reported that the GSR responsivity to a word stimulus was a function of the affective connotation of the stimulus and the level of arousal of the subject in relation to that stimulus.

In addition, many studies have attempted to show a relationship between personality traits and the latency and/or amplitude of the electrodermal response to one type of stimulus or another. GSR measures have been utilized in the study of psychoses[71] and in brain damage,[72] in some cases

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68 E. McGinnies, "Emotionality and Perceptual Defense", Psychological Review, 1949, 56, 244-251.

69 C.E. Noble, "Emotionality (e) and Meaningfulness (m)", Psychological Reports, 1958, 4, 16.

70 S.I. Cohen, A.J. Silverman and N.R. Barch, "A Technique for the Assessment of Affect Change", Journal of Nervous and Mental Disease, 1956, 124, 352-360.

71 A.S. Bernstein, "Phasic Electrodermal Orienting Response in Chronic Schizophrenics: II. Response to Auditory Signals of Varying Intensity", Journal of Abnormal Psychology, 1970, 75, 146-156.

72 F.A. Holloway and O.A. Parsons, "Unilateral Brain Damage and Bilateral Skin Conductance Level in Humans", Psychophysiology, 1969, 6, 138-148.

to clarify the nature of the defect, in others to improve classification or diagnosis. In general, most of these studies have adopted an arousal model in their interpretations.

As well, many studies have attempted to show significant differences in the GSR responses of groups selected on the basis of scores on psychological tests such as the MMPI or the Tayler Manifest Anxiety Scale. While most of these studies have been validation or classification studies, some attempts have been made to interpret differences in terms of the significance of the type of behavior manifested in GSR activity. Lacey[73,74] has viewed electrodermal activity as enhancing or facilitating the interaction between an organism and its environment. He has suggested that the pattern of GSR responsiveness can be viewed in terms of whether the organism accepts or rejects his environment. In a similar way, Fisher[75] has related the regional dist-

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73 J.I. Lacey, "Psychophysiological Approaches to the Evaluation of Psychotherapeutic Process and Outcome", Research in Psychotherapy, 1959, 1, 160-208.

74 J.I. Lacey, D.E. Bateman and R. Van Lehn, "Autonomic Response Specificity: An Experimental Study", Psychosomatic Medicine, 1953, 15, 8-21.

75 S. Fisher, "Head-body Differentiation in Body Image and Resistance Level", Journal of Abnormal and Social Psychology, 1960, 60, 283-285.

ribution of the skin resistance response to body image and Roessler, Alexander and Greenfield[76] have related GSR responsivity to ego strength on the basis of the adaptive function of autonomic responses.

Of the few definitive studies which have attempted to assess the reliability of the GSR response as an indicator of arousal, probably the best is a study by Burch and Greiner[77] who demonstrated that there was an S-shaped curve relating the increasing frequency of spontaneous GSR activity to the increasing level of arousal as manipulated pharmacologically. The amplitude of the response to a standard stimulus resembled an inverted U-shaped function with the maximal response at intermediate levels of arousal. The diminution in the response amplitude at higher levels of arousal was considered to reflect a breakdown in appropriate biological performance as a consequence of the loss of selective inhibition. In another study, Chien[78] found that

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76 R. Roessler, A.A. Alexander and N.S. Greenfield, "Ego Strength and Physiological Responsivity:I", Archives of General Psychiatry, 1963, 8, 142-154.

77 N.R. Burch and T.H. Greiner, "Drugs and Human Fatigue: GSR Parameters", Journal of Psychology, 1958, 45, 3-10.

78 J.Y.C. Chien, Introversion-Extraversion and the Role of the Orienting Reaction Habituation Rate and Recognition Sensitivity to Neutral and Affective Words. Unpublished Doctoral thesis presented to the Faculty of Psychology, University of Ottawa, Ontario, 1973, xi-131 p.

Introverts and Extraverts varied significantly in their orienting reaction habituation rate to neutral and affective word stimuli as measured by the vasomotor, heart rate and galvanic skin response. Finally, Stennett[79] has shown a direct relation of skin conductance to arousal as manipulated by tasks of graded difficulty.

6. Summary, Rationale and Statement of Hypotheses.

This chapter has reviewed various theoretical models and relevant studies designed to investigate pupillary reactivity, the Galvanic skin response, the Eysenckian dimension of Extraversion and the relationship of the concept of arousal to the Eysenckian dimension.

With regard to pupil reactivity it can be seen from the review that there is much evidence to support Hess's statement that:

> .....one of the greatest values of pupillometric research is that it more reliably and easily measures a person's true attitudes towards some person, concept or thing than do other techniques when there is an involvement of cultural processes, either to mask emotional responses or to profess only certain types of emotional feelings.[80]

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79 R.G. Stennett, "The Relationship of Performance Level to Level of Arousal", Journal of Experimental Psychology, 1957, 54, 54-61.

80 E.H. Hess, op. cit., 1972, p. 511.

Moreover, at the physiological level, it seems established both from reference to studies of other response systems and by a host of controlled experiments, that the pupillary response is a general measure of activation.

Finally, the pupil has certain distinctive features which are particularly pertinent to its use as a psycho-physiological variable in introversion-extraversion studies. Although it is not unique in being reciprocally innervated by the sympathetic and parasympathetic systems, the pupil is distinctive in that it provides a partially autonomous index of parasympathetic activity.

A. Rationale and Hypotheses.

From a review of the literature it can be stated that pupil reactivity is related to stimuli that are emotionally laden although dilation or constriction in response to specifcally 'toned' words (pleasant or unpleasant) remains speculatory.

Inadequate definition and control of the stimuli has been a deficiency in many studies relating pupil size to affective stimuli. Some authors did not control the visual field or light intensity, while others did not attempt to measure or control the physical complexity or the psycho-

logical meaningfulness of the stimuli used.[81] In the proposed study words that have been judged as emotionally laden will be used. That simple words can elicit emotional responses has been repeatedly demonstrated.[82] That auditory presentation of stimuli in pupillometric studies is more preferable to visual presentation has also been repeatedly demonstrated.[83]

In summary, it has been shown that there are significant individual differences in terms of arousal potential between people varying in personality structure. Secondly, it has been shown that words used as visual or auditory stimuli can result in the elicitation of affective states. Thirdly, it has been shown on a physiological basis that pupil reactivity should be related to the emotional or affective component of word stimuli. It is therefore the general hypothesis of this investigation that pupil reactivitiy, as measured by average pupil size across pre-stimulus, stimulus and post-stimulus periods, will be significantly greater when emotionally laden words (affective and taboo) are used as stimuli than when neutral words are used as stimuli, and that these words should result

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81 J.L. Woodmansee, "Methodological Problems in Pupillographic Experiments", Paper presented at the 74th American Psychological Association Convention, 1966, 133-134.

82 J. Bruner and L. Postman, "Emotional Selectivity in Perception and Reaction", Journal of Personality, 1947, 16, 69-77.

83 J.L. Woodmansee, op. cit., 1966, p. 133.

in differential responsiveness for groups varying in degree of extraversion (Introverts, Ambiverts and Extraverts).

In its null form, the major hypothesis may be stated as follows:

1. There are no significant differences between Introverted, Ambiverted and Extraverted subjects in their pupil reactivity to neutral, affective and taboo word stimuli during pre-stimulus, stimulus and post-stimulus periods.

Two other dependent measures related to pupil reactivity are eye blinks, defined as the number of full eyelid closings during the 5 second period prior to the stimulus onset and the 10 seconds after the stimulus onset; and overt eye movement responses, defined as the number of overt ocular movements during the 5 seconds prior to the stimulus onset and the 10 seconds after the stimulus onset. The two null hypotheses related to these variables are:

2. There are no significant differences between Introverted, Ambiverted and Extraverted subjects in their blink rate to neutral, affective and taboo word stimuli during pre-stimulus, stimulus and post-stimulus periods.

3. There are no significant differences between Introverted, Ambiverted and Extraverted subjects in their number of overt eye movement responses to neutral, affective and taboo word stimuli during pre-stimulus, stimulus and post-stimulus periods.

For the Galvanic skin response it was hypothesized that the magnitude and latency of the GSR should reflect corresponding changes in arousal level as they related to the stimulus words. As well, it was hypothesized that the GSR changes should reflect parallel changes in pupil reactivity, blink rate and overt eye movement responses. The null hypotheses, as they related to the GSR latency and amplitude can be expressed as follows:

4. There are no significant differences between Introverted, Ambiverted and Extraverted subjects in their Galvanic Skin Response latency to neutral, affective and taboo word stimuli during pre-stimulus, stimulus and post-stimulus periods.

5. There are no significant differences between Introverted, Ambiverted and Extraverted subjects in their Galvanic Skin Response amplitude to neutral, affective and taboo word stimuli during pre-stimulus, stimulus and post-stimulus periods.

The following chapter will describe in detail the methods used to test the stated hypotheses.

CHAPTER II

EXPERIMENTAL DESIGN

This chapter presents the procedures involved in testing the hypotheses proposed in the preceding chapter. The selection of the subjects, the psychological instruments, the method of construction of the stimulus tapes and the physiological instruments are described. Subsequently, an analysis of the procedure of the study is detailed. The quantification and scoring methodology of the pupillary and GSR data as well as a description of the experimental design and statistical procedures employed in the data analysis are presented.

1. The Subjects.

The subjects were thirty-three males varying in age from nineteen to thirty-two years old. The mean age for the total group was 23.6 with a standard deviation of 4.1 years. All subjects were differentiated into one of three groups: Introverted, Ambiverted or Extraverted based on their scores on the Eysenck Personality Inventory, Form A. Participation was solicited by telephone and was voluntary although some subjects received experimental credit for their participation.

2. The Psychological Instruments.

The psychological instruments used in the present study were the Eysenck Personality Inventory, Form A, and a post-experimental questionnaire constructed by the writer. Copies of the above instruments are presented in Appendices 1 and 2.

The subjects' reactions to the stimulus words were assessed by a rating scale similar in design to one suggested by Guilford.[1] The subjects were asked to rate all of the words that they had heard, in the order that they had heard them, in terms of an eleven catagory rating scale ranging from most pleasant imaginable to most unpleasant imaginable. The questionnaire required approximately ten minutes to complete.

3. Construction of the Stimulus Tapes.

The 'emotionality' of the words used in this study was determined in the following manner. A list containing twenty-five affective words and another list containing twenty-five taboo words were prepared by the author from various sources. The two lists were then presented in a

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1 J.P. Guilford, Psychometric Methods. McGraw-Hill, New York, 1954.

random order to five students and five faculty members of the Faculty of Psychology, University of Ottawa who served as raters. These raters were asked to judge the words on the lists in terms of their 'emotionality', that is, having the greatest shock value for naive male university students. The judgements of these raters----none of whom served as subjects in the experiment----were then summed. Emotionality of the stimuli used in this study were thus describable on a scale ranging from a score of zero; that is, none of the raters judged the word to be emotional, up to a score of ten; that is, all of the raters judged the word to be emotional. The twelve words in each list with the highest ratings were then selected. The scores of the twelve words in each list that were chosen are presented in Appendix 3. Only five of the twelve affective words and two of the twelve taboo words occurred in the Thorndike-Lorge[2] count. However, bearing in mind some evidence given in The Trial of Lady Chatterley,[3] one imagines that if they did, their frequency in written English might not reflect too reliably their frequency in spoken English, a point which has also

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2 E.L. Thorndike and I. Lorge, The Teacher's Wordbook of 30,000 Words, N.Y., Bureau of Publications, Teachers College, 1944.

