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INTERACTION BETWEEN EXTRAVERSION AND AROUSAL REFLECTED IN ROTATIONAL NYSTAGMUS

by Stanley C. Ferneyhough

Thesis presented to the School of Graduate Studies of the University of Ottawa as partial fulfillment of the requirements for the degree of Doctor of Philosophy

Ottawa, Canada, 1984

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UNIVERSITÉ D'OTTAWA
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CURRICULUM STUDITORIUM

Stanley C. Ferneyhough was born April 18, 1946 in Schenectady, New York, U.S.A. He received the Bachelor of Arts degree from the State University of New York at Buffalo, Buffalo, New York in 1969, and the Master of Arts degree in Psychology from the University of Ottawa, Ottawa, Ontario in 1976. In 1979-1980 he completed an internship at New York University Medical Center, Goldwater Memorial Hospital, New York, New York in the Department of Rehabilitation Medicine.

ABSTRACT OF

Interaction Between Extraversion and Arousal Reflected in Rotational Nystagmus[1]

Differences in cortical arousal have been proposed by Eysenck as being the underlying principal of personality differences--particularly the introversion-extraversion continuum. The precise relationship of the effects of variations of levels of arousal on the groups of individuals defined on the extremes of this continuum, as measured by the *Eysenck Personality Inventory: Form A* (*EPI*) has not been completely clarified. Previous research leads to the hypothesis that there may be an interaction effect between levels of extraversion, as defined by Eysenck, and the induced arousal levels in these groups of subjects.

This hypothesis was tested in detail by varying arousal level, using instructional tasks, in groups of subjects operationally defined by their scores on the *EPI*. The selected dependent measure of the differences in arousal is slow phase, primary nystagmic velocity; this

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[1]Stanley Ferneyhough, doctoral thesis presented to the School of Graduate Studies of the University of Ottawa, Ontario, 1984, xi-146 p.

measure is chosen since it is a gauge of cortical excitation found to be a reflexive response contingent upon mental arousal. It is, therefore, hypothesized that there is an interaction effect between the defined levels of extraversion and the defined levels of arousal.

The subjects for the present investigation consist of 120 undergraduate volunteers. The subjects' obtained score on the EPI determined if they would be assigned to the introvert, ambivert or extravert grouping on the basis of a predetermined classification. Slow phase, primary nystagmic velocity was elicited by the horizontal, angular acceleration of the subject. Each individual experienced the same five experimental, unidirectional accelerations of 9.4 degrees per second squared, which presented maximal stimulation to the horizontal semicircular canal while summated, horizontal eye movements were recorded. A practice rotation and a basal recording were also obtained. The five, experimental conditions were defined by levels of mental arousal, elicited by instructional tasks ranging from reverie to complex choice situations. The presentation order for the five instructional tasks was counterbalanced between subjects.

The slow phase, primary nystagmus dependent measurement was analyzed in a personality by arousal level two factor analysis of variance with repeated measures on one factor. A significant interaction between the five levels of arousal and the three levels of extraversion was found. For extraverts, there was a direct relationship such that the increasing mental arousal was directly reflected in increased nystagmic velocity, the indicator of cortical excitation. For introverts, conversely, there was a curvilinear relationship. The results indicate that differences in levels of cortical arousal, elicited in different personality groups defined by the <u>EPI</u>, produced different effects on cortical excitation. This curvilinear relationship, found in introverts, is discussed in terms of transmarginal inhibition.

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Evidence has accumulated that there may be individual differences in the way cortical arousal varies, and consequently how different people may be affected. One personality classification of individual differences based on the principle of differences in cortical arousal is that proposed by Eysenck. Although much research has been completed on the relationship of arousal to the personality differences proffered by Eysenck, there remains a need for further clarification. A previous study (Ferneyhough, 1976), which used nystagmus as an objective measure of cortical arousal, found an unexplained interaction effect between the personality extremes defined by Eysenck as introverts and extraverts, and the induced arousal levels in these groups of subjects. However, this study evaluated only the extreme points of the arousal continuum and, therefore, did not provide an explanation for this interaction. It is hypothesized that there is a difference in the linearity of the relationship between the two personality groups of introverts and extraverts, and the differences in level of arousal.

The present study proposes to use slow phase, primary nystagmic velocity as the objective, dependent measurement of arousal. The levels of arousal (five in all) will be elicited by use of mental arousal sets. Subjects will be divided into high, medium and low scores based on the extraversion scale of Eysenck's test of introversion-extraversion. It is specifically hypothesized that changes in the nystagmus output during the increasing mental arousal states will vary linearily for extraverted individuals and curvilinearly for introverted individuals. This finding will be important in explaining the behavior between introverts and extraverts. Although further clarification in the role of the reticular formation and the cortex have been proposed (A. B. Scheibel, 1981; M. E. Scheibel & Scheibel, 1967; Skinner & Yingling, 1976), the basic theoretical postulate of differences in arousal underlying personality differences remains a plausible hypothesis for further psychological investigation. Eysenck suggests that extraverts have a chronically low level of cortical arousal compared to introverts who are constitutionally predisposed to higher excitation.

Although previous research has supported differential arousal levels in introverts and extraverts, little research has been done in how objective manipulations of arousal levels influence the actual cortical arousal level as measured by an objective dependent measurement. Such a relationship may proceed on different lines. In general, it may be hypothesized that performance is differentially affected by arousal in different groups of individuals.

The possibility of individual differences in personality have been proposed by many authors. H. J. Eysenck (1967) postulated that personality differences exist on a continuum, the two extremes being introversion and extraversion. These differences in personality and performance are based upon a basic biological difference. Eysenck hypothesized that differences in the functioning of a cortical-reticular loop would result in basic personality differences. In the cortical-reticular loop, sensations going along the ascending afferent pathways relay to the particular projection areas involved in the cortex. They also send colaterals into the reticular formation, which in turn send arousal messages to the cortex to keep it in a state of functional tone. Differences in basic cortical arousal are postulated by Eysenck to explain the differences in the relationship to be either linear or non-linear. A linear hypothesis suggests that increasing arousal will result in correlative increasing excitation of the cortex. However, since Eysenck has postulated that there is a basic fundamental difference in threshold between introverts and extraverts, it is possible that the linear relationship may not exist for both groups. Specifically, introverts, who have a higher excitation level, may reach a ceiling of arousal followed by a decrease in cortical arousal measurement. Behaviorally, this would likely reflect the impairment in efficiency of performance for introverts, because an optimal level of arousal is no longer present. Extraverts, conversely, have a chronically low level of cortical arousal. Increasing levels of arousal would result in linear increments in cortical arousal. H. J. Eysenck (personal communication, April 6, 1983) feels, however, that a decrement (curvilinearity) in the performance of extraverts is possible at even higher arousal levels.

The study is presented within five chapters which are organized to highlight the constituent parts of the overall work. The chapters consist of a review of the literature that is relevant to the subject; the experimental design which relates the mechanics of how the actual experimentation was conducted, the presentation of the results which gives the scoring of the nystagmic testing and an evaluation of the hypothesis; the discussion of the results with regard to the interpretation of the findings presented, the curvilinear effect shown and suggested avenues for the direction of future research; and finally, a general summary and conclusion are given.

There are four supplemental appendices in the main presentation. They detail the information and instructions given to the subjects prior to, and during, the actual testing as outlined in the experimental design; they give a description of the electronic equipment used in the experimental procedure; they present representations of the recorded eye movements; and they list the converted, summated data.

CHAPTER I

REVIEW OF THE LITERATURE

This chapter discusses the literature which represents the most important theoretical and experimental works providing the basis for the problem to be investigated. Sections 1 through 5 discuss the main aspects which are essential to the comprehension of the study. The first and most important section contains Eysenck's neurophysiological theory of personality which provides the understanding of the problem to be presented, and subsequent development.

The second section discusses the relationship of arousal to Eysenck's 1967 theory of extraversion. Investigators have postulated that the effect of arousal on dependent measures is not a linear function but may vary in an inverted-U fashion. The relation of this inverted-U function to Eysenck's theory is presented within the third section.

The fourth section presents the phenomenon of nystagmus as a dependent measure of cortical excitation. The fifth and final aspect presents the concept of mental, instructional set as a manipulator of arousal and how instructional tasks change the mental state of the subject and thus, the nystagmic response.

Section 6 provides for a transition to the remaining chapters of this study. The purpose of the study is established, the rationale for the research objective is presented, the strategy for experimentation is reviewed, and a summary and statement of the hypothesis is given.

1. Eysenck's View of Extraversion

Eysenck has postulated that personality may be divided into an extraversion variable of which introverts and extraverts are individuals located at the extreme points on this continuum. In the evolution of this theory, Eysenck has developed two models--an inhibition model which was later refined as an arousal model. This chapter reviews the theory of the inhibition model as well as how research has led to the growth of the arousal model. A recent challenge to this theory by Gray is also presented.

A. Definition of Extraversion

Personality, by many authors, has been defined in terms of traits. One typological system uses the concept of extraversion. Extraversion literally means "a turning outward." It is the tendency to direct one's interests towards the outer world as opposed to the inner world of the self and subjective experiences. Extraversion figured prominently in Carl Jung's psychology in which extraverts and introverts were the basic personality types. Freud also used these terms, but did not regard them as basic personality types. Both Jung and Freud defined these characteristics in terms of the direction in which the libido expressed itself, whether inwardly or outwardly.

Many hypotheses have been offered to explain the biological differences in individuals. Eysenck has offered two explanations of extraversion: an "excitation-inhibition balance" (H. J. Eysenck, 1957), and a newer version based on "arousal level" (H. J. Eysenck, 1967). An excellent critique of the theories, parts of which are presented in the following sections, is given by Gray (1981) and Levey and Martin (1981). The two accounts have much in common; both theories accept as a given premise that individuals maintain neurotic trends and that formation of either a dysthmic or hysterio-psychopathic personality is determined by the ease with which individuals form conditioned reflexes during their social development. The individual who conditions easily becomes an introvert and is susceptible to dysthymia, and the individual who conditions with difficulty becomes an extravert and is susceptible to hysteria or psychopathy.