3 C.H. Rolph, The Trial of Lady Chatterley, London, Penguin Books, 1961.

been made by Postman.[4] Thus, it was not possible to match a given affective or taboo word against others of equal frequency since no frequencies were known. Dodwell,[5] investigating this problem, has shown that the response to a taboo word is essentially the same, regardless of the frequency of the word.

Twenty four neutral words were chosen as partners to the twelve affective and twelve taboo words according to the following criterion. All of the neutral words had the same number of syllables as their affective and taboo partners. They were all structurally similar in length, first letter, place of accent and syllabular break. Thus, a given neutral word sounded like its affective or taboo partner although its meaning was vastly different.

After the words were selected they were randomized using a table of random numbers. The first six affective and the first six taboo words, together with their neutral pairs, (total of 24 words) were used as Stimulus Tape 1, with the other half of the words being used as Stimulus Tape 2. A female voice was used in the recording of the stimulus tapes

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4 L.J. Postman, W.C. Bronson and G.L. Grepper, "Is There a Mechanism of Perceptual Defense?", Journal of Abnormal and Social Psychology, 1953, 48, 215-224.

5 P.C. Dodwell, "Some Factors Effecting the Hearing of Words Presented Dichotically", Canadian Journal of Psychology, 1964, 18, 72-91.

as it was felt that this would increase the emotional impact of the affective and taboo words. Care was taken to make the word presentations consistent in terms of loudness, emphasis and speed of enunciation. Tapes were only accepted for use in the experiment when these criterion appeared to be met.

Each word, whether it was neutral, affective or taboo, was separated by the word "relax", so that the sequence was: "relax", "stimulus word", "relax", "stimulus word", and so on. The interval between a stimulus word and the word "relax" was ten seconds, as was the time from "relax" to the next word. The order of presentation of the words is presented in Appendix 4.

Both experimental lists of words were preceded by a practice list, which served to accustom the subject to the experimental situation, and presented an opportunity for the experimenter to calibrate his equipment.

4. The Physiological Instruments.

The three dependent measures of pupil size, blink rate and overt eye movement responses were recorded on a pupillometer system manufactured by the Polymetric Company (Model V-1165-IR). The component parts of the pupillometer system included a stimulus presentation unit containing the

stage, a rear projection screen, the subject's head rest and chin rest, and the mounting supports for the image transducer and eye lamp. The image transducer contained an infrared Vidicon tube and associated circuits that converted the optical image of the pupil into electrical signals. The eye lamp contained a light source used to illuminate the subject's right eye, and an infrared filter. The analyzer unit contained the controls and associated circuits needed for monitoring and recording of pupil diameter. There was also a video monitor (ITC) which provided a large size screen image of the subject's pupil, and of the overlay display that was used for limiting the measurement area. The pupillary data, blinks and overt eye movement responses were recorded on a Heathkit Servo Recorder, Model EUW 20A. This unit had a ten inch pen sweep and a paper speed of twelve inches per minute.

For the purpose of recording the GSR responses, two standard GSR chrome finger electrodes were placed on the palmer surface of the right hand, one on the index finger, and the other on the second finger. The contact sites on the skin were cleansed with alcohol and covered with a minimum of Beckman-Offner electrode paste prior to the placing of the electrodes.

The electrodes were attached to a Lafayette (Model 7603-2A) Polygraph. The frequency response of the AC GSR signal ranged from .2 to 2.0 Hz with a sensitivity of 2.5 volts with a 3 kilohm change in subject resistance. The sensitivity was set at 5 and kept constant for all subjects over all trials throughout the experiment.

The stimulus tapes were recorded and presented on a Sharp Solid State Stereo Tape Recorder and the words were heard simultaneously by the subject and the experimenter via Pioneer Stereo (SE-2P) headphones.

5. The Experimental Procedure.

The subject was ushered into the experimental room and was then administered the EPI, Form A. Though no time limit was given, all subjects completed the test within 15 minutes. The subject was then seated at the pupillometer and the operation of the pupillometric and GSR apparatus was explained. GSR electrodes were then attached followed by a 5 minute GSR calibration period. At this point the lights in the experimental room were turned off except for three 'nite-lites' which illuminated the rear projection screen of the pupillometer.

The subject was then placed in the proper position

and the chair was adjusted to the subject's height. The headrest and chinrest were adjusted so that the subject's head was comfortably resting on the chin rest, and his forehead was placed against the two rubber pads on the headrest. The camera and eyelamp were then adjusted and focused on the subject's right eye. Headphones were then placed on the subject's ears, the tape recorder was turned on, and after 1 minute the subject heard the following instructions:

> In this experiment you will be hearing some words while the camera will be photographing your eyes. It is important that you do not move your head now that the camera is set; therefore, try to get into a comfortable position, and meanwhile the final adjustments will be made on the equipment.
>
> You will hear a word presented through your headphones. After the word is presented, I want you to try to picture in your mind the image that is suggested by this word. By an image, I mean that I want you to try to picture the words that I say as vividly as you can. Keep the image in your mind until you hear the word relax, which is the signal to relax mentally.
>
> Do not talk during this part of the experiment. Keep your eyes directed towards the center of the screen where the circle is and try not to move your head.
>
> Remember, picture what I say.
>
> Do you have any questions?

If the subject didn't have any questions then the tape continued and the experiment was begun. Two tapes were made so that half of the subjects heard the words in the order of Part 1 followed by Part 2 and half

of the subjects heard the words in the order of Part 2 followed by Part 1. This counterbalancing procedure was employed in order to control for the possible extraneous effects of fatigue and/or stimulus sensitization. The instructions were identical on both tapes.

Presentation of the first set of words required a total of 7½ minutes. After this, the subject was given a 5 minute break during which he could move his head about freely. At no time were the lights in the room turned on.

After the rest period the subject was readjusted in the pupillometer, the pupillometer was recalibrated, and after 1 minute the subject heard the following instructions:

> We will now begin again. Please try to adjust yourself to the same position as before.
> Remember, after the word is presented I want you to try to picture in your mind the image that is suggested by this word. By an image, I mean that I want you to try to picture the words that I say as vividly as you can. As before, keep the image in your mind until you hear the word relax, which is the signal to relax mentally.
> We will now begin again.

Like the first half, the second part of the tape required 7½ minutes. At the termination of this period the subject completed the rating scale. He was then told the hypotheses of the study and the reactions expected to the stimulus words. In addition, he was asked about his overall

reactions and comments concerning the stimuli and experiment.

6. Data Quantification and Scoring Methodology.

A. Pupillary Data.

The majority of pupil size studies have employed a scoring procedure modelled after Hess[6] who defined the pupillary response as the change in pupil diameter from the presentation of the control stimulus to the presentation of the next stimulus, expressed as a percentage of pupil diameter during the control period. Criticism of this technique of between stimulus analysis has been voiced by Goldwater[7] in a comprehensive review. Kahneman and his co-workers[8,9] and Freidman, Hakarem, Sutton and Fleiss[10] have carried out tightly designed studies in which pup-

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6 E.H. Hess, "Attitude and Pupil Size", Scientific American, 1965, 212, 46-54.

7 B.C. Goldwater, "Psychological Significance of Pupillary Movements", Psychological Bulletin, 1972, 77, 340-355.

8 D. Kahneman and J. Beatty, "Pupillary Responses in a Pitch Discrimination Task", Perception and Psychophysics, 1967, 2, 101-105.

9 D. Kahneman, B. Tursky, D. Shapiro and A. Crider, "Pupillary, Heart Rate and Skin Resistance Changes During a Mental Task", Journal of Experimental Psychology, 1969, 79, 164-167

10 D. Freidman, et al., "Effect of Stimulus Uncertainty on the Pupillary Dilation Response and the Vertex Evoked Potential", Electroencephalography and Clinical Neurophysiology, 1973, 34, 475-484.

illary movements have been carefully time locked to paced performance on various tasks. Following the recommendations of these researchers, the author has operationally defined the pupillary response as the average response during each stimulus presentation, not the comparison from the stimulus word to a preceding control word. Thus, the main concern is not pupil reactivity between stimulus presentations, but rather, pupil reactivity during each stimulus presentation.

Furthermore, in order to analyze completely the dynamic events which occur during a stimulus presentation, the author has undertaken analysis of both pre- and post-stimulus pupil diameters. "Pre-stimulus diameter in particular is thought to be a critical factor, for it is a well-accepted principle in psychophysiology that the magnitude of an autonomic response is in part a function of pre-stimulus or initial value, (Law of Initial Value)."[11] With these considerations in mind, the exact scoring procedure can now be elaborated.

The five second period prior to the presentation of a stimulus word was operationally defined as the pre-stimulus period. The first five seconds after the presentation of the

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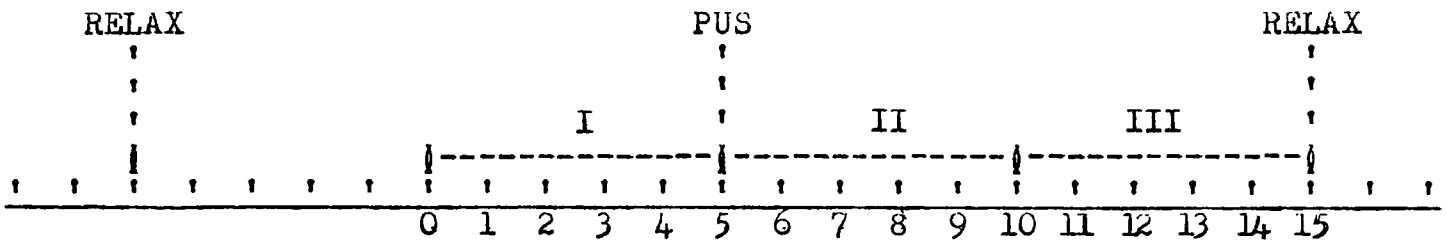
11 B.C. Goldwater, op. cit., 1972, p. 351.

stimulus word was operationally defined as the stimulus period. The next five seconds were defined as the post-stimulus period. Fifteen measurements for each word were thus obtained. The five measurements for each period were then averaged, yielding one value for each of the three periods for each word. This procedure was followed for all the stimulus words and is graphically presented in Figure 1. Many times, pupil diameters were not measurable. There were three main reasons for this: (i) the pupil was too indistinct for measurements to be recorded, due either to excessive eye movement, or hippus, or the angle at which the eye of the subject was fixated at the rear projection screen, or combinations of these; (ii) the subject blinked so that the pupillometer recorded a shut eye; or (iii) the subject was looking entirely away from the fixation point. However, these problems appeared to be evenly distributed among the entire subject population so that no subject had to be eliminated, although in many cases individual words in a subject's record could not be scored.

B. Blink and Eye Movement Data.

Blinks and eye movements were scored if they occured during the fifteen second interval described above. It was also noted in which second during the pre-stimulus, stimulus or post-stimulus period they occured.



I.- Pre-stimulus period - 5 seconds before stimulus word.

II.- Stimulus period - First 5 seconds after stimulus word.

III.- Post-stimulus period - Last 5 seconds after stimulus word.

Figure 1.- Graphic Example of Pupillary Data Scoring Procedure.

C. GSR Data.

The amplitude of the raw GSR data was measured manually in millimeters at each 1 second interval, and these values were converted to ohms according to the setting of the amplifier sensitivity. How long it took for the maximum GSR pen deflection after the presentation of a stimulus word (the latency), and the extent of the deflection (the amplitude), were the two values that were recorded for each word. The maximum pen deflection had to occur within ten seconds of the stimulus onset in order for it to be scored.

7. Experimental Design and Statistical Procedures.

The experimental design followed the three-factor analysis of variance model with repeated measures on the last two factors.[12] The three factors were Extraversion (A), type of Word (B), and Time Interval (C). The Extraversion factor was made up of three levels: an Introverted group, an Ambiverted group, and an Extraverted group. The repeated measures were taken on the Word factor, which was made up of three levels: Neutral, Affective and Taboo, and on the Time

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12 B.J. Winer, Statistical Principles in Experimental Design. N.Y. McGraw-Hill, 1962. p. 319-322.

Interval factor: which was also composed of three levels: Pre-Stimulus, Stimulus and Post-Stimulus. All subjects in each group were tested under the three word conditions and the three time interval conditions. The dependent measures were pupillary reactivity, eye blinks, overt eye movement responses, GSR latency and GSR amplitude.

In order to test for significant differences between the three groups of subjects on the Extraversion and Neuroticism dimensions and the Lie Scales of the Eysenck Personality Inventory, a one-factor analysis of variance model was used.[13]

In order to test for significant differences between the three groups of subjects on their ratings of the three different types of words, a two-factor analysis of variance model with repeated measures on the second factor was employed.[14]

When these procedures gave over-all significant differences at the .05 level or above, the post hoc procedure employed was the Newman-Keuls test.[15]

It has been the aim of this chapter to describe the

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13 Ibid. p. 56-70.

14 Ibid. p. 302-312.

15 V. Keith, Design and Analysis in Experimentation. Ottawa, University of Ottawa Press, 1972. p. 142-149.

sample and the tools used in the present study, and to discuss in detail the experimental procedure and the method of data analysis. The results of this experiment will be presented and discussed in the following chapter.

CHAPTER III

PRESENTATION OF RESULTS

The obtained results are analyzed and elucidated within this chapter. The chapter is divided into four sections. In section one, the selection data for the subjects is reported. In the next section the pupillary reactivity, blink rate and overt eye movement response data is reported. Section three deals with the GSR latency and amplitude scores, while the final part analyzes the rating scale data.

1. Selection Data for the Subjects.

Once the Eysenck Personality Inventories, Form A, were scored for the thirty-three subjects, they were trichotomized into three groups of eleven Introverted, eleven Ambiverted and eleven Extraverted subjects. The means of the Extraversion and Neuroticism factors for the total sample were 12.70 and 10.82. The means of the Extraversion factor for the Introverted, Ambiverted and Extraverted groups were 7.00, 12.91 and 18.18; with corresponding standard deviations of 1.41, 0.99 and 1.69 respectively. The means of the Neuroticism factor for the Introverted, Ambiverted and Extraverted groups were 10.09, 10.36 and 12.00; with corresponding standard deviations of

3.26, 3.39 and 5.76 respectively. For the Lie Scales, the grand mean was 2.27, with the Introverted, Ambiverted and Extraverted groups having means of 2.65, 2.09 and 2.09 respectively. The standard deviations for the three groups were 1.30, 0.90 and 1.24.

Analyses of variance on the sample data revealed that the three groups of subjects differed significantly from each other on the Extraversion factor ($F_{2,30}$=159.98, p .01); but did not differ significantly from each other on either the Neuroticism factor ($F_{2,30}$=.577, p .01), or on the Lie Scales ($F_{2,30}$=.737, p .01).

The mean ages for the Introverted, Ambiverted and Extraverted groups were 24.36, 22.64 and 24.00 years, with corresponding standard deviations of 3.91, 4.64 and 3.88 years. Analysis of variance of the age data indicated that the three groups of subjects did not differ significantly from each other with respect to age ($F_{2,30}$=.479, p .01).

It was therefore concluded that this datum supported the position that the three groups of subjects differed significantly from each other on the Extraversion dimension, but did not differ significantly from each other with respect to the Neuroticism dimension, EPI Lie Scale scores, or age.

2. Pupil Data.

A. Pupillary Reactivity Analysis.

To test the first hypothesis a design was employed that allowed examination of the pupillary reactivity of each of the subject groups to each type of word during each time interval. An A x B x C analysis of variance with repeated measures across factors B and C was utilized.

For the first analysis there were three levels of factor A (groups representing the three levels of Extraversion), three levels of factor B (Neutral, Affective and Taboo words), and three levels of factor C (Pre-Stimulus, Stimulus and Post-Stimulus). This analysis was based on the raw pupil size scores, and therefore the directionality of the pupillary response was considered. A summary of the analysis of variance is presented in Table I.

The Extraversion factor was significant at the .05 level. The Word factor was not significant and the Time Interval factor was significant at the .01 level. Two of the two factor interactions, Extraversion x Time Interval and Words x Time Interval were also significant at the .05 level.

To test for significant differences between pairs of means for the Extraversion and Time Interval factors, the

Table I.-

Analysis of Variance of Raw Pupil Size Scores to Neutral, Affective and Taboo Words (B), during Pre-Stimulus, Stimulus and Post-Stimulus Time Intervals (C), for Introverted, Ambiverted and Extraverted Groups (A).

Source of Variation	df	SS	MS	F ratio
Between Subjects	32			
A (Extraversion)	2	34.70	17.35	5.061[a]
R:A	30	102.84	3.42	
Within Subjects	264			
B (Words)	2	.32	.16	2.083
AB	4	.21	.05	.681
R:B	60	4.59	.08	
C (Time Intervals)	2	3.47	1.74	50.987[b]
AC	4	.35	.09	2.537[c]
R:C	60	2.04	.03	
BC	4	.23	.06	5.931[d]
ABC	8	.16	.02	1.975
R:BC	120	1.18	.01	

[a] p .05; F .05 (2,30) = 3.32

[b] p .01; F .01 (2,60) = 4.98

[c] p .05; F .05 (4,60) = 2.52

[d] p .01; F .01 (4,120)= 3.48

Newman-Keuls procedure was employed. For the Extraversion factor, only the A_1-A_2 (Introverts-Ambiverts) means were found to differ significantly (p .01). For the Time Interval factor, C_1 (Neutral) was found to be significantly different from C_2 (Affective) and C_3 (Taboo) at the .01 level; but C_2 was not significantly different from C_3.

For descriptive purposes the means of the AC (Extraversion x Time Interval) interaction are represented graphically in Figure 2. The significant ordinal AC interaction supported the first hypothesis of the study.

Because this study was concerned with autonomic reactivity it was decided to perform a second analysis with the same data but omitting the positive and negative signs that indicate the directionality of pupillary response. In other words, the analysis was performed on the change scores, with the signs disregarded. This analysis was neccessary because consideration of directionality serves to attenuate the magnitude of group means for groups whose members responded with mixed directionality, that is, with constriction as well as dilation.

The analysis of variance for absolute pupillary change is summarized in Table II. From this table it can be seen that all three main factors were significant at the .01 level. All

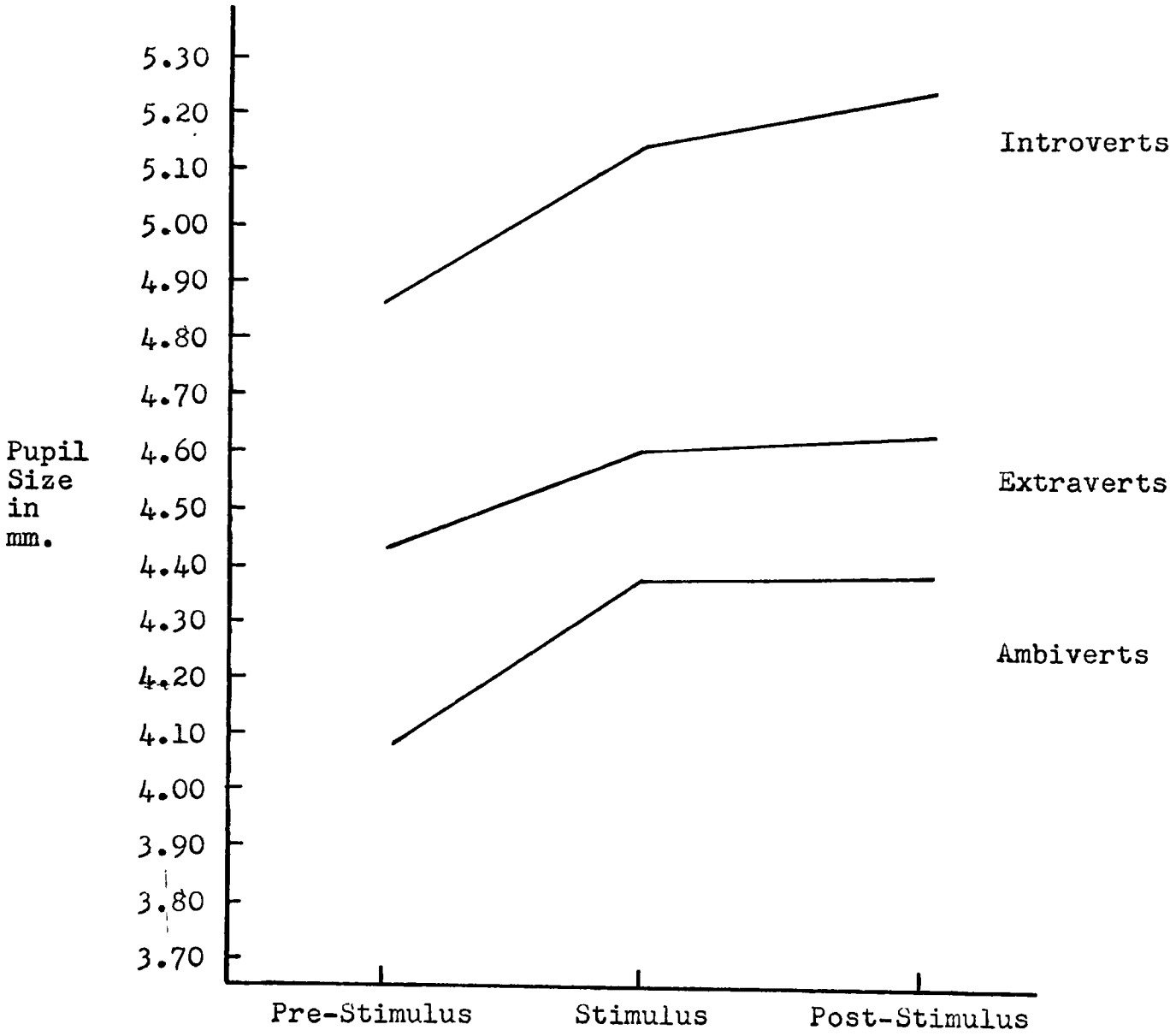

Figure 2.- Graphic Representation of the Interaction Between Extraversion and Time Interval for the Raw Pupil Size Scores.