The difference between Eysenck's two theories lies in the basis for conditionability. In the 1957 theory the difference in introversion-extraversion was intended as a difference in an excitation-inhibition balance of an unknown physiological origin. In 1967 the difference was interpreted in the cortical arousal level which originated in the ascending reticular system. Although high arousal level can relate to high excitation and low inhibition, and vice versa, the two concepts led to different predictions.

Support for the excitation-inhibition theory is found in studies of involuntary rest pauses during massed practice (H. J. Eysenck, 1964). Extraverts showed more pauses in tapping than introverts which supports the hypothesis that with repeated taps reactive inhibition, an inhibitory potential resulting from an evocative stimuli, builds up and effects extraverts more than introverts.

Inhibition theory, however, gained very little support from vigilance testing studies. Certain experiments (Bakan, Belton & Toth, 1963; Claridge, 1960) reported that introverts performed vigilance tasks better than extraverts not because of a steeper decline in the extraverts' performance over time, as hypothesized by the inhibition theory, but because the introverts initially began at a higher level of performance. Colquhoun and Corcoran (1964) also failed to support the inhibition theory. Introverts performed better than extraverts in isolation and in the morning; whereas extraverts performed better in groups and in the afternoon. The effects of group versus isolation could be explained (refer to Claridge's

1960 use of distractors and disinhibitors), yet the time of day effect could not be explained within inhibition theory.

Arousal levels rise steadily over the day (Blake, 1971; Kleitman, 1939). Therefore, in the morning during a level of generally low arousal, introverts would perform better if they were initially at a higher level of arousal than extraverts. But by the afternoon, when an increase in arousal has occurred, extraverts come closer to their optimum performance level while introverts go beyond this level and, consequently, show decrements in performance. This "inverted-U" relationship between performance and arousal can also be applied to the change from isolation testing to group testing conditions as seen in the Colquhoun and Corcoran (1964) study.

In eye blink conditioning experiments which initially support inhibition theory (Franks, 1956, 1957), all the major results can now be explained using the arousal theory (H. J. Eysenck & Levey, 1972). The results from eye blink conditioning experiments showed that introverts would condition better than extraverts under low intensity reinforcement air puffs, and under a short conditioned stimulus.

B. Eysenck's Recent Views

Eysenck's arousal theory began to replace inhibition theory of personality about 1960 (Claridge, 1960) following the formulation of the general theory of arousal (Freeman, 1948; Duffy, 1962; Moruzzi & Magoun, 1949) and after the decline of Hull's theory (Hull, 1943) of reactive inhibition (Gleitman, Nachmias & Neisser, 1954). By 1967 Eysenck had fully formulated his arousal theory (H. J. Eysenck, 1967) of extraversion.

The major influence upon the evolution of this theory was Pavlovian typology with modifications by Teplov and Nebylitsyn. The basic Pavlovian typology (Pavlov, 1927, 1955) was derived from conditioning experiments, the experimental neurosis paradigm, and response to administration of caffeine. Dogs differed in temperamental excitability of the "strength of the nervous system." The final typology ascribed three properties to the nervous system: strength, equilibrium and mobility. Strength reflected the availability of the excitatory processes and was indexed by how fast conditioned reflexes were formed. Equilibrium reflected the ease of excitatory versus inhibitory conditioned reflexes shown by the balanced individual's ability to form positive and negative conditioned responses with equal ease, and the unbalanced individual's ability to form excitatory conditioned responses more readily than inhibitory ones. Mobility represented the ease with which an individual changed from positive to negative conditioned responses.

Nebylitsyn (1972) noted that the weak nervous system was more sensitive to low intensities of stimulation and, therefore, independent of how fast conditioned responses were formed. He used the term "strength" to denote sensitivity to stimulation which was separate from "dynamism" which referred to the speed of conditioned response formation. As a result, a major shift in emphasis replaced "conditionability" with that of "work capacity" which resembled the concept of arousal level.

In his 1967 book, Eysenck drew parallels between his arousal theory of extraversion-introversion and Nebylitsyn's theory of the strength of the nervous system. In his new formulation (H. J. Eysenck, 1967), extraverts were postulated to have a chronically low level of cortical arousal and to be more susceptible to arousal decrements than introverts who have a relatively high level of cortical arousal associated with a lesser susceptibility to arousal decrements. Therefore, using terms in the sense intended by Nebylitsyn, introverts correspond to the weak nervous system and extraverts correspond to strong nervous system. Also, the introvert manifests a predominance of excitation in dynamism and the extravert manifests a predominance of inhibition in dynamism.

Since the 1960's, research on arousal theories has presented certain anomalies which can not be accounted for within the theory itself. For example, the data of Revelle, Humphrey, Simon and Gilliland (1980) indicate that introverts demonstrate more "dysthmic qualities" in the morning, when arousal is lowest (Blake, 1971; M. W. Eysenck & Folkard, 1960; Folkard, Gynn & lloyd, 1976), and "psychopathic qualities" in the evening, when arousal is high.

Gray (1970, 1972, 1982 a;b) formulated a tentative, alternative theory to that of Eysenck's which incorporates both the Drive component of Spence (1958), indexed by the dimension of neuroticism, and the extraversion component. Areas which have been studied address active and passive avoidance learning and susceptibility to punishment and frustrative non-reward. Gray formulated dimensions of anxiety, which are controlled by an underlying physiological system called the "behavioral inhibition system" (Gray, 1977), and "impulsivity," whose physiological system is independent of that of anxiety but whose structures are yet to be defined. Increasing levels of anxiety reflect increasing levels of sensitivity to signals of punishment and non-reward. Increasing levels of impulsivity reflect increasing levels of sensitivity to signals of reward and non-punishment. Extraversion and neuroticism are secondary consequences of the interaction between the anxiety and impulsivity system. Introverts are individuals who are most sensitive to signals of punishment and non-reward rather than to signals of reward and non-punishment. Extraverts are individuals who are most sensitive to signals of reward and non-punishment. Thus, extraversion reflects the relative strength of the two systems, while neuroticism reflects the joint strength of the two systems.

The present study of individual differences is based on the arousal theory of H. J. Eysenck (1967). This framework is currently acknowledged to accommodate an impressive body of data. Admittedly, the theory has not been able to explain certain anomalies described above but no better theory, including Gray's has been advanced.

2. Arousal as Related to Extraversion

This section provides a description of the hypothetical concept of arousal by reviewing the empirical and theoretical models of past researchers. The technique of using electroencephalographic recording to measure arousal, as induced by various mental states, is described.

A. Definition of Arousal

Arousal is the cortical vigilance, readiness, or tone which is presumed to occur in response to sensory stimulation via the reticular activating system. This system serves a general arousal function which differentiates levels of consciousness, and which regulates the level of attention to specific stimuli.

Pavlov's (1927) "orienting reflex" and Cannon's (1929) "generalized energy" are two examples of the conceptualization of an arousal/physiological relationship. This hypothetical construct was actually introduced by Duffy (1934) to explain variations in responsiveness to stimulation that were not related to change in specific drive states. Duffy's explanation forms the basis of Hull's (1943) conceptualization of non-specific drive.

Arousal as a determinant of behavior was suggested when Magoun and his associates (Lindsley, Bowden & Magoun, 1949; Lindsley, Schreiner, Knowles & Magoun, 1950; Moruzzi & Magoun, 1949) demonstrated that the midbrain reticular formation seemed to control the cortical activation that determines an organism's responsiveness to its environment. Research, however, has raised some disquieting questions about how this control is maintained. Some neurons of the reticular formation do respond to stimuli of several modalities but the large majority of neurons respond specifically to inputs from only one sensory system; many neurons exhibit no reaction to any sensory signal (M. E. Scheibel, Scheibel, Mollica & Moruzzi, 1955). Moreover, the activity of most cells in the reticular formation is not correlated, in any simple way, with cortical arousal

(Machne, Calma & Magoun, 1955; Palestine, Rossi & Zanchetti, 1957). Indeed, a majority of cells in the reticular formation decrease their spontaneous activity during the transition from sleep to wakefulness (Huttenlocher, 1961), and those cells that do show an increase in firing rate during arousal return to low baseline levels long before the cortical electroencephalogram arousal response subsides.

As can be seen from these studies, a perfect correlation between cortical cellular activity and cortical arousal has not been found. However, certain researchers have attempted to develop the arousal theory to describe behavioral manifestations.

B. Physiological Basis Related to Extraversion

Eysenck, in his 1967 formulation of the biological basis of personality, attributes extraversion and neuroticism to two individual but related circuits in the brain. He drew a distinction between arousal and activation or, more specifically, between cortical-reticular arousal and limbic-autonomic activation. Arousal is regulated largely by the reticular activating system which has an ascending influence upon the neocortex and sustains the normal range of functional activity within the individual. Activation is essentially dependent upon systems in the brain related to emotional response and it is involved in the functioning of the autonomic nervous system. Since the neocortex, the reticular system and the limbic system are richly interconnected, cortical arousal can result from either reticular arousal or autonomic activation.

Eysenck's extraversion-introversion is associated with the reticular arousal system. Since it is postulated that the reticular system of the introvert is initially more aroused than that of the extravert, the introvert is therefore more cortically aroused. The autonomic activation system is associated with neuroticism.

The physiological evidence supporting the above formulation primarily comes from electrocortical and electrodermal measurements (Stelmack & Plouffe, 1983). Savage (1964) found that the relative difference in inhibition between extraverts and introverts was measurable by electrocerebral activity. Extraverts have higher alpha rhythm amplitude than introverts (whose cortical inhibition is lower). Experimentation has since revealed inconsistencies and contradictions. For example, Frigon (1976), Morris and Gale (1974), Marton (1972), and Gale, Coles and Blaydon (1969) obtained results which support Savage's hypothesis, while the experiments of Winter, Broadhurst and Glass (1972), Gale, Coles, Kline and Penfold (1971), Becker-Carus (1971), and Fenton and Scotton (1967) failed to support the hypothesis. Gale, Harpham and Lucas (1972), and Broadhurst and Glass (1969) even reported evidence which supported the premise that the initial arousal level of extraverts was higher than that of introverts. While Venturini, De Pascalis and San Martini (1981) found no difference in basic alpha rhythm between introverts and extraverts, Eysenck's arousability hypothesis was confirmed when considering the alpha attenuation response in which introverts expressed a greater duration. Many of these inconsistencies could possibly be attributed to the types of experimental procedures, to the differences in subjective mental arousal, and to the methods of preparation, recording and scoring.