Table II.-

Analysis of Variance of Absolute Pupillary Change Scores (Directionality Disregarded) to Neutral, Affective and Taboo Words (B), during Pre-Stimulus, Stimulus and Post-Stimulus Time Intervals (C), for Introverted, Ambiverted and Extraverted Groups (A).

Source of Variation	df	SS	MS	F ratio
Between Subjects	32			
A (Extraversion)	2	153.49	76.74	10.511[a]
R:A	30	219.05	7.30	
Within Subjects	264			
B (Words)	2	31.85	15.92	24.828[b]
AB	4	18.66	4.66	7.275[c]
R:B	60	38.48	.64	
C (Time Interval)	2	166.36	83.18	63.614[d]
AC	4	25.51	6.37	4.817[e]
R:C	60	78.45	1.30	
BC	4	4.77	1.19	5.887[f]
ABC	8	5.74	.71	3.544[g]
R:BC	120	24.33	.20	

[a] p .01 F .01 (2,30) = 5.39

[b] p .01 F .01 (2,60) = 4.98

[c] p .01 F .01 (4,60) = 3.65

[d] p .01 F .01 (2,60) = 4.98

[e] p .01 F .01 (4,60) = 3.65

[f] p .01 F .01 (4,120)= 3.48

[g] p .01 F .01 (8,120)= 2.66

of the two factor interactions (AB, AC and BC) were significant at the .01 level as was the three factor interaction ABC.

The Newman-Keuls procedure was again applied to identify the significant differences among the A, B, and C factors. For the A (Extraversion) factor, A_1 (Introverts) were found to be significantly different from A_2 (Ambiverts) and A_3 (Extraverts) at the .01 level, but A_2 was not significantly different from A_3. For the B (Word) factor, B_3 (Taboo) was found to be significantly different from B_2 (Affective) and B_1 (Neutral) at the .01 level, but B_2 was not significantly different from B_1. For the C (Time Interval) factor, all times (Pre-Stimulus, Stimulus and Post-Stimulus) were found to be significantly different from each other at the .01 level.

All of the significant interactions, AB, AC, BC and ABC were found to be ordinal in nature. For descriptive purposes the means of the AB and AC interactions are presented graphically in Figures 3 and 4. These figures are included because they show the important relationship between Extraversion and the type of word stimuli used, and Extraversion and the speed of reaction to the word stimuli.

In view of the above statistical findings, the first hypothesis of the present study was rejected. That is, there is a significant difference between groups differing in degree of Extraversion in terms of their pupillary reactivity in

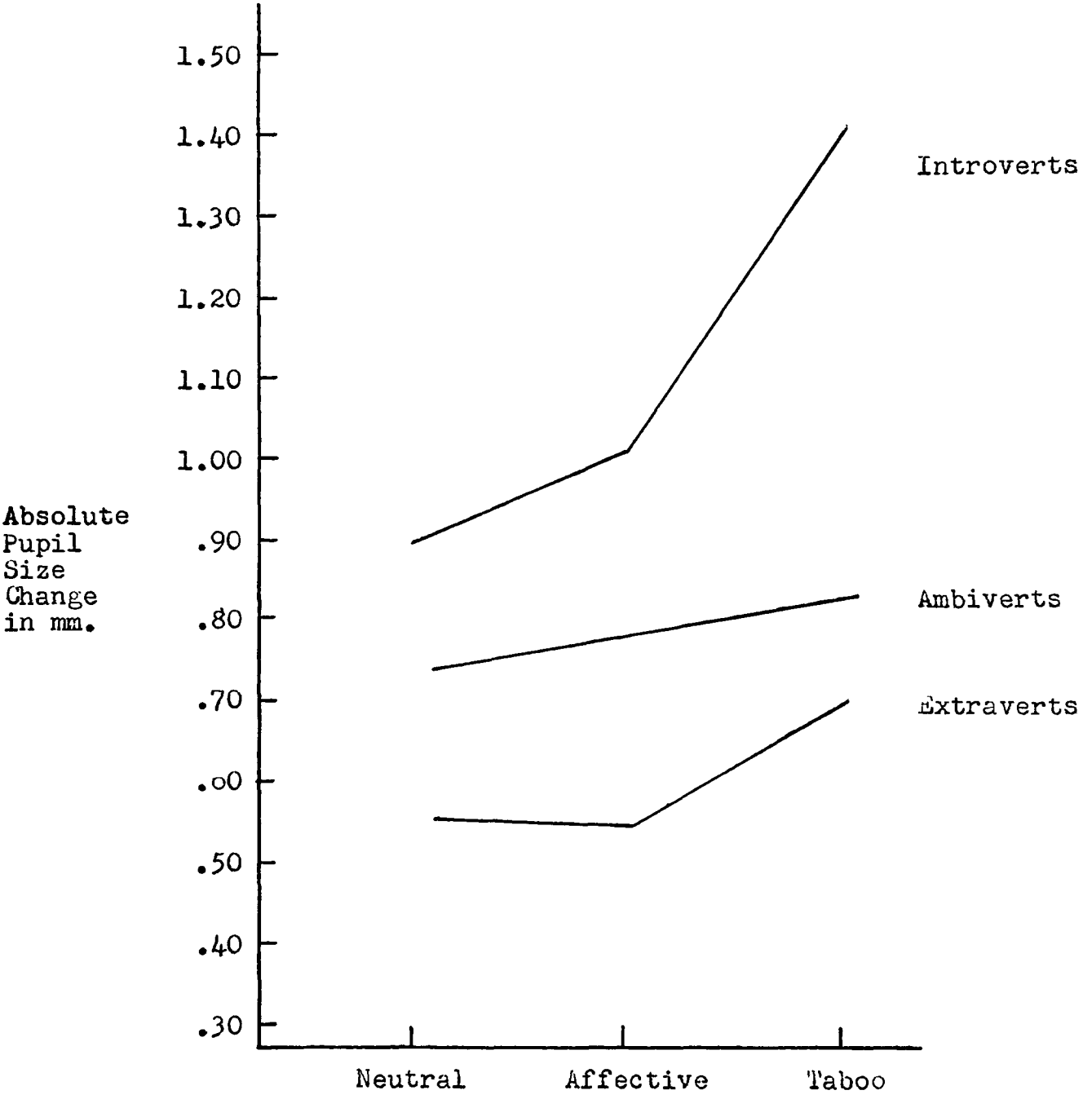

Figure 3.- Graphic Representation of the Relationship Between Extraversion and Word Type for the Absolute Pupillary Change Scores.

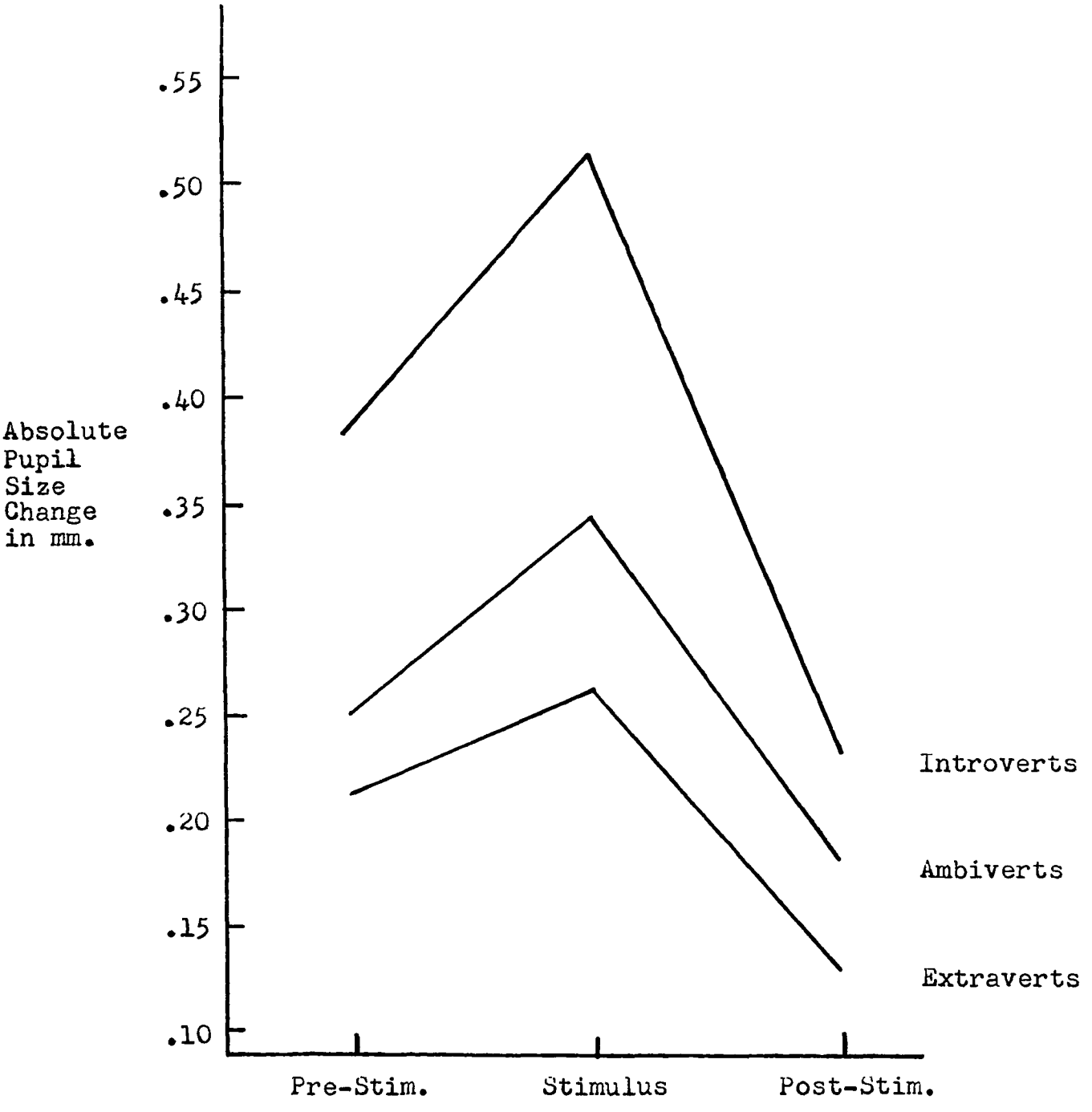

Figure 4.- Graphic Representation of the Relationship Between Extraversion and Time Interval for the Absolute Pupillary Change Scores.

different time intervals to neutral, affective and taboo words.

To summarize at this point, the results of the analyses on pupil size indicated that:

1. Introverts, Ambiverts and Extraverts have significantly different pupillary reactions to neutral, affective and taboo words.

2. Introverts, Ambiverts and Extraverts have significantly different pupillary reactions before the stimulus word was presented and after the stimulus word was presented.

3. With regard to Hess's dilation-constriction hypothesis, it was found that the characteristic response was a pupillary constriction for a few stimuli and a few individuals. However, dilation was linearly related to the affective loadings of the words in at least 85% of all cases.

B. Blink Rate Analysis.

The second hypothesis was that there was no significant difference between groups differing in degree of extraversion in terms of their blink rate in different time intervals to neutral, affective and taboo words.

This hypothesis was tested in the same paradigm as that used to test the first hypothesis. The analysis of variance on the blink rate data indicated that there was no significant difference between the groups in terms of their blink rate, and in terms of which words they blinked to, although there was a significant difference with regard to

when they blinked. The results of this analysis are presented in Table III. One significant interaction, BC, was obtained (p .05). The Newman-Keuls was again applied to identify the significant differences with regard to the time interval (C factor). It was found that all of the means of the pre-stimulus, stimulus and post-stimulus periods were significantly different from each other at the .01 level. The BC interaction was ordinal.

C. Overt Eye Movement Response Analysis.

The third hypothesis was that there was no significant difference between groups differing in degree of extraversion in terms of their overt eye movement responses in different time intervals to neutral, affective and taboo words.

The analysis of variance, which is presented in Table IV, indicated that the null hypothesis should be rejected. It was found that there was a significant difference between the three groups (p .01) in terms of the number of overt eye movement responses, and in terms of when these responses were made (p .01), although there was no significant difference in terms of the differential responsiveness of the groups to the different types of words. No significant interaction was obtained.

The Newman-Keuls was applied to identify the

Table III.-

Analysis of Variance of Blink Rate Scores to Neutral, Affective and Taboo Words (B), during Pre-Stimulus, Stimulus and Post-Stimulus Time Intervals (C), for Introverted, Ambiverted and Extraverted Groups (A).

Source of Variation	df	SS	MS	F ratio
Between Subjects	32			
A (Extraversion)	2	108.08	54.04	.613
R:A	30	2644.13	88.14	
Within Subjects	264			
B (Words)	2	2.06	1.03	.212
AB	4	26.96	6.74	1.387
R:B	60	291.47	4.86	
C (Time Interval)	2	1435.03	717.52	28.170[a]
AC	4	79.90	19,97	.784
R:C	60	1528.23	25.47	
BC	4	27.15	6.79	3.284[b]
ABC	8	10.11	1.26	.611
R:BC	120	248.07	2.07	

[a] p .01 F .01 (2,60) = 5.39

[b] p .05 F .05 (4,120)= 2.45

Table IV.-

Analysis of Variance of Overt Eye Movement Response Scores to Neutral, Affective and Taboo Words (B), during Pre-Stimulus, Stimulus and Post-Stimulus Time Intervals (C), for Introverted, Ambiverted and Extraverted Groups (A).

Source of Variation	df	SS	MS	F ratio
Between Subjects	32			
A (Extraversion)	2	823.36	411.68	13.280[a]
R:A	30	929.97	30.99	
Within Subjects	264			
B (Words)	2	11.04	5.52	1.616
AB	4	23.37	5.85	1.711
R:B	60	204.96	3.42	
C (Time Interval)	2	391.22	195.61	15.374[b]
AC	4	97.10	24.28	1.908
R:C	60	763.40	12.72	
BC	4	8.74	2.18	.752
ABC	8	22.57	2.82	.971
R:BC	120	348.80	2.91	

[a] p .01 F .01 (2,30) = 5.39

[b] p .01 F .01 (2,60) = 4.98

significant differences between the means for the A and C factors. For the A factor it was found that all means were significantly different from each other at the .01 level. For the C factor, it was found that the pre-stimulus mean was significantly different from both the stimulus mean and the post-stimulus mean (p .01), but that the stimulus mean was not significantly different from the post-stimulus mean.

To summarize at this point, the results of the analyses on blinks and eye movements indicated that:

1. Introverts, Ambiverts and Extraverts have significantly different numbers of eye movements to neutral, affective and taboo words; but not significantly different numbers of blinks.

2. Introverts, Ambiverts and Extraverts have significantly different numbers of blinks and eye movements before the stimulus word was presented, during the stimulus word, and after the stimulus word was presented.

For the purposes of description and later discussion a complete listing of basic statistics on pupil reactivity, blink rate and eye movements are presented in Appendix 5.

3. GSR Latency and Amplitude Analysis.

The fourth hypothesis was that there was no significant difference between groups differing in degree of extraversion in terms of their GSR latencies to neutral, affective and

taboo words.

A two-way analysis of variance with repeated measures on the second factor revealed that this hypothesis should be rejected. The results indicated that the main effect due to extraversion was significant (p .01), as was the main effect due to the word stimuli. The analysis of variance results for the GSR latencies are presented in Table V. The Newman-Keuls procedure, as applied to the extraversion factor, revealed that the Introverts were significantly different from the Extraverts (p .01) but not from the Ambiverts, although the Extraverts were significantly different from the Ambiverts (p .01). The Newman-Keuls procedure for the word factor showed that the mean for the taboo words was significantly different from the means of the affective and neutral words (p .01), but that the mean for the affective words was not significantly different from the mean for the neutral words.

The fifth hypothesis was that there was no significant difference between groups differing in degree of extraversion in terms of their GSR amplitudes to neutral, affective and taboo words. The analysis of variance results revealed that this hypothesis should be rejected. The main effect due to extraversion was significant at the .01 level, as was the main effect due to the words. The results are presented in Table VI.

Table V.-

Analysis of Variance of GSR Latency Scores to Neutral, Affective and Taboo Words (A), for Introverted, Ambiverted and Extraverted Groups (B).

Source of Variation	df	SS	MS	F ratio
B (Extraversion)	2	80.316	40.158	10.188[a]
R:B	30	118.249	3.942	
A (Words)	2	8.503	4.252	21.459[b]
AB	4	1.216	.304	1.534
R:A	60	11.887	.198	

[a] p .01 F .01 (2,30) = 5.39

[b] p .01 F .01 (2,60) = 4.98

Table VI.-

Analysis of Variance of GSR Amplitude Scores to Neutral, Affective and Taboo words (A), for Introverted, Ambiverted and Extraverted Groups (B).

Source of Variation	df	SS	MS	F ratio
B (Extraversion)	2	481.97	240.98	7.343[a]
R:B	30	984.48	32.81	
A (Words)	2	341.93	170.96	50.150[b]
AB	4	13.71	3.43	1.000
R:A	60	204.54	3.42	

[a] p .01 F .01 (2,30) = 5.39

[b] p .01 F .01 (2,60) = 4.98

The Newman-Keuls procedure revealed that the Introverts were significantly different from the Ambiverts (p .05) and from the Extraverts (p .01), but that the Ambiverts were not significantly different from the Extraverts. For the word factor, it was found that the three types of words were all significantly different from each other at the .01 level. None of the interactions, either for the latencies or the amplitudes were significant.

4. Rating Scale Data.

The rating scales were ordered along a continuum extending from 1 (most pleasant imaginable) to 11 (most unpleasant imaginable), with 6 being classified as neutral. The mean ratings for the Introverts, Ambiverts and Extraverts for the neutral words were 5.30, 5.09 and 5.20 with standard deviations of .41, .33 and .31 respectively. The three groups of subjects' mean ratings for the affective words were 7.82, 7.89 and 7.89 with standard deviations of 1.02, .51 and .85 respectively. The mean ratings for the taboo words were 5.48, 5.58 and 5.62 with standard deviations of .61, 1.13 and 1.00.

A two-way analysis of variance (degree of extraversion x the ratings of the neutral, affective and taboo words) was performed with the results presented in Table VII. The results

of the analysis indicated that the main effect due to extraversion was not significant although the main effect due to the word ratings was highly significant (p .01). The Newman-Keuls again was applied to identify the significant differences among the types of words and all of the differences between the means were found to be significant at the .01 level. The interaction of extraversion x ratings of words was not significant.

The results of the rating scale data suggested that all of the subjects rated the words in the same way, although the actual ratings that they assigned to the three types of words were different.

Table VII.-

Analysis of Variance of Ratings to Neutral, Affective and Taboo Words (A), for Introverted, Ambiverted and Extraverted Groups (B).

Source of Variation	df	SS	MS	F ratio
B (Extraversion)	2	.039	.019	.038
R:B	30	15.219	.507	
A (word Ratings)	2	138.850	69.424	102.550[a]
AB	4	.330	.082	.122
R:A	60	40.621	.677	

[a] p .01 F .01 (2,60) = 4.98

CHAPTER IV

DISCUSSION OF RESULTS

This chapter begins with a summary of results and is followed by an evaluation of the hypotheses which guided the investigation. An analysis of Hess's dilation-constriction hypothesis in light of the obtained results is then undertaken. Pupil reactivity in relation to arousal and the Law of Initial Values are also discussed. The final section discusses the implications of the study and gives recommendations for further research.

1. Summary of Results.

This investigation has demonstrated that pupillary reactivity is a sensitive indicator of differences in a psychological variable. That is, under the conditions of this experiment it was demonstrated that subjects trichotomized as Introverts, Ambiverts and Extraverts exhibited highly significant differences in pupillary reactivity to neutral, affective and taboo words presented through the auditory mode. The Introverts produced significantly larger pupillary responses than did the Ambiverts or the Extraverts. The results of the pupillary reactivity analysis also showed

that the neutral, affective and taboo word stimuli varied significantly in their effect on the pupil responses of the subjects. The times at which the changes in pupil size occurred, that is, whether they were pre-stimulus, stimulus or post-stimulus were also found to vary significantly.

The analysis on blink rate revealed that there was no significant difference between the groups in terms of their blink rate, and in terms of which words they blinked to, although there was a significant difference in terms of when they blinked.

The overt eye movement response analysis showed that there were significant differences between the Introverts, Ambiverts and Extraverts in terms of their respective numbers of eye movements, and in terms of when these eye movements were made, although there was no significant difference in terms of which words these movements were made to.

The analysis of variance on the GSR data revealed that there were significant differences between the groups of Introverts, Ambiverts and Extraverts in terms of both their GSR latencies and amplitudes. The results also showed that the neutral, affective and taboo word stimuli varied significantly in their effect on the GSR latencies and amplitudes. In general, it was found that the Introverts

had the shortest latency with the largest amplitude. Taking all of the subjects as a group, it was found that the taboo words had the shortest latency with the largest amplitude, followed by the affective and then the neutral words.

The results of the rating scales suggested that the three groups of subjects tended to rate the words in the same way, although the actual ratings assigned to the three types of words were found to differ significantly.

2. Evaluation of the Hypotheses.

The first null hypothesis, which stated that there was no significant difference between Introverted, Ambiverted and Extraverted subjects in their pupil reactivity to neutral, affective and taboo words during pre-stimulus, stimulus and post-stimulus periods, was rejected. Significant differences were found among the three types of subjects to the three types of words under the three different time intervals. The trend of the results was consistently in the direction that would be predicted from Eysenck's[1] theory; that is, that Introverts would react more to the arousing stimulus words than would Extraverts. However, Extraverts have been postulated to manifest a strong inhibitory central nervous system and weak

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1 H.J. Eysenck, The Biological Basis of Personali
Springfield, Illinois, Charles C. Thomas, 1967, xv-399 p.

excitatory tendencies that result in reduced cortical effeciency, while Introverts are thought to manifest the opposite. Therefore, a higher level of arousal is maintained in Introverts which leads to sensory sensitization in contrast to sensory repression in Extraverts. The results of this study clearly support this interpretation. The pupil reactivity results also appear to support Gray's[2] position that Introverts are cortically more aroused for greater periods of time, and display greater physiological reactivity.