Increased amplitude of cortical evoked potentials reflect increased intensity of stimulation (Regan, 1972) and increased levels of attention (Friedman & Meares, 1979; Näätänen, 1975) in the subject. Shagass and Schwartz (1965), using somatosensory evoked responses, obtained supporting data for Eysenck's arousal theory; however, similar studies by Burgess (1973) and Haseth, Shagass and Straumanis (1969) were unsuccessful in supporting these findings. Studies using the contingent negative variation (Dincheva & Piperova-Dalbokova, 1982; Walter, Cooper, Aldridge, McCallum & Winter, 1964; Tecce, 1972) proved more successful (Ashton, Millman, Telford & Thompson, 1974; Janssen, Mattie, Plooij-van Gorsel &

Werre, 1978). Studies recording the auditory evoked response (Campbell, Baribeau-Braün & Braün, 1981; Stelmack & Wilson, 1982) suggest that an elaboration of the neurophysiological basis of extraversion should be developed to accommodate differences in synaptic transmissions.

Electrodermal studies of the orienting reaction have produced inconsistent evidence. Studies consistent with the hypothesis of greater initial cortical arousal for introverts (Fowles, Robert & Nagel, 1977; Nielsen & Petersen, 1976; Smith & Wigglesworth, 1978; Smith, Wilson & Rypma, 1981; Stelmack, Bourgeois, Chain & Pickard, 1979; Stelmack, Plouffe & Falkenberg, 1983; Wigglesworth & Smith, 1976) are countered by negative findings (Bartal & Martin, 1974; Coles, Gale & Kline, 1971; Krupski, Raskin & Bakan, 1971; Sadler, Mefferd & Houck, 1971).

3. Curvilinearity as Related to Extraversion

This section presents the theories explaining the curvilinear function of response found in arousal and performance tasks. The varying theories, which include transmarginal inhibition, are correlated with studies found in the personality literature evaluating the dimensions of extraversion.

A. Definition of Curvilinearity of Response

The extensive literature on the inverted-U function, the Yerkes-Dodson law (Yerkes & Dodson, 1908) and trans-marginal inhibition (Gray, 1980, p. 109) show the almost universal tendency for increases in response as a function of increases in stimulation to be self-limiting. Although numerous theories explaining this curvilinear relation between drive or arousal and performance have been put forth [M. W. Eysenck (1982, pp. 47-66) gives an excellent review of theories on arousal and performance which includes the studies of Easterbrook (1959), Thayer (1970), Broadhurst (1971), Näätänen (1973), Kahneman (1973), and Hasher and Zacks (1979)], no firm theory has arisen to account for all instances of the curvilinear response. It is probable that different responses may be subject to different laws and, therefore, require a separate theory for each class of response.

Examples of theories range from Easterbrook's (1959) notion of "concentration to attention" accompanied by decrement of non-central perception and attention to "post-activation reticular depression" after prolonged bombardment of a group of neurons possessing rhythmic activity (Dell, Bonvallet & Hugelin, 1961) or cortical inhibitory effects of arousal (Demetreacu, Demetreacu &

Iosif, 1965; Steriade, 1970). Soviet theory of curvilinear responding is based on Pavlov's two laws of "strength" [an increase in response] and "transmarginal inhibition" [beyond a certain point further increases in stimulation will produce increasing inhibition to protect the neurons against possible damage] (Gray, 1980, p. 109; Mangan, 1972; Zhorov & Yermolayeva-Thomina, 1972). To restate this concept, transmarginal inhibition is an impairment in the efficiency of performance at high levels of arousal, whether the high level of arousal is induced by the presentation of an ultra strong stimulus, the protracted application of a stimulus of moderate intensity, or frequent presentations of stimuli of moderate intensity at time intervals short enough to allow summation of the excitation. Individuals high in dimension of arousability respond at a lower duration or a lower frequency of stimulation than individuals low in this dimension. This holds true among individuals having "weak nervous systems" or who are "introverted" (Gray, 1964, 1965).

In outlining neuroanatomical models, Zuckerman (1959) gave direct experimental evidence that the activity of the reticular formation has a definite influence on curvilinear responsing. Dell, Bonvallet and Hugelin (1961) have discussed a number of possible mechanisms of reticular deactivation. One possibility is that of a postactivation depression after prolonged bombardment of a group of neurons possessing rhythmic activity, such as in the reticular formation. A second possibility is that of a negative feedback loop between the mesencephalic activating structure and the inhibitory structures of the medulla oblongata. Another suggestion is that of a similar negative feedback loop between the reticular actuating system of the brain stem and the cortex. Dell feels that the latter possibility is most correct. This model is basically the same as the one adopted by Gray. Stimulation of the reticular formation increases the level of cortical activation which increases the inhibitory effect of the cortex upon the reticular formation with a consequent decrease in the organism's general responsiveness to stimulation. Oswald (1962) found that both intense stimulation and repetitive stimulation can lead to sleep.

In electroencephalogram recording, Gastaut (1957) found that desynchronization of the electroencephalogram caused by an arousing stimulus is immediately followed by a return at higher amplitude of the previously existing rhythm. Dell, Bonvallet and Hugelin (1961) state that the greater the activity of the cortex, the greater will be the dampening effect on the reticular formation. Therefore, the appearance of curvilinear responding depends on the degree of the reticular activation of the cortex such that the greater the activation, the sooner transmarginal inhibition will arise. The degree to which an organism's reticular system activates the cortex will be dependent on the intensity, duration and frequency of repetition of the stimulation used. The introvert is the most susceptible to transmarginal inhibition for any given intensity of stimulation because he has the greatest bombardment of the cortex from the reticular formation.

B. Extraversion and the Curvilinear Response

As of 1964, Gray noted that in the Western literature no behavioral experiments were directly relevant to curvilinearity of responding. This has changed in recent years since there is much evidence (H. J. Eysenck, 1967, 1976) supporting the correlation between extraversion and given types of performance which may be positive or negative depending on the part of the U-shaped curve linking the two.

Corcoran (1965) argues for the usefulness of the curvilinear relationship and its correlation with introversion-extraversion for experimental studies. Using sleep deprivation, incentives and loud noise as arousing conditions, Corcoran supported the curvilinear hypothesis by measuring performance on multiple reaction time and complex tracking tasks. Frith (1967) put forth a similar argument testing critical flicker fusion performance under conditions of quiet and noise. Initial works in the area (H. J. Eysenck & Eysenck, 1967) showed that introverts produced larger amounts of saliva than did extraverts when lemon juice was placed on their tongue; the reverse was true when the lemon juice was swallowed immediately (stronger stimulus). Wardell (1974) tentatively supported these findings, while Ramsay (1969) did not. The methodology employed by Ramsay, however, differed from that used by Eysenck's study.

The personality dimension of extraversion's effect on intersensory facilitation, the stimulation of one sensory receptor facilitating the perception of stimuli in another sensory area through increased arousal level, was studied by Shigehisa (D. M. J. Shigehisa, Shigehisa & Symons, 1973; T. Shigehisa & Symons, 1973a;b) who utilized the interpretation of transmarginal inhibition to reconcile differences in results. Auditory thresholds were measured under conditions in which illumination was varied in intensity. Under low intensity of light, thresholds for all subjects were found to be high; with increasing intensities the threshold for extraverts continually decreased while the introverts' decreased and then increased, as predicted. Another example of an inverse relationship between intensity of stimulus and performance is the work of H. J. Eysenck and Levey (1972) on eye blink conditioning with strength of the unconditioned stimulus. The correlation with introversion is positive for weak stimuli and negative for strong stimuli.

Although several studies support the predicted results (Gupta & Kaur, 1978; Mangan, 1972; Stelmack & Campbell, 1974; Zhorov & Vermolayeva-Tomina, 1972), other research raises further questions. Using visual after images, White, Mangan, Morrish and Siddle (1969), and White and Mangan (1972) found that neuroticism, not extraversion, is related to strength of excitation. Asratyan (1961) reported that transmarginal inhibition can operate in a highly selective manner, i.e., one stimulus may be able to elicit transmarginal inhibition where another might not; the outcome depends upon such factors as presence of other conditioned stimuli and the amount of reinforcement.

More recent work by Smith (Smith, 1983; Smith, Wilson & Davidson, 1984; Smith, Rypma & Wilson, 1981; Smith, Wilson & Jones, 1983) using electrodermal activity has identified the interaction of extraversion levels by arousal levels which results in an inverted-U relationship.

Using stimulus intensity and caffeine to manipulate arousal, his results are supportive of the basic arousal of Eysenck.

4. Measuring Arousal Using Nystagmus

This section presents the relationship between arousal and nystagmus. The presentation includes the pertinent research in the field since 1914 when vestibular reactivity was first identified as being affected by excitation.

A. Definition of Nystagmus

The human vestibular system is highly developed for maintaining equilibrium (Wendt, 1951). Nystagmus is the term applied to a particular form of involuntary eye movement which originates in the vestibular system, although it can also result from ocular pathology. Vestibular nystagmus is the result of an imbalance in neural activity generated by receptor organs on opposite sides of the head. Once the unequivalence between right and left vestibular potentials occurs, the subsequent pattern of neural and muscular events culminating in deviation of the eyes is essentially the same regardless of the precipitating cause of the imbalance (Elpern, 1972; Lowenstein, 1967).