The second null hypothesis, which stated that there was no significant difference between the three types of subjects in their blink rates to the three types of words during the three time intervals, was not rejected, in view of the insignificant over-all effect due to extraversion and to the stimulus words. The findings of the present study were therefore inconsistent with previous research[3,4] which found that Introverts had significantly

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2 J.A. Gray, "The Psychophysiological Basis of Introversion-Extraversion", Behavior Research and Therapy, 8, 1970, 249-260.

3 C.M. Franks, "Ocular Movements and Spontaneous Blink Rate as Functions of Personality", Perceptual and Motor Skills, 1963, 16, 178.

4 H.C. Holland, "Measures of Perceptual Function", in H.J. Eysenck (Ed.), Experiments in Personality. Vol. II, London, Routledge and Kegan Paul, 1960, pp. 193-233.

greater blink rates than Extraverts. A possible explanation for these results, especially in light of the over-all significance of the time factor, may be drawn from the work of Meyer.[5] In his theory of the interaction of simultaneous responses, Meyer has suggested that, because of the strategic location of the eyelid in the motor center, the eyeblink can be thought of much more as an indicator of muscular tension than of anxiety although the two are parallel. Furthermore, Meyer showed that the failure of the eye blink to serve as a consistent index of the degree of anxiety may be due to the fact that strongly visual tasks inhibit blinking. Thus, the failure to find significant differences for blink rate for the extraversion and word factors may have been due to the nature of the task, that is, fixating on a single point, or a lack of other experimental controls in the pupillometric procedure.

The null hypothesis that there was no significant difference between the three levels of extraversion with regard to overt eye movement responses to the three types of words during the three time intervals, was rejected. Significant differences were found with regard to extraversion and time, but not to the different levels of words.

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5 D.R. Meyer, "On the Interaction of Simultaneous Responses", Psychological Bulletin, 1953, 50, 204-220.

The results in relation to this hypothesis, taken in conjunction with the trend of the blink rate hypothesis leads the author to speculate that perhaps Introverts, Ambiverts and Extraverts adopt different strategies for dealing with anxiety provoking stimuli. The Introvert, as a 'natural' response, may close his eyes or look away when presented with an anxiety provoking stimulus, possibly because of the affective or emotional impact of the stimulus. The Extravert does not need to employ these defensive procedures, probably because he is much less effected by the stimulus. Commenting on this point, Francis[6] has said that it is consistent to consider pupillary changes as somatic responses and overt responses as motor outlets (and anxiety reducers).

The null hypothesis that there was no significant difference between degree of extraversion and GSR latency to neutral, affective and taboo words was rejected as was the null hypothesis that there was no significant difference between the degree of extraversion and the GSR amplitude to neutral, affective and taboo words. The GSR latency and amplitude data for the three groups appeared to correspond quite well with the pupillary reactivity data. These results are consistent with those found by other researchers

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6 R.D. Francis, "Neuroticism and Optical Pupil Changes in Response to Auditory Stimuli", British Journal of Social and Clinical Psychology, 1969, 8, 344-349.

such as Kahneman et al[7] and Colman and Paivio.[8] In both of these studies it was found that the pupillary response was a more sensitive peripheral response than GSR during cognitive tasks; although both studies, like this one, found that GSR and pupil size reflected changes in a similar manner.

3. Analysis of Hess's Dilation-Constriction Hypothesis.

The data of this study did not agree with the hypothesis advanced by Hess that aversive or unpleasant stimuli lead to pupillary constriction, while pleasant stimuli lead to dilation. While it was found that the characteristic response was a pupillary constriction for a few stimuli and a few individuals, the general underlying characteristics of those stimuli that produced constriction could not be found. The words that were rated as 'most unpleasant imaginable' never produced a constriction response in any of the thirty three subjects, a result clearly contrary to Hess's hypothesis. Rather, constriction was most associated with words towards the center of the continuum (on either side of indifferent). The words with

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7 D. Kahneman, et al., "Pupillary, Heart Rate, and Skin Resistance Changes During a Mental Task", Journal of Experimental Psychology, 1969, 79, 164-167.

8 F. Colman and A. Paivio, "Pupillary Response and Galvanic Skin Response During an Imagery Task", Psychonomic Science, 1969, 16, 296-297.

the greatest arousing properties always evoked a dilation response, regardless of the pleasantness or unpleasantness of the word. The data of this study appear to support the 'traditional' position, which is that emotional stimuli, regardless of their affective characteristics, tend to evoke dilation responses.

One striking variable in technique has been emphasized by Fredericks and Groves,[9] who strongly support the hypothesis of pupillary constriction to unpleasant stimuli, and dilation to pleasant ones. They felt that their success in making this demonstration was attributable to their control of the level of illumination, chosen on the basis of a pilot study, so that "the pupil was allowed an equal chance to dilate or constrict."[10] In the present study, the mean baseline pupil size was 4.60 mm., a size optimally suited for maximum dilation or constriction possibilities.[11] Thus, their contention that the direction of the pupillary reaction depends upon the initial conditions appears erroneous.

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9 R.S. Fredericks and M. Groves, "Pupil Change and Stimulus Pleasantness", Proceedings of the 79th Annual Convention of the American Psychological Association, 1971, 371-372.

10 Ibid. p. 371

11 O. Lowenstein and I.E. Loewenfeld, "The Pupil", in in H. Davson (Ed.), The Eye, Vol. 3., Muscular Mechanisms, N.Y., Academic Press, 1969, p. 256-337.

4. Pupillary Reactivity and Arousal.

The present findings are in agreement with the findings of previous researchers into the pupillary correlates of arousal. Past investigations have usually demonstrated that pupillary reactivity accompanies any condition which elicits other signs of arousal. Gray[12] noted that the psychological activity which is being reflected in pupil reactivity is best characterized by the construct of arousal. Kahneman and Beatty[13] also recognized the potential of pupillary change for bolstering the arousal construct but did not elaborate on specific mechanisms.

By employing levels of Extraversion as a classification criterion in a pupil size study, an opportunity was provided to explore the differences in physiological arousal between groups differing in potential arousability. As was discussed previously, pupil reactivity appears to be a new and powerful variable to support Gray's[14] conclusion that Introverts are cortically more aroused for longer periods of time, and display greater physiological reactivity, than do Extraverts.

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12 K.C. Gray, "Anticipation and Stuttering: A Pupillographic Study", Dissertation Abstracts, 1968, No. 68-10, 656.

13 D. Kahneman and J. Beatty, "Pupil Diameter and Load on Memory", Science, 1966, 154, 1583-1585.

14 J.A. Gray, op. cit., 1970, p. 258.

The differences in arousability, as assessed by the pupillary and GSR responses for the Introverts, Ambiverts and Extraverts are also interpretable within the model proposed by Klein.[15] He argues that motivated perceiving is not simply need reducing, nor is it neccessarily distorting, but rather "the rules of perceptual selectivity are much of the time highly stable across changes in need states, and even when perception is responsive to specific needs it is usually effectively coordinated with environmental structures and conditions."[16] Personality embodies stabilized dispositions of perception and cognition, or what Klein calls cognitive styles. These stable modes of cognitive control are presumed to reflect basic personality invariants.

Within this context it can be hypothesized that the Introvert, because of his greater sensitivity to the environment, may develop a greater wealth of associations and imaginal capabilities due to a different mode of perceptual catagorization, that is, due to a different cognitive style. In this study, the Introverts and Extraverts were asked to imagine for ten seconds the words that they heard. It is possible that the Introvert because of a

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15 G. Klein, Perception, Motives and Personality. New York, Knopf, 1970, 464 p.

16 Ibid. p. 10.

richer and greater capacity to imagine was more effected by the word and hence was more aroused as demonstrated by his greater pupil and GSR reactivity. This interpretation appears parsimonious with Eysenck's postulate that Extraverts, because of a relative lack of sensitivity, have a preference for strong sensations. Whether Extraverts are better able to tolerate very high levels of sensation has not been proven conclusively, although the greater pain tolerance of Extraverts is suggestive of such a state of affairs.[17]

5. The Law of Initial Values and the Pupillary Response.

One result of a study by Dureman and Sholander[18] is relevant in this section. They pointed out the fact that within the first three trials in their study, a decline in areal pupil change was accompanied by a decline in post-stimulus diameter, and a rise in pre-stimulus diameter. This result was interpreted as indicating that an increase in the initial phase of the tonic pupillary component induces a resistance towards further dilation, thus causing a decline in both measures of phasic reactivity. This result is directly

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17 R. Lynn and H.J. Eysenck, "Tolerance for Pain, Extraversion and Neuroticism", Perceptual and Motor Skills, 1951, 12, 161-162.

18 I. Dureman and T. Scholander, "Studies in the Psycho-Sensory Pupillary Reflex I. Habituation to Auditory Stimuli", Journal of Psychosomatic Research, 1962, 6, 49-54.

related to a problem commonly encountered in psychophysiological research----The Law of Initial Values. Simply stated, the law is, "As the function of an organ rises, the size of the response to a given stimulus diminishes."[19] In terms of the pupillary response, this means that the larger the initial diameter, the smaller the subsequent dilation, and conversely, the smaller the initial diameter, the smaller the subsequent constriction.

Some research dealing with the relationship between pre-stimulus diameter and post-stimulus reaction has been accomplished,[20] although a review of the recent literature has shown that few studies have incorporated the appropriate checks within their designs and methodology.

The Law of Initial Values was satisfied by the data in this study, in fact it was built into the design and methodology of the study. Careful consideration was given to the lighting so that the initial pupil diameters of the

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19 J.D. Block and W.H. Bridger, "The Law of Initial Values in Psychophysiology: A Reformulation in Terms of Experimental Theoretical Considerations", In W. Wolf, (Ed.), "Rhythmic Functions in the Living System", Annals of the New York Academy of Science, 1962, 98, 1229-1241.

20 I.E. Loewenfeld and D.A. Newsome, "Iris Mechanics I: Influence of Pupil Size on Dynamics of Pupillary Movements", Sixth Colloquium on the Pupil, Bethesda, Maryland, 1969.

subjects averaged at about 4.60 mm., and therefore allowed an equal chance for dilation or constriction. As well, in the scoring procedure there was a systematic dependence of response magnitude upon base level. That is, all stimulus and post-stimulus pupil size changes were considered in relation to pre-stimulus diameter. This procedure greatly differs from Hess's studies where there is sometimes a marked variation in the obtained magnitude of the relationship between base level and response.[21]

6. Implications and Recommendations.

In considering the implications of the study for further research it seems appropriate to focus primarily on pupil reactivity because issues which relate to it relate to most of the other variables as well.

The pupillary response has very rarely been related to objective personality variables despite its potential validity and usefulness. The capacity of the pupillary response to accurately reflect attitudes and feelings towards various stimuli would seem to make it particularly relevant to research with personality variables that can be investigated via visual or auditory stimuli.

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21 E.H. Hess, op. cit., 1972, p. 507.

Another possibility would be to relate the pupillary response to many other autonomic indices, and in particular heart rate. Only two studies have done this,[22,23] and both reported results that showed directional fractionalization of the cardiac and pupillary responses.

The pupillary response also has potential value in the areas of Clinical Psychology and personality theory. One possibility would be to assess the value of pupil reactivity in interpersonal situations. That is, a study could be done to assess the potential of the pupillometric technique in identifying the emotional impact of specifiable visual or auditory stimuli representing conflict situations. The rationale for such a study would be that greater pupil reactivity would represent the person's problem area. Also, changes in emotional responsivity to conflict situations may be utilized as a measure of change in therapy. Kell and Mueller[24] have suggested that emotional experiences often become compacted into particular words and phrases. It is suggested that pupillometrics offers a procedure for detecting such compacted words or phrases in a given client.

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22 D. Kahneman, et al., op. cit., 1969, p. 167.

23 W.L. Libby, B.C. Lacey and J.I. Lacey, "Pupillary and Cardiac Activity During Visual Attention", Psychophysiology, 1973, 10, 270-294.

24 B. Kell and W. Mueller, Impact and Change: A Study of Counselling Relationships. Appleton, Century-Crofts, New York, 1966.

SUMMARY AND CONCLUSIONS

This study was conducted to determine the applicability of Eysenckian theory to the explanation of pupillary changes. An attempt was made also to clarify the dilation-constriction controversy within this context. Differences in cortical excitability, as determined by the Extraversion scores of the EPI, were found to be a significant and systematic source of individual differences in pupillary reactivity.

The inquiry focused on the differences in pupillary response, blink rate, overt eye movement responses, GSR latency and GSR amplitude between groups of Introverts, Ambiverts and Extraverts. The five hypotheses stated that there would be no significant difference between the groups when compared on the five physiological measures, to the three types of words under the three time intervals. Ratings of the stimulus words were obtained at the conclusion of the experimental procedure.

Statistically significant differences in pupil reactivity were found among the groups, among the words, and among the time intervals. The results with regard to pupil size were interpreted as demonstrating the applicability of the Eysenckian concept of Extraversion to the explanation

of pupil reactivity. The data of this study did not agree with the hypothesis advanced by Hess that aversive or unpleasant stimuli lead to pupillary constriction, while pleasant stimuli lead to dilation. Rather, the data of this study appeared to support the 'traditional' position, which is that emotional stimuli, regardless of their affective characteristics, tend to evoke dilation responses.

The trend of the results on blink rate, and the statistically significant results on overt eye movement responses were used as evidence to support the position that Introverts and Extraverts adopt different stratagies for dealing with anxiety-provoking situations.

The results of the GSR latency and amplitude analysis were consistent with previous research employing GSR and pupil size, and they were used as further support for the position that pupil size is a reliable and consistent indicator of arousal in relation to other measures.

Pupil reactivity was discussed as a measure of a generalized physiological response to emotionally meaningful stimuli within the context of both Eysenck's and Klein's theories. The plausibility of Hess's dilation-constriction hypothesis and the Law of Initial Values in relation to the pupillary response were also discussed.

Several research implications were suggested, both in the investigation of the characteristics of the pupil response itself, and in the utilization of the pupil response in investigating the emotional properties of psycho-sensory stimuli.

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Eysenck, H.J., The Biological Basis of Personality, Springfield, Illinois, Charles C. Thomas, 1970, xv-399 p.

The most comprehensive statement of Eysenck's theory of personality. The relevant sections of this book provide a neurophysiological model for extraversion based on empirical evidence.

Francis, R.D., "Neuroticism and Optical Pupil Changes in Response to Auditory Stimuli", British Journal of Social and Clinical Psychology, 1969, 8, 344-349.

This study examined the capacity of auditory stimuli to evoke pupillary responses. The study included administration of the EPI to determine if the Extraversion and Neuroticism scores differed for high and low pupillary responders.

Goldwater, B.C., "Psychological Significance of Pupillary Movements", Psychological Bulletin, 1972, 77, 340-355.

A thorough, recent, and comprehensive review of the pupil size research. This theoretical article provides evidence for the effectiveness of the pupil as an index of autonomic activity in psychophysiological research. Methodological problems in the pupillary literature are discussed, and possibilities for further research are suggested.

Hess, E.H., "Attitude and Pupil Size", Scientific American, 1965, 212, 46-54.

The most important experimental paper by the most prominent researcher in the area of pupillometrics. In this article he explicitly delineates his dilation-constriction hypothesis.

Hess, E.H., "Pupillometrics", in N.S. Greenfield and R.A. Sternbach, (Ed.), Handbook of Psychophysiology, Holt, Rinehart and Winston, N.Y., 1972, p. 491-531.

A survey article covering eleven years of pupillometric research. Several relevant, and as yet unpublished papers are discussed within this article.

Holmes, D.S., "Pupillary Response, Conditioning and Personality", Journal of Personality and Social Psychology, 1967, 5, 98-103.

This research tested the relationship between ACh and ChE, as inferred from the speed of pupillary constriction and dilation, to awareness of an environmental contingency, performance on a verbal conditioning task and EPI scores.

Kahneman, D., Tursky, B., Shapiro, D., and Crider, A., "Pupillary, Heart Rate, and Skin Resistance Changes During a Mental Task", Journal of Experimental Psychology, 1969, 79, 164-167

In this study, subjects performed a paced mental task at three levels of difficulty, while time-locked recordings of pupil size, heart rate and GSR were made. A similar pattern of sympathetic-like activity was found in the three autonomic measures. This was a very important study for the rationale and methodology of the present investigation.

Libby, W.L., Lacey, B.C., and Lacey, J.I., "Pupillary and Cardiac Activity During Visual Attention", Psychophysiology, 1973, 10, 270-294.

In this study the authors monitored pupillary response, heart rate and blood pressure, and reported results that indicated directional fractionalization of the cardiac and pupillary responses. This paper was of great assistance in interpreting the results of the present study.

Lowenstein, O., and Loewenfeld, I.E., "The Pupil", in H. Davson, (ed.), The Eye, Volume 3, Muscular Mechanisms, 2nd Edition, N.Y., Academic Press, 1969, p. 256-337.

This paper provides the most extensive review of the physiology of the pupil, pupillary constriction and pupillary dilation. When these phenomena occur, how they occur, and what stimuli will elicit these responses are elaborated.

Nunnally, J.C., Knott, P.D., Duchnowski, A., and Parker, R., "Pupillary Response as a General Measure of Activation", Perception and Psychophysics, 1967, 2, 149-155.

This paper includes five different studies on the relationship of the pupillary response to activation. From these studies the authors conclude that the pupillary response relates as reliably, or more reliably, to a variety of forms of activation then does other forms of activation. This was an important paper from both a theoretical and methodological standpoint.

APPENDIX 1

EYSENCK PERSONALITY INVENTORY, (EPI), FORM A

EYSENCK PERSONALITY INVENTORY

FORM A

By H. J. Eysenck
and Sybil B. G. Eysenck

Name_____ Age_____ Sex_____

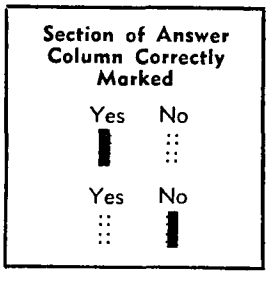
Grade or Occupation _____ Date_____

School or Firm_____ Marital Status_____

INSTRUCTIONS

Here are some questions regarding the way you behave, feel and act. After each question is a space for answering "Yes," or "No."

Try and decide whether "Yes," or "No" represents your usual way of acting or feeling. Then blacken in the space under the column headed "Yes" or "No."



Work quickly, and don't spend too much time over any question; we want your first reaction, not a long drawn-out thought process. The whole questionnaire shouldn't take more than a few minutes. Be sure not to omit any questions. Now turn the page over and go ahead. Work quickly, and remember to answer every question. There are no right or wrong answers, and this isn't a test of intelligence or ability, but simply a measure of the way you behave.

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BOX 7234, SAN DIEGO, CALIFORNIA 92107

1. Do you often long for excitement? Yes No
2. Do you often need understanding friends to cheer you up? Yes No
3. Are you usually carefree? Yes No
4. Do you find it very hard to take no for an answer? Yes No
5. Do you stop and think things over before doing anything? Yes No
6. If you say you will do something do you always keep your promise, no matter how inconvenient it might be to do so? Yes No
7. Does your mood often go up and down? Yes No
8. Do you generally do and say things quickly without stopping to think? Yes No
9. Do you ever feel "just miserable" for no good reason? Yes No
10. Would you do almost anything for a dare? Yes No
11. Do you suddenly feel shy when you want to talk to an attractive stranger? Yes No
12. Once in a while do you lose your temper and get angry? Yes No
13. Do you often do things on the spur of the moment? Yes No
14. Do you often worry about things you should not have done or said? Yes No
15. Generally do you prefer reading to meeting people? Yes No
16. Are your feelings rather easily hurt? Yes No
17. Do you like going out a lot? Yes No
18. Do you occasionally have thoughts and ideas that you would not like other people to know about? Yes No
19. Are you sometimes bubbling over with energy and sometimes very sluggish? Yes No
20. Do you prefer to have few but special friends? Yes No
21. Do you daydream a lot? Yes No
22. When people shout at you, do you shout back? Yes No
23. Are you often troubled about feelings of guilt? Yes No
24. Are all your habits good and desirable ones? Yes No
25. Can you usually let yourself go and enjoy yourself a lot at a gay party? Yes No
26. Would you call yourself tense or "highly-strung"? Yes No
27. Do other people think of you as being very lively? Yes No
28. After you have done something important, do you often come away feeling you could have done better? Yes No
29. Are you mostly quiet when you are with other people? Yes No
30. Do you sometimes gossip? Yes No
31. Do ideas run through your head so that you cannot sleep? Yes No
32. If there is something you want to know about, would you rather look it up in a book than talk to someone about it? Yes No
33. Do you get palpitations or thumping in your heart? Yes No
34. Do you like the kind of work that you need to pay close attention to? Yes No
35. Do you get attacks of shaking or trembling? Yes No
36. Would you always declare everything at the customs, even if you knew that you could never be found out? Yes No
37. Do you hate being with a crowd who play jokes on one another? Yes No
38. Are you an irritable person? Yes No
39. Do you like doing things in which you have to act quickly? Yes No
40. Do you worry about awful things that might happen? Yes No
41. Are you slow and unhurried in the way you move? Yes No
42. Have you ever been late for an appointment or work? Yes No
43. Do you have many nightmares? Yes No
44. Do you like talking to people so much that you would never miss a chance of talking to a stranger? Yes No
45. Are you troubled by aches and pains? Yes No
46. Would you be very unhappy if you could not see lots of people most of the time? Yes No
47. Would you call yourself a nervous person? Yes No
48. Of all the people you know are there some whom you definitely do not like? Yes No
49. Would you say you were fairly self-confident? Yes No
50. Are you easily hurt when people find fault with you or your work? Yes No
51. Do you find it hard to really enjoy yourself at a lively party? Yes No
52. Are you troubled with feelings of inferiority? Yes No
53. Can you easily get some life into a rather dull party? Yes No
54. Do you sometimes talk about things you know nothing about? Yes No
55. Do you worry about your health? Yes No
56. Do you like playing pranks on others? Yes No
57. Do you suffer from sleeplessness? Yes No

APPENDIX 2

SUBJECTIVE RATING SCALE

NAME_____

Please rate each word on the following pages in terms of how pleasant or unpleasant you think it is.