When the head is motionless, the cristae produce a relatively stable potential referred to as the resting discharge. With regard to either labyrinth, the discharge increases when the head rotates ipsilaterally and decreases on contralateral rotation, with the magnitude of the change directly related to the rate of angular acceleration. Resting discharges on either side of the head elicit tonic contraction of those muscles which move the eyes in either direction, so the eyes remain stationary. However, if the head is turned, for example, in a horizontal plane to the right, inertia causes the endolymph and cupula of the right lateral canal to be displaced anteriorly toward the utricle, bending the sensory hairs and increasing the firing rate of the right vestibular nerve with resultant contraction of the muscles which pull the eyes to the left. Simultaneously, in the left lateral canal the endolymph and cupula are displaced away from the utricle, decreasing the discharge of the left vestibular nerve and relaxing the muscles which pull the eyes to the right (Egmond, Groen & Jongkees, 1949).

Scientific testing during the flight of the space shuttle Columbia, in December of 1983, found results which questioned the necessity of endolymph movement to elicit nystagmus. Caloric testing of astronauts in weightlessness elicited nystagmus (Overbye, 1984) even though there is no movement of fluids without gravity's influence. Although stimulation of the cupula by movement of endolymphic fluid apparently does elicit nystagmus in earthbound individuals, the reason is currently in question.

The pair of semicircular canals act synchronously to control eye movements in their common plane through synergistic muscle activity. Regardless of how intense or prolonged the stimulus, the eyes do not continue to turn in the same direction but are deflected only a certain distance in the direction dictated by the vestibular imbalance and they are then reversed. As long as the stimulus remains adequate, the vestibulo-ocular stimulation remains adequate; the vestibulo-ocular reflex will continue to deflect the eyes contralateral to the direction of head rotation, and the limiting mechanism will continue periodically to interrupt this activity with reverse deflections (Kestenbaum, 1957).

Of the two phases which constitute each cycle of vestibular nystagmus, the reflex movement is somewhat slower than the reversing movement. As a matter of convention, nystagmus is described as being directed toward the side of the faster motion, even though the slow phase is actually of greater significance with regard to reflecting the compensatory response of the vestibular mechanism (Coats, 1972). Therefore, in the horizontal rotation of the head to the right, nystagmus would be described as beating to the right. In each cycle the eyes would move relatively slowly to the left before being returned quickly to the right by the central limiting mechanism.

The onset of rotation initiates a nystagmus whose slow phase increases in speed for slightly longer than the duration of acceleration and then the nystagmus shows gradual decrement lasting for usually less than one minute. This phenomenon is called primary nystagmus. As their drift slows to zero velocity, the eyes immediately begin to drift in the opposite direction producing an inverse nystagmus called secondary nystagmus. The speed of the inverse nystagmus increases over a period of approximately ninety seconds and then gradually decreases over a period of three to ten minutes. The duration of the cessation of the original nystagmus, the duration of the maximum speed of the inverse nystagmus and the duration of the inverse nystagmus vary greatly among individuals; however, the recorded duration times for the same individual show a remarkable degree of consistency (Jongkees & Philipszoon, 1964).

Slow phase, primary nystagmus represents a measure of how sensitive the semicircular canals are to the rate of angular acceleration (Wendt, 1951, p. 1200). All studies discussed in the next sections use slow phase, primary nystagmus as the measure of arousability.

B. The Relationship of Arousal to Nystagmus

Collins (1974) gives an excellent summary of the history of arousal and nystagmus. He states that as early as 1895 Bach had written that relatively weak nystagmus was generally produced in "stupid", "indifferent" or "phlegmatic" personalities while anxious, easily excitable individuals gave relatively stronger nystagmic responses. Eleven years later, Ruppert ascribed low threshold and high frequency nystagmus to the increased nervous irritability of individuals, while Bárány commented on differences in vestibular responses between neurasthenics and normals.

The general problem of identifying the relationship between arousal and vestibular reactivity was approached by Guttich (1914). He found that the repeated administration of rotational stimulation produced decrements in the duration of nystagmus. Rather than attributing his findings to habituation, however, he indicated that this decline in response was probably the result of decreasing nervous tension in the subject from the first rotation through the following series of rotations. This decline in nystagmus with repeated stimulation was found to be reversed (Griffity, 1928) when the subject engaged in violent exercise just prior to testing.

Recently, researchers have used instructional tasks to induce arousal change. The order of the level of excitement produced by each task has been qualitatively described in numerous articles (Collins, 1962, 1963; Collins & Guedry, 1962, 1967; Collins, Guedry & Posner, 1962; Collins & Poe, 1962; Dowd, 1966; Sokolovski, 1966; Wendt, 1951); also, quantitative measures of subjective arousal have been reported by Brown and Crampton (1964). The general consensus is that the positional order of excitement, from low to high, is reverie, temporal reproduction, sense of rotation and mental arithmetic. [Please refer to the next section for a description of these instructional tasks.] Electroencephalographic studies (Collins & Posner, 1963; Lidvall, 1962; Pendleton & Paine, 1961) attempting to support this gross ordering remain inconclusive. Researchers (Collins, Crampton & Posner, 1961; Goto, Tokumasu & Cohen, 1968) have concluded that slow phase, primary nystagmic velocity is one of the most sensitive indicators of alertness of any measurement.

Since the early 1970's, research on the effects of arousal states on nystagmus has been limited to the study of vertigo (W. E. Collins, personal communication, April 25, 1983) except for a few articles (Collins, Schroeder & Elam, 1975; Furman, O'Leary & Wolfe, 1981; Guedry, Gilson, Schroeder & Collins, 1975; Rosenberg, 1980a,b; Schroeder & Collins, 1979). With the recent interest in the space shuttle program, however, further research in this area will possibly occur.

5. Manipulating Arousal Using Instructional Tasks

This section describes how instructions given to a subject to complete a specific task create a certain mental set in that individual and, thus, effect his or her arousal level. The pertinent research in this area since 1934, when the first investigator studied the experimenter effect on subjects' nystagmic response, is presented.

A. Definition of Instructional Tasks

Specific techniques employed in emperic research differ widely depending on the aim of the study and the current technological sophistication in the area. This is especially true in the problem of instrumentation (i.e., the operational assessment and manipulation of psychological variables). Experimentalists employ a variety of methods, from complex electronic hardware to instructional tasks, in their manipulation of variables.

In the area of arousal manipulation, numerous techniques have been developed. Although physiological interventions, such as drug ingestion or electrical stimulation, have been used to induce arousal, non-invasive induction techniques have largely prevailed. Because of the enormity of the field, only the literature supporting electroencephalographic (EEG) changes in response to subjective mental state variations with introverts-extraverts will be outlined.

Gale, Morris, Lucas and Richardson (1972) showed that for easy, low arousal tasks, the imagining of high imagery words reduces EEG abundance, whereas in difficult, high arousal tasks, content that yields imagery only with some effort reduces abundance more than content which is easy to imagine. Generalized arousal and imagery interact, therefore, as a function of experimental instruction. The relationship of imagery and extraversion to EEG alpha production was investigated in the study of Morris and Gale (1974). Subjects allowed images, which were associated with words presented on slides, to form in their minds. A significant positive correlation between alpha production and extraversion gives support for higher levels of cortical arousal in introverts than in extraverts. Winter, Broadhurst and Glass (1972) also demonstrate that stable introverts present with higher levels of cortical arousal than stable extraverts when engaged in solving mental arithmetic problems with their eyes open.

Research conducted in nystagmus uses instructional tasks almost exclusively to manipulate the subject's arousal state (W. E. Collins, personal communication, April 25, 1983). The following section develops this topic further.

B. Effects of Tasks on Nystagmus

An incidental observation made during a study (Fearing & Mowrer, 1934) led Mowrer to become the first investigator to purposefully manipulate arousal factors in order to test their influence on the vestibular response. He produced "excited" and "unexcited" pigeons by different pre rotation handling of the birds and found longer durations of nystagmus under the excited condition (Mowrer, 1934). Similar results were found in rabbits (Hood & Pfaltz, 1954) and cats (Crampton & Schwam, 1961). Due to the vastness of the literature, the remaining paragraphs of this section will be limited to the manipulation of mental states in humans.

Wendt (1951) was the first investigator to attempt to define arousal (excitation) in terms of conditions basic to the state of the human subject. He found that under conditions of darkness an "inward orientation of attention" would account for nystagmus reduction while an "environment directed orientation" would restore nystagmus or prevent its decline (p. 1215). An abundance of studies based on Wendt's analysis of mental or attentional states has been conducted. Collins, Crampton and Posner (1961) evaluated several instructional procedures aimed at controlling alertness during rotational stimulation of subjects. They demonstrated that both the quantity and quality of nystagmic output could be manipulated in the same subject by instructions regarding mental activity. If subjects were asked to relax, daydream and pursue no particular line of thought (i.e., reverie), relatively weak nystagmic responses were recorded; vigorous nystagmus was recorded when the same subject performed continuous mental arithmetic or signalled turning sensation of specific ninety degree rotations.

A series of investigations by Collins (1962, 1963, 1964, 1965) examined influence of instructions (regarding mental activity) on rotational, nystagmic reactions. The instructions employed were reverie, time estimations of auditory stimuli, signalling of turning sensations, and continuous mental arithmetic. Subjects in the relaxed state of reverie produced significantly less nystagmus than those doing mental arithmetic. The nystagmus produced by the other states fell between these two extremes (Collins, 1963, 1965; Collins, Guedry & Posner, 1962). \Clear differences occur in the amount of slow phase eye displacement by rotational stimuli favoring mental arithmetic over reverie.

A number of studies (Barber & Wright, 1967; Benson, Goorney & Reason, 1966; Brand, 1968; Dowd, 1966; Gillingham, 1969; Lachman, Aarons & Erikson, 1968; Marshall & Brown, 1966; Sokolovski, 1963; Torok, 1978) have confirmed that assigned instructions regarding mental activity are important in the maintenance of vigorous nystagmus or the restoration of an attenuated response. Instructions have also had a predictable effect with drugs (Benton & Brand, 1968; Collins & Poe, 1962), with alcohol (Schroeder, 1971, 1972), and with hypnosis (Aschan, Finer & Hagbarth, 1962; Johner & Perlman, 1968).

6. Statement of the Problem

Previous research, using various experimental procedures (see Chapter 1, Section 3), has strongly suggested that there are differences in cortical arousal between the personality groups of introverts and extraverts as defined by Eysenck. This suggests, therefore, that there may be a difference in the effects of variations in levels of arousal on dependent measurements, such that for one personality group the relationship may be linear and for another group it may be nonlinear. Such speculations have been particularly supported by previous research (Ferneyhough, 1976; Smith, 1983; Smith, Wilson & Davidson, 1984). Specifically, for extraverts there may be a direct relationship such that increases in mental arousal are directly reflected in cortical excitation, whereas for introverts this may be curvilinear--or at least nonlinear.

Ferneyhough (1976) tentatively found that slow phase, primary nystagmic velocity could be used as an objective measure of individual differences in Eysenck's model of extraversion, which is based on differences in cortico-reticular arousal (H. J. Eysenck, 1967, 1981). The use of this dependent measure is based on the well established fact (see Chapter I, Sections 4 and 5) that slow phase, primary nystagmus is a measure of cortical arousal.

The present study assesses directly, through a dependent measurement reflecting cortical excitation, the effect of the manipulation of cortical arousal in three groups of subjects who vary on the arousal continuum defined by Eysenck. The hypothesis, based upon the literature, is that there is a statistical interaction between levels of extraversion, defined by the <u>Eysenck Personality Inventory</u>: <u>Form</u> <u>A</u>, and the levels of arousal, defined by the mental tasks, on slow phase, primary nystagmus, the dependent measure of cortical excitation. Specifically, this interaction will be demonstrated by linear increments in slow phase, primary nystagmic responding, the measure of cortical arousal, to varying arousing conditions of mental tasks in extraverts, and a curvilinear response pattern in introverts. The experimental procedure employed to test this hypothesis is described in the following chapter.

CHAPTER II

Experimental Design

This chapter gives a detailed description of the experimental design to test the hypothesis as stated in Chapter I. The respective sections describe the subjects, the instructions, the apparatus, the experimental procedure, and the statistics used in the analysis of the data.

1. The Subjects

The subjects consisted of 120 individuals (49 males and 71 females) who were enrolled in introductory psychology courses at the University of Ottawa or in an abnormal psychology course given by the nursing department of Algonquin College, Ottawa, Ontario, Canada; these classes were given in the Fall semester of the school year 1976-1977. This subject size is well within specifications based on previous findings (Ferneyhough, 1976). At $p=.05$ for a power of F of 0.86, only eight subjects are needed. Using thirty subjects the power is over 0.99.

A. Selection

The subjects were unpaid volunteers who were able to complete the testing sessions and who met the following conditions. (The exact statement to the classes used when soliciting subjects is given in Appendix 1a.)

1. They had no prior history of labyrinthine disorder;
2. They had not taken part in a rotational experiment in the past year;
3. They had not experienced high centrifugal force;
4. They had not taken illicit or prescribed drugs during the previous month;
5. They would abstain from alcohol for no less than fifteen hours, and tobacco, coffee and tea for at least two hours prior to nystagmic testing; and
6. They had their normal amount of sleep the night before nystagmic testing.

The first prohibition against subjects having past or present labyrinthine disorders (Clark, 1970) is obvious. Any physiological aberrations could affect nystagmic responding of the individual. Further, J. W. Wolfe (personal communication, September 1973) advises the rejection of individuals who have experienced moderate to severe rotational or centrifugal force (second and third prohibitions). Air Force pilots, who have experienced severe gravitational force, produced aberrant nystagmic responding which continued for several months without any apparent physiological cause.

Drugs which affect physiological arousal, as listed in prohibitions four and five, are the most obvious factors which must be controlled. Stimulants such as nicotine in tobacco (Tibbling & Henriksson, 1968) or caffeine in coffee, and depressants, such as alcohol, are the most commonly used drugs; it has been known for years that these drugs affect nystagmic response (Collins & Poe, 1962). Current prescribed drug users were banned from participation because most people are not sure as to the exact content of the medications they are taking.

Prohibition six is not as obvious a confounding factor. Although all current information relating nystagmus to sleep is indirect (Wolfe & Brown, 1968), the disruption of fast phase nystagmus does exist. Rapid eye movement (REM) in sleep bears a striking resemblance to vestibular nystagmus. Lesions of the medial and ascending vestibular nuclei abolish REM sleep (Kawahara, 1980; Pompeiano & Morris, 1965). This indicates the effect of some kind of neurophysiological interaction between the vestibular nuclei and the centers responsible for sleep, possibly via the cerebrum, mesencephalic or pontine reticular formations. The fast phase response in both REM sleep and nystagmus is directly mediated by the vestibular nuclei. Slow phase nystagmus does not originate from the same neurological structure as REM. (Slow eye movement in nystagmus is governed by cupulae deflections, whereas no neurological structure responsible for REM sleep has been identified.) Wolfe and Brown (1968) have found that subjects having only moderate sleep deprivation will show significant increases in fast frequency. If sleep deprivation causes loss of alertness then the slow phase would also be affected. Subjects who were constantly rotated over several days noted that they were extremely tired even after their normal amount of sleep. Wolfe and Brown considered that this sense of sleep deprivation is due to REM sleep being inhibited.

Preconditions concerning gender or age were not required nor were race or educational background considered as influential factors. A case could be made for age as a confounding variable since not only nystagmus but also the E scale on the Eysenck Personality Inventory (Schneider & Gibbins, 1982) are both affected by age differences. End organ changes of stiffening cupulae are found in people over fifty years old; for reasons yet unknown, there is a trend for the E scale to drop with increasing age. For whatever reasons, the age required to cause a difference would have to be advanced. The group from which the subjects were selected was judged to be young and very homogenous with regard to age, education, etc.

B. Regrouping

Those subjects who met all the pre-conditions, and who wished to participate further, listened to a five minute summary (refer to Appendix 1a) of the experimental procedure that they would be experiencing. After the subjects had agreed to participate, the final selection was based on the subject's E score on the extraversion scale of the Eysenck Personality Inventory: Form A (EPI), regardless of the N or L scale scores. Although one hundred and eighty-eight subjects completed the "EPI" only the first forty individuals falling into each of three categories were asked to participate. Based on a pilot study using thirty subjects, the E score groupings were designated as 1 to 9 for introverts, 10 to 15 for ambiverts, and 16 to 24 for extraverts. Percentile norms taken for American college students (H. J. Eysenck & S. Eysenck, 1964) show that the cutoffs are closely related: the lower third of the sample achieved an E score (Form A) of 10 or lower and the upper third a score of 14 or greater.

2. The Instruments

This section describes the instruments used in the experiment. Conceptually, they can be divided into the psychological parameters of personality testing and the changing of subjective mental states, and the physical apparatus used for rotational stimulation and recording.

A. Personality Inventory

The Eysenck Personality Inventory (EPI) is published by the Educational and Industrial Testing Services of San Diego, California. The EPI testing manual (H. J. Eysenck & Eysenck, 1964) describes this paper and pencil test as a measure of personality in terms of the two independent dimensions of extraversion (E scale) and neuroticism (N scale). Each of these traits is measured by twenty-four "yes" and "no" questions selected on the basis of item and factor analysis. A response distortion lie scale (L scale) is included to detect attempts to falsify responses. Parallel forms (Form A and B) are available if retesting is desired (H. J. Eysenck & Eysenck, 1964, p. 5). In this study, however, only Form A is considered.

The EPI is a further development of an earlier Maudsley Personality Inventory (MPI) and it also correlates highly to the MPI. However, the improvements which have been incorporated into the EPI make it a more useful test. It consists of two parallel forms that make retesting possible after experimental treatment without interference from memory factors. It has been reworded to make each statement understandable, even by subjects of low intelligence or education. Item selection has negated even the small correlation between the E and N scales of the MPI. The EPI contains a L scale to identify subjects trying to show a desirability response set. The retest reliability of the same form is somewhat higher on the EPI than on the MPI [r=0.85 even after several months] (H. J. Eysenck & Eysenck, 1964, p. 5).

Subjects used in the test construction of the EPI were widely representative of the general population, including university students, middle and working class groups varying in age and sex, as well as a general representative sample of the whole population of England. The total number of the sample exceeded 30,000. A factor analytic study was carried out which produced a matrix of 108 entries which included all the items in Form A and B, as well as a set of substitute items.

The test-retest reliability using two groups of normal English subjects (n=92 and 27), after a time lapse of one year, runs between 0.80 and 0.97 for separate forms. The split-half reliability (Form A and B) for 1655 normals, 210 neurotics, and 90 psychotics for the combined scales run from 0.74 to 0.91 (H. J. Eysenck & Eysenck, 1964, p. 15). The relationship between EPI scores and age shows that there is a significant trend for E and N scales to decline with advancing age (H. J. Eysenck & Eysenck, 1964, p. 15). The cause of this effect is still speculative. The correlation with sex is small; women tend to score high on N and low on E. This finding varies greatly and rarely exceeds one third of the standard deviation. There is a general tendency for working class groups to have higher N scores than middle class groups, but these groups show no differences in E scores. Urban samples are higher on N and E scales. [Refer to S. B. G. Eysenck's (1960) discussion of social class and gender.]

Research continually suggests that the construct validity of the EPI is high. Dysthymic neurotics (anxiety, reactive depression, obsessional-compulsive symptoms) score high on neuroticism and low on extraversion while psychopaths and hysterics score high on neuroticism and higher on extraversion than dysthymics. The EPI scales are highly correlated with other measures which are supposed to measure the extraversion [e.g., hypomania scale of the MMPI] and neuroticism [e.g., Taylor Manifest Anxiety Scale] dimensions (H. J. Eysenck & Eysenck, 1964, p. 17). Also, the cross-cultural universality of typology for the EPI and its' newer version--the Eysenck Personality Questionnaire--is found to be high (Abdel-Khalek, 1981; S. B. G. Eysenck, 1981, 1982; S. G. B. Eysenck & Chan, 1982; S. B. J.