DEFINITIONS.

Pleasant: agreeable to the senses; having a pleasant aspect; comfortable with.

Unpleasant: not pleasant; not amiable or agreeable to the senses; having a displeasing aspect; offensive.

DIRECTIONS.

For each word, place the number on the line next to the word which best fits your feeling of pleasantness or unpleasantness towards that word.

Evaluate each word only once.

Now turn to the sample items CANDY on the next page.
BLOOD

SAMPLE WORDS: CANDY
BLOOD

CATAGORIES

most pleasant imaginable	:	1
most pleasant	:	2
extremely pleasant	:	3
moderately pleasant	:	4
mildly pleasant	:	5
indifferent	:	6
mildly unpleasant	:	7
moderately unpleasant	:	8
extremely unpleasant	:	9
most unpleasant	:	10
most unpleasant imaginable	:	11

CANDY 3

In the example, a 3 was marked in next to CANDY. This would mean that the person answering thought that the word CANDY was extremely pleasant.

BLOOD 8

In the example, an 8 was marked in next to BLOOD. This would mean that the person answering thought that the word BLOOD was moderately unpleasant.

REMEMBER, MAKE ONLY ONE RATING FOR EACH WORD.

CATAGORIES

most pleasant imaginable	:	1
most pleasant	:	2
extremely pleasant	:	3
moderately pleasant	:	4
mildly pleasant	:	5
indifferent	:	6
mildly unpleasant	:	7
moderately unpleasant	:	8
extremely unpleasant	:	9
most unpleasant	:	10
most unpleasant imaginable	:	11

WORDS

farm	_____
slime	_____
fuck	_____
shoe	_____
valley	_____
cripple	_____
cloverleaf	_____
masturbation	_____
bench	_____
cradle	_____
nipple	_____
pimple	_____
mosquito	_____
prick	_____
muffin	_____
infection	_____
parasite	_____
scarf	_____
penny	_____
balls	_____
coat	_____
bitch	_____
particle	_____
filth	_____

WORDS

sled	_____
fart	_____
vomit	_____
pillar	_____
field	_____
cunt	_____
fork	_____
pus	_____
home	_____
prince	_____
shit	_____
guts	_____
inspection	_____
clitoris	_____
noodle	_____
mucous	_____
whore	_____
purse	_____
bells	_____
scab	_____
corn	_____
penis	_____
goats	_____
corpse	_____

APPENDIX 3

RATINGS OF WORDS CHOSEN AS STIMULI

RATINGS OF WORDS CHOSEN AS STIMULI

The scores of the twelve affective and twelve taboo words that were chosen as word stimuli are presented below. A rating of 10 means that all ten judges thought that the word was emotional. The neutral words that were paired with the affective and taboo words are also presented.

TABOO WORDS		NEUTRAL WORDS	AFFECTIVE WORDS		NEUTRAL WOR
Fuck	-10	Fork	Vomit	-10	Valley
Prick	-10	Prince	Pus	-10	Purse
Balls	-10	Bells	Mucous	-9	Muffin
Cunt	-10	Corn	Parasite	-9	Particle
Masturbation	-9	Mosquito	Scab	-8	Scarf
Fart	-9	Farm	Corpse	-8	Coat
Shit	-8	Shoe	Slime	-7	Sled
Whore	-8	Home	Cripple	-7	Cradle
Nipple	-7	Noodle	Infection	-7	Inspection
Clitoris	-7	Cloverleaf	Pimple	-7	Pillar
Penis	-7	Penny	Filth	-5	Field
Bitch	-5	Bench	Guts	-5	Goats

APPENDIX 4

ORDER OF PRESENTATION OF STIMULUS WORDS

ORDER OF PRESENTATION OF STIMULUS WORDS

TAPE I	TAPE II
sled	farm
fart	slime
vomit	fuck
pillar	shoe
field	valley
cunt	cripple
fork	cloverleaf
pus	masturbation
home	bench
prince	cradle
shit	nipple
guts	pimple
inspection	mosquito
clitoris	prick
noodle	muffin
mucous	infection
whore	parasite
purse	scarf
bells	penny
scab	balls
corn	coat
penis	bitch
goats	particle
corpse	filth
farm	sled
slime	fart
fuck	vomit
shoe	pillar
valley	field
cripple	cunt
cloverleaf	fork
masturbation	pus
bench	home
cradle	prince
nipple	shit
pimple	guts
mosquito	inspection
prick	clitoris
muffin	noodle
infection	mucous
parasite	whore
scarf	purse
penny	bells
balls	scab
coat	corn
bitch	penis
particle	goats
filth	corpse

APPENDIX 5

BASIC STATISTICS ON PUPIL REACTIVITY, BLINK RATE AND OVERT EYE MOVEMENT RESPONSES

BASIC STATISTICS: PUPIL REACTIVITY (RAW SCORES)

	INTROVERTS			AMBIVERTS			EXTRAVERTS		
	N	A	T	N	A	T	N	A	T
Maximum	6.67	6.84	6.38	5.62	4.71	5.24	5.51	5.54	5.54
Minimum	3.75	3.23	3.78	3.23	3.19	3.16	3.45	3.57	3.30
Range	2.92	3.61	2.60	2.39	1.52	2.08	2.06	1.97	2.24
Mean	5.05	4.99	5.08	4.29	4.16	4.20	4.51	4.48	4.55
Variance	.53	.71	.43	.32	.18	.23	.40	.35	.43
Standard Deviation	.72	.84	.65	.57	.42	.48	.64	.59	.66
Mean Deviation	.58	.67	.54	.42	.32	.36	.56	.48	.56
Median	5.11	5.01	5.16	4.27	4.24	4.20	4.67	4.54	4.48
Mode	----	----	5.42	----	4.07	4.47	4.97	----	----

N = neutral

A = affective

T = taboo

BASIC STATISTICS: PUPIL REACTIVITY (RAW SCORES)

	Mean	Standard Deviation	Variance
Introverts (All Conditions)	5.05	.739	.545
Ambiverts (All Conditions)	4.22	.491	.242
Extraverts (All Conditions)	4.52	.624	.390
Neutral Words (All Subjects)	4.62	.717	.514
Affective words (All Subjects)	4.55	.722	.522
Taboo Words (All Subjects)	4.62	.701	.492

BASIC STATISTICS

PUPIL REACTIVITY (ABSOLUTE PUPILLARY CHANGE SCORES)

	INTROVERTS			AMBIVERTS			EXTRAVERTS		
	N	A	T	N	A	T	N	A	T
Maximum	.80	.83	1.02	.52	.53	.68	.45	.37	.57
Minimum	.11	.11	.14	.08	.05	.05	.07	.08	.06
Range	.69	.72	.88	.44	.48	.63	.38	.29	.51
Mean	.31	.34	.46	.24	.26	.27	.18	.18	.23
Variance	.024	.030	.046	.015	.017	.020	.007	.004	.013
Standard Deviation	.15	.17	.21	.12	.13	.14	.08	.06	.11
Mean Deviation	.11	.13	.16	.10	.10	.11	.06	.05	.09
Median	.26	.31	.45	.22	.25	.23	.16	.18	.23
Mode	.20	.27	.45	.18	.25	.18	.12	.17	.27

N = neutral

A = affective

T = taboo

BASIC STATISTICS

PUPIL REACTIVITY (ABSOLUTE PUPILLARY CHANGE SCORES)

	Mean	Standard Deviation	Variance
Introverts (All Conditions)	.37	.19	.037
Ambiverts (All Conditions)	.26	.13	.017
Extraverts (All Conditions)	.20	.09	.008
Neutral Words (All Subjects)	.24	.13	.017
Affective Words (All Subjects)	.26	.14	.021
Taboo Words (All Subjects)	.32	.19	.036

BASIC STATISTICS: NUMBER OF BLINKS

	INTROVERTS			AMBIVERTS			EXTRAVERTS		
	N	A	T	N	A	T	N	A	T
Maximum	39	36	45	37	34	45	20	20	15
Minimum	0	0	0	0	0	1	3	2	2
Range	39	36	45	37	34	44	17	18	13
Mean	12.4	11.6	14.5	10.9	10.2	11.4	8.6	9.4	7.1
Variance	127	100	173	109	117	174	27	35	17
Standard Deviation	11.2	10.0	13.1	10.4	10.8	13.2	5.1	5.9	4.1
Mean Deviation	7.7	6.7	9.1	7.2	8.6	9.3	3.9	4.8	3.1
Median	9	10	13	10	6	8	7	9	6
Mode	--	10	15	14	--	8	5	2	6

N = neutral

A = affective

T = taboo

BASIC STATISTICS: NUMBER OF OVERT EYE MOVEMENT RESPONSES

	INTROVERTS			AMBIVERTS			EXTRAVERTS		
	N	A	T	N	A	T	N	A	T
Maximum	25	28	26	22	28	24	12	6	8
Minimum	1	2	2	3	1	2	0	0	0
Range	24	26	24	19	27	22	12	6	8
Mean	15.1	14.9	18.1	8.7	9.9	9.2	4.6	2.7	4.1
Variance	49.0	57.6	52.7	34.7	63.2	59.6	10.8	5.4	7.1
Standard Deviation	7.0	7.6	7.3	5.9	7.9	7.7	3.3	2.3	2.7
Mean Deviation	5.1	5.4	5.6	4.4	6.2	6.3	2.3	1.9	2.2
Median	16	15	19	7	7	6	4	3	5
Mode	--	14	22	4	7	-	1	0	5

N = neutral

A = affective

T = taboo

APPENDIX 6

ABSTRACT OF

An Investigation of Differential Pupillary and GSR Reactivity Between Groups Differing in Degree of Extraversion

APPENDIX 6

ABSTRACT OF

An Investigation of Differential Pupillary and GSR Reactivity Between Groups Differing in Degree of Extraversion[1]

This thesis attempted to determine the applicability of Eysenckian theory to the explanation of pupillary changes. An attempt was also made to clarify the nature of Hess's dilation-constriction hypothesis. The inquiry focused on the differences in pupillary response, blink rate, overt eye movement responses, GSR latency and GSR amplitude between groups differentiated on the Extraversion dimension of the Eysenck Personality Inventory.

Three groups of eleven Introverts, Ambiverts and Extraverts were selected on the basis of their scores on the EPI. Neutral, affective and taboo word stimuli were utilized to elicit the physiological responses, and a pre-stimulus, stimulus and post-stimulus analysis was undertaken in order to assess the effects of the word stimuli on the subjects over time.

Statistically significant differences in pupil reactivity were found among the three groups, the three types of words and the three time intervals. These results,

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1 Nathan Mandelzys, Master's thesis presented to the Faculty of Psychology of the University of Ottawa, Ontario, September, 1973, x-106 p.

taken in conjunction with the trend of the blink rate analysis, and the statistically significant results with regard to overt eye movement responses, were interpreted as demonstrating the applicability of the Eysenckian concept of Extraversion to the explanation of pupillary dynamics.

The data of this study did not agree with the hypothesis advanced by Hess that aversive or unpleasant stimuli lead to pupillary constriction, while pleasant stimuli lead to dilation.

The GSR latency and amplitude analysis was consistent with previous research and was interpreted as lending support to the position that pupil size is a reliable and consistent indicator of arousal in relation to other measures.