Eysenck, Humphrey & Eysenck, 1980; Iwawaki, Eysenck & Eysenck, 1980 a,b; Lojk, Eysenck & Eysenck, 1979; Nyborg, Eysenck & Kroll, 1982; Saklofske & Eysenck, 1978; Tarrier, Eysenck & Eysenck, 1980).

It has been shown that the EPI is susceptible to faking when subjects are instructed to falsify their responses. Such faking of good distortions significantly affects neuroticism scores in a downward direction, but not the extraversion score (Braun & Gomez, 1966). The L score, however, is also increased and is an aid in detecting this desirability response set. The L scale has 18 items. No absolute guidance has been given for its use; however, a score of ten for both forms combined, or five for either form implies that good faking has occurred. This scale has been shown to be modified downward when the subjects have been instructed to fake well but were forewarned that a response distortion scale was built into the inventory. Studies discussing this scale concluded that it is a better indicator of a subject's social desirability than it is an indicator of lying (Braun & Gomez, 1966; Gibson, 1962; Salas, 1968; Williams, 1969). Similar findings are noted for the Lie scale of the Eysenck Personality Questionnaire (Crookes & Pearson, 1981; O'Hagan & Edmunds, 1982).

B. Instructional Tasks

This section documents the influence of instructions (the reader is asked to also refer to Sections 4 and 5 of Chapter I) regarding mental activity on rotational nystagmic reaction. Descriptions of the tasks selected for use in this study are as follows:

1. REVERIE-The subjects were instructed to ignore the stimuli in the environment, to relax and daydream, but to keep their eyes open. They were requested not to pursue any particular line of thought.

2. TEMPORAL REPRODUCTION-Tones (510 Hz at 86 dB) were systematically presented throughout a given trial for durations varying between one and five seconds. Subjects were instructed to attend carefully to the onset of sound and, at its conclusion, to reproduce its duration by pressing a switch which produced the same audible sounds.

3. SENSE OF ROTATION (otherwise called Key Pressing)-The subject was instructed to attend to the sensation of rotation and to indicate, by pressing a switch, the onset and cessation of rotation, as well as each experience of a 90° subjective rotation.

4. MENTAL ARITHMETIC-Subjects were presented simple addition, subtraction and multiplication problems (listed in Appendix 1b) to complete promptly at the end of each presentation. It was emphasized that the individual should continue with a maximum effort of speed and accuracy until the conclusion of the trial.

5. COMPLEX CHOICE-The subjects were challenged to differentiate which ear heard the last highest tone in a four tone series (500 Hz, 1.05 kHz, 2 kHz and 3.7 kHz at an average intensity of 87 dB) and press a switch to indicate their choice. Each ear received a different, complex, five second, presentation simultaneously.

The intensities and frequencies of all the tones used in the above tasks were considered within the average range of stimulation (Stelmack, Achorn & Michaud, 1977) and are not disturbing to the individual.

For this study, two other subjective mental states were produced to familiarize the subject with the experimental conditions (Practice Session) and to record their baseline response (Basal). The purpose of the practice sessions was to decrease the subjects' emotional response to testing. The literature documenting previous nystagmic experimentation does not cover these two conditions, yet they are extremely important for reasons previously discussed. The parameters of each task are as follows:

1. PRACTICE SESSION- After the equipment and experimental manipulations were described, the subjects were asked to begin counting continuously from one upward until the end of the task.

2. BASAL- The subjects were asked to sit quietly, as if waiting for an appointment, without attending to any particular cues.

The verbatim transcript of the instructions presented to the subjects is given in Appendix 1b.

C. Apparatus

This section describes the tools employed in evoking and recording the nystagmic response. The apparatus can be considered in two categories: the stimulator and the accessory equipment necessary to communicate to and record from the subject. The stimulator consisted of a variable motor controlled by a silicon controlled rectifier and an integrator, described in Appendices 2a and 2b, and the rotating platform. Due to the expense of purchasing the equipment, the stimulator was primarily built on site and the accessory equipment was either commercially obtained or partially built by the experimenter.

Variations in motor speed were translated to a platform holding a chair as shown in Figure 1. A stationary platform provided the housing for the motor, two speed reducing pulleys, and a heavy metal frame containing two flanged bearings and a metal disc. The rotating platform was bolted to the disc, and the chair was bolted to the moving platform. A back supporting frame was also attached to the rotating platform and to the center pole of a five ring commutator.

After the subject was in position, a front table was positioned across his lap. The table is shown in Figure 2. Three pairs (one on each side radiating outward) of lights were used for calibration. The lights used were determined by the distance between the subject's eyes and the center of the board. When following the alternating flashing lights, the subject's eyes traveled 20° (10° each

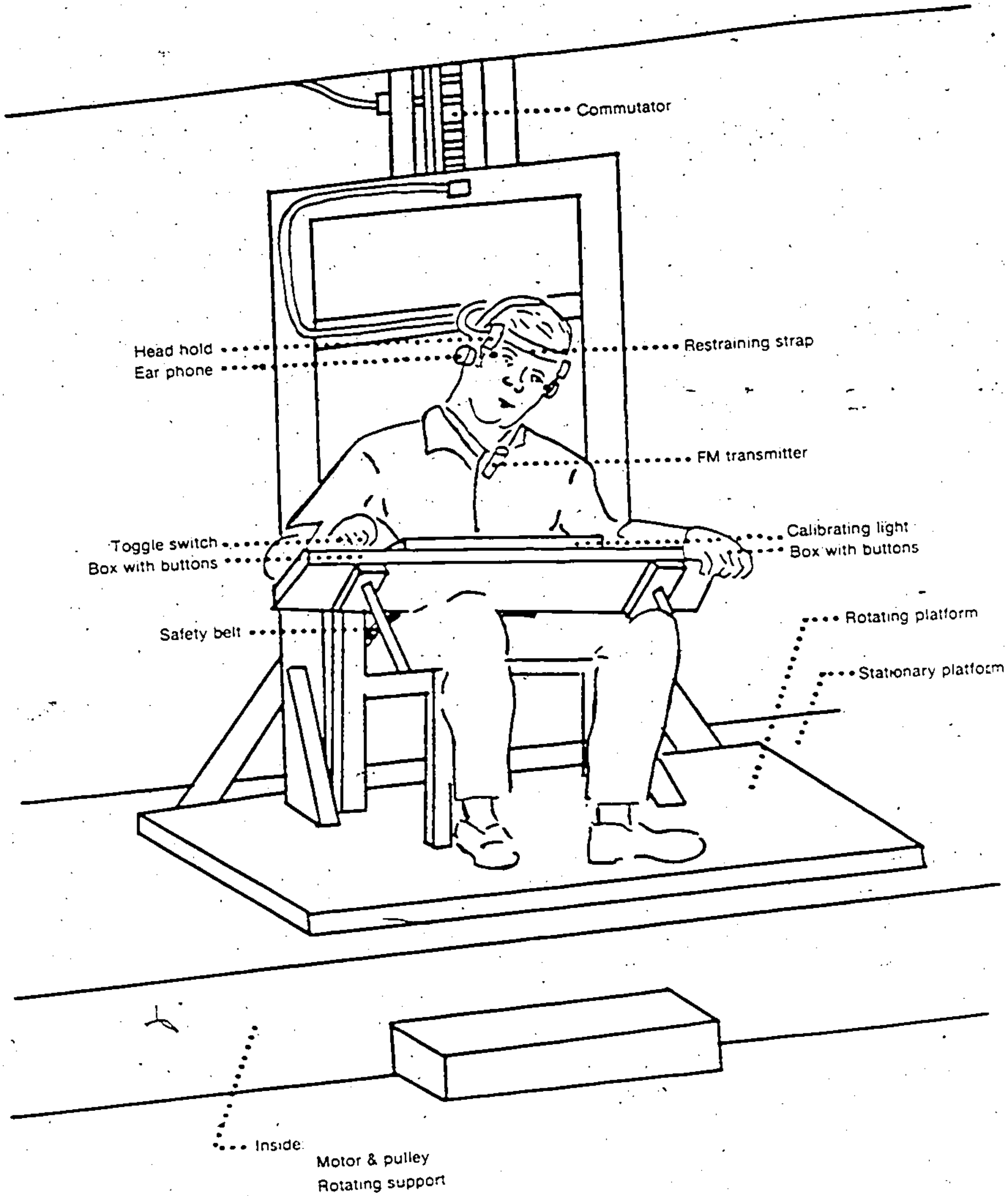


Figure 1— Rotating apparatus with subject attached to the equipment.

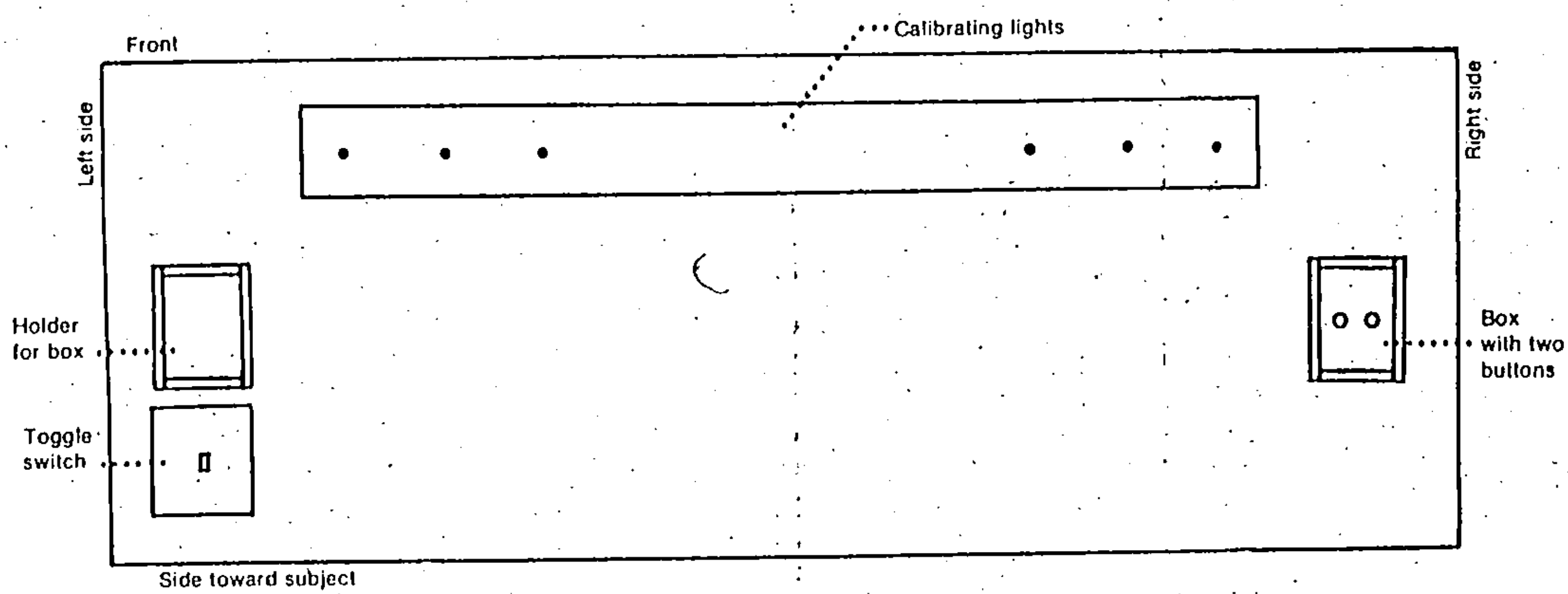


Figure 2— Front table on rotating chair.

side of center). The toggle switch and buttons were operated as discussed in Section 3b and Appendix 1b.

A mechanical problem in the rotating frame was discovered in the pulley system. Rotations greater than approximately 75°/second caused an oscillation in the belts which translated into a hardly perceptible vibration at the platform that increased with increasing velocity. However, maximum stimulation (full deflection of the cupulae) occurred at 72°/second and, in this study, maximum velocity reached only 65.8°/second. The performance of the platform was well within the specifications required for nystagmic testing.

Variations in platform speed, and thus stimulation, within the same experimental condition were strictly regulated, otherwise inter- and intra-data evaluations would have been meaningless. Initial calibrations of the rotational speed were achieved by a magnet attached to the center shaft of the rotating platform tripping a microswitch upon each complete rotation. The time per rotation, accurate to one tenth of a second, activated a Lafayette Instrument printer (Model 56025) by Lafayette triple pulse unit (Model 5821).

A 140 pound weight was placed in the chair on every calibration check throughout this study. (The mean weight per subject in the pilot study was 138.9 pounds, SD of 21.4). At the start of each testing day, the apparatus was checked for vibration and a calibration check was completed. Also, during actual testing each rotation triggered a stimulus marker on the physiograph; continuous monitoring of the rotational stimulation rate was accomplished.

The operating motor temperature affected platform speed. Continuous temperature measurements were taken electronically with a heat sensor that was taped to the motor shell. Stimulations were given only during the motor's optimal operating temperature of 40°C.

The rotational device was housed in a completely dark room that was located within another room where only a low wattage, red light was used during testing. All external noise was stopped during testing. The variable motor was packed in insulation to absorb the localized effect of its noise.

Communication to and from the subject, as well as the recording of the subject's nystagmus, were achieved via the accessory equipment. Figure 3 illustrates the component relationships of the equipment used. The items used inside the room housing the platform are also shown.

A five ring, noncommercial, commutator allowed for the inter-connections between the subject and the

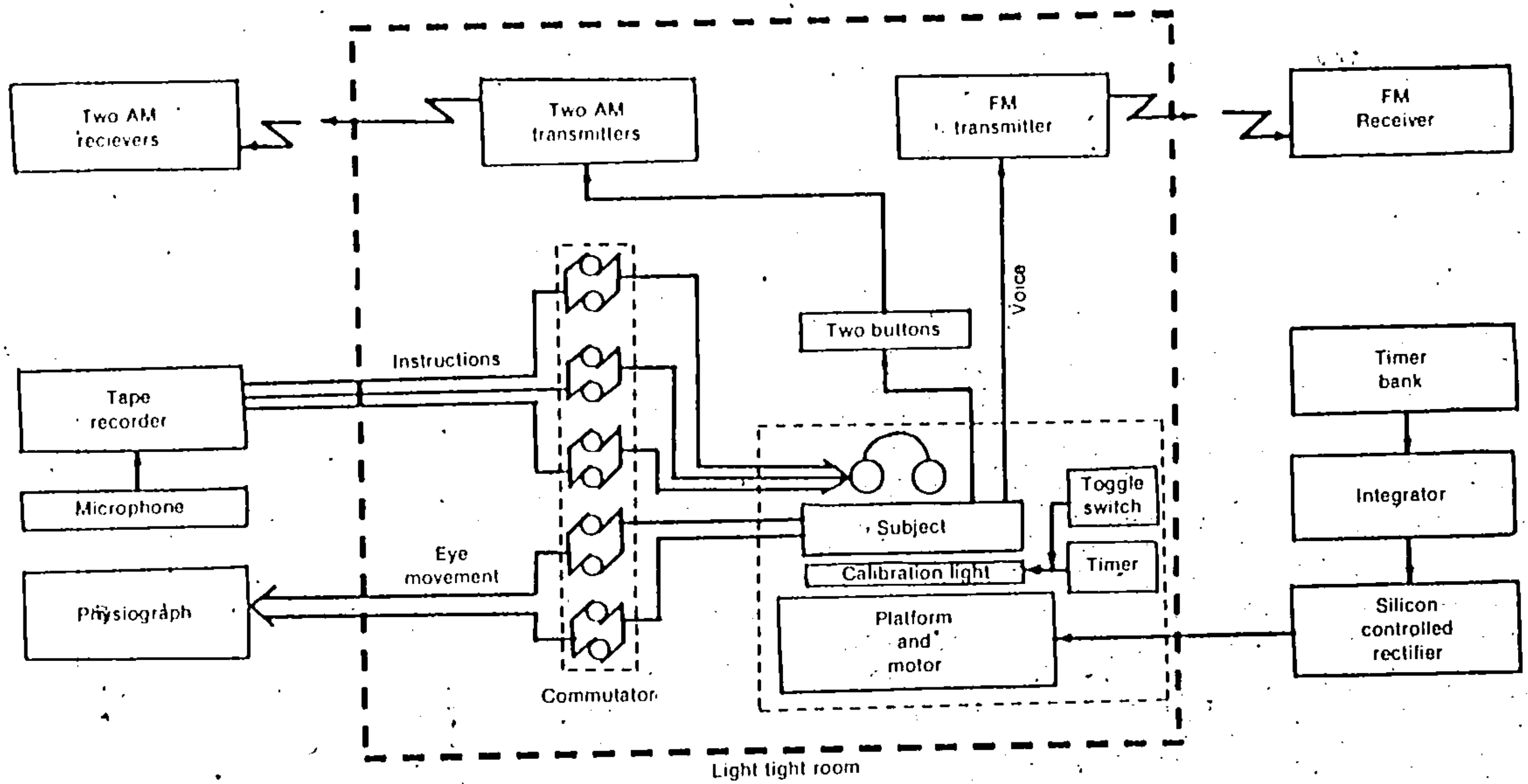


Figure 3— Equipment arrangement.

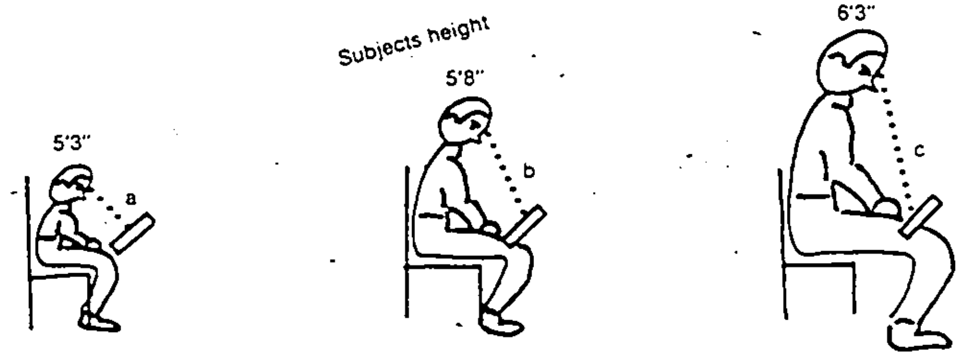
equipment. A Sony TC-630 tape recorder played prerecorded instructions to Koss Pro 4A headphones (9-25,000 Hz). The subject spoke to the experimenter via a Realistic Appollo FM-91 transmitter, transmitting on 91 MHz. Eye movements were recorded on a Watanobi Multi-recorder MC 611-56L in conjunction with a Nihon-Kohden RDU-5 high gain amplifier.

As part of three separate tasks completed during different subjective mental states (complex choice, sense of rotation and temporal reproduction), two buttons were depressed in answer to questions. Each button controlled the onset and offset of the carriers of an AM transmitter (set for 1490 or 1482 KHz). Two portable AM receivers were used for reception of the tones.

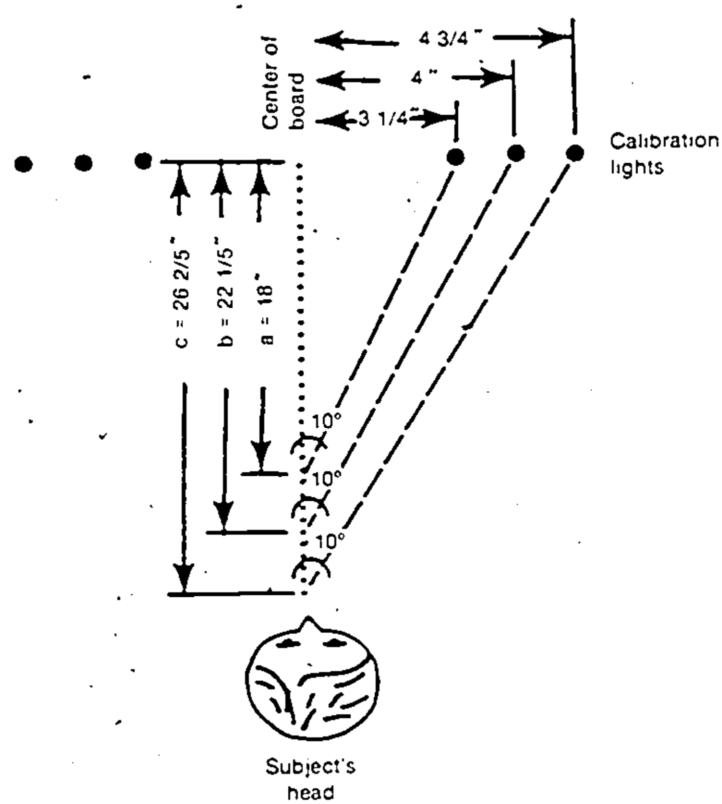
Eye calibration via the alternating calibration lights, shown in Figure 4, were accomplished by a relay and timing system whose schematic is given in Appendix 2c. This system is a noncommercial unit developed at the University of Ottawa's psychology department.

3. The Experimental Procedure

Initially, four classes of one hundred to two hundred students each were visited for subject recruitment. The first part of the actual experiment required administering the <u>Eysenck Personality Inventory</u> to those students who



a. Eye to board distance



b. Distance to board from eye effect 10° eye travel

Figure 4 — Calculation to choose calibration light set.

met the six pre-test conditions as discussed in Section 1 of this chapter. The last phase consisted of the actual physiological eliciting and recording of nystagmus.

A. Personality Testing

The instructions from the Eysenck Personality Inventory: Form A were read aloud to the group without alteration while they read along silently. Any questions asked during test taking were answered by the statement, "Read the question again and answer as best you can." No interpretation or advice was given.

After the questionnaires were collected, all copies were carefully checked to ensure that all questions had been answered. If answers were missing, the testee was advised and encouraged to answer all items. Only two cases involved unanswered questions.

Overlay stencils were used for scoring the E, N and L scales. Subjects were divided into three groups based upon their scores on the extraversion scale. Scores were grouped as follows: introverts (0-9), ambiverts (10-15) and extraverts (16-24). The literature provides many examples of identical subdivisions of scores for experimental purposes. Based on a recent pilot study and studies from past years using equivalent university populations, the cutoff scores are realistic.

B. Nystagmus Testing

Care was taken to ensure that the subject was at ease concerning his involvement with the equipment and the actual rotation. The subject was assured that he would always be in control of what happened to himself in the experiment and that he would be in voice contact with the experimenter at all times. If he wished to leave the experiment he could be freed from the apparatus in less than one minute, even during rotation. The apparatus was shown and explained in detail. The chair was rotated with the subject standing nearby. Only then was he placed in position for testing. (Refer to Appendix 1b for the specific discussion.)

Beckman 5 mm diameter electrodes, with Beckman electrode paste, were applied to the outer canthi of each eye (Wolfe & Wendt, 1967) after the area was cleaned with a 70% alcohol solution. The subject sat in the rotating chair and the FM transmitter was placed around his neck. The headphones were placed over his ears, and the safety belt was strapped across his lap. His head was placed in the head holder facing the center of the calibrating lights. His forehead was strapped into position so that an imaginary line drawn from the outer canthus of the eye to the lowest extremity of the external auditory canal formed an angle of 30° to the floor pointing forward and upward. (This angle placed the horizontal semicircular canal horizontal to the floor.) At this time the subject was informed of the importance of keeping his head in this position throughout the experiment. Even though the head restraint was capable of inhibiting any inadvertent head movement, the subject was informed that he should immediately tell the experimenter if he felt that he had moved from position so that the necessary adjustment could be made.

The distance between the center of the subject's forehead and the center of the calibrating light board was measured to determine which pair of pinpoint, red lights (light emitting diodes referred to as LEDs) would be used. The object of looking between the alternating lights, with the head stationary and pointing towards the center of the board, was to have the eyes sweep a 20° arc (10° each side of the mid line). Figure 4 illustrates the problems encountered in the calculation. The necessity for this calibration becomes apparent after review of the discussion on eye polarity in this section.

A half hour before testing, all the equipment was energized and allowed to stabilize. This period was especially important because it provided an opportunity to counter possible frequency drift during the functioning of the variable speed motor, and all transmitters and receivers.

The period between the personality and nystagmus testing sessions, with five exceptions, was shorter than twenty days and was usually within one week. The first test was given on October 29, 1976 and the last test was given on December 2, 1976. As previously discussed, the EPI testing categorized the subject into one of three groups based on the extraversion scores. With the aid of a computer generated random chart, the subject was assigned as to order of subjective mental states presentation. This ordering is shown in Table 1.

As shown in Table 1, the first introvert, the first ambivert and the first extravert presenting themselves for nystagmic testing were accelerated with the order of subjective mental states being: practice session, basal, reverie, sense of rotation, mental arithmetic, complex choice and temporal reproduction. The last subject in each personality grouping was rotated with the order of subjective mental states being: practice session, basal, reverie, complex choice, mental arithmetic, temporal reproduction, and sense of rotation. The first stimulation was always given during the practice session and the second always during basal. The last five stimulations were determined by the table. Thus, presentation order was

Table 1

Selection of Stimulus Presentation

Subject Number[a]	Order of Presentation of Subjective Mental States[b] 1st	2nd	3rd	4th	5th	Subject Number[a]	Order of Presentation of Subjective Mental States[b] 1st	2nd	3rd	4th	5th
1	R	SR	MA	CC	TR	21	CC	MA	TR	SR	R
2	SR	CC	TR	MA	R	22	TR	SR	R	CC	MA
3	R	CC	MA	TR	SR	23	MA	TR	SR	R	CC
4	SR	R	CC	MA	TR	24	CC	MA	TR	SR	R
5	R	CC	MA	TR	SR	25	TR	SR	R	CC	MA
6	SR	R	CC	MA	TR	26	R	SR	MA	CC	TR
7	CC	R	SR	TR	MA	27	MA	TR	SR	R	CC
8	CC	MA	TR	SR	R	28	TR	MA	CC	R	SR
9	MA	TR	R	SR	CC	29	SR	R	CC	MA	TR
10	MA	TR	R	SR	CC	30	CC	R	SR	TR	MA
11	TR	MA	CC	R	SR	31	MA	TR	R	SR	CC
12	CC	MA	TR	SR	R	32	R	SR	MA	CC	TR
13	SR	CC	TR	MA	R	33	SR	CC	TR	MA	R
14	R	SR	MA	CC	TR	34	CC	R	SR	TR	MA
15	TR	MA	CC	R	SR	35	TR	MA	CC	R	SR
16	MA	TR	SR	R	CC	36	MA	TR	R	SR	CC
17	MA	TR	SR	R	CC	37	CC	R	SR	TR	MA
18	TR	SR	R	CC	MA	38	R	CC	MA	TR	SR
19	SR	CC	TR	MA	R	39	SR	R	CC	MA	TR
20	TR	SR	R	CC	MA	40	R	CC	MA	TR	SR

[a]One is the first extravert (ambivert or introvert) of this study and forty is the last extravert (ambivert or introvert).

[b]Abbreviations: CC=complex choice; MA=mental arithmetic; SR=sense of rotation; TR=temporal reproduction; and R=reverie.

counterbalanced. Rotation was always from left to right. Acceleration rate was 9.4°/sec^2.

The presentation given to the subject is fully discussed in the text of Appendix 1b and it is outlined in Table 2. The exact time sequence correlating to these instructions and stimulations is given in Figure 5. After the subjects' eyes had been dark adapted for five minutes, seven, seven second, clockwise rotations of 9.4°/sec^2 were administered, followed by a seventy-six second period of constant velocity (except during the practice session which lasted forty-five seconds), and a seven second deceleration. Five minutes between rotations elapsed; during these rest periods the subjects continued to be rotated at a constant velocity of 1°/sec. Throughout each acceleration and constant velocity period, the subjects continued to perform their assigned mental tasks.

During eye movement recordings several problem areas must be controlled. The easiest to identify and correct is facial muscle tension. If the subject has his eyes open and muscle interference is still shown on the recording, he is then asked to relax and try to release all tension in his forehead and jaw muscles. He is reminded that during every task, rotation and eye recording, he must have his eyes open normally.

A second problem easily corrected is eye potential

Table 2

Description of Stimulus Presentation

Order[a]	Description of Task	Apparatus S Interacts with
	(100 watt white light illuminated the room)	
1	Equipment check:	
	Tones to ears	Earphones
	Buttons and toggle switches	Buttons, Switch
	Calibrating eyes	Switch, LEDs
2	Practice Session (PS)	
	Explanation of equipment	
	(Lights turned off in rooms)	
	CV rotation of 1^{o}/sec begins	
	Instructions of PS:	
	Count forward beginning at one	FM transmitter
	Calibrating eyes	Switch, LEDs
	Begin	
	Rotation[b]	
	CV rotation of 1^{o}/sec	
	Stop task	
	Wait quietly for next task	
3	Basal (B)	
	Instructions: Sit quietly	
	Calibrating eyes	Switch, LEDs
	Begin	
	Rotation[b]	
	CV rotation of 1^{o}/sec	
	Stop task	
	Wait quietly for next task	
4	Complex choice (CC)	
	Instructions: Hear series of tones which are different for each ear for last note indicate which ear heard highest tone	
	Practice	Earphones, Buttons
	Calibrating eyes	Switch, LEDs
	Begin	
	Rotation[b]	
	CV rotation of 1^{o}/sec	
	Stop task	
	Wait quietly for next task	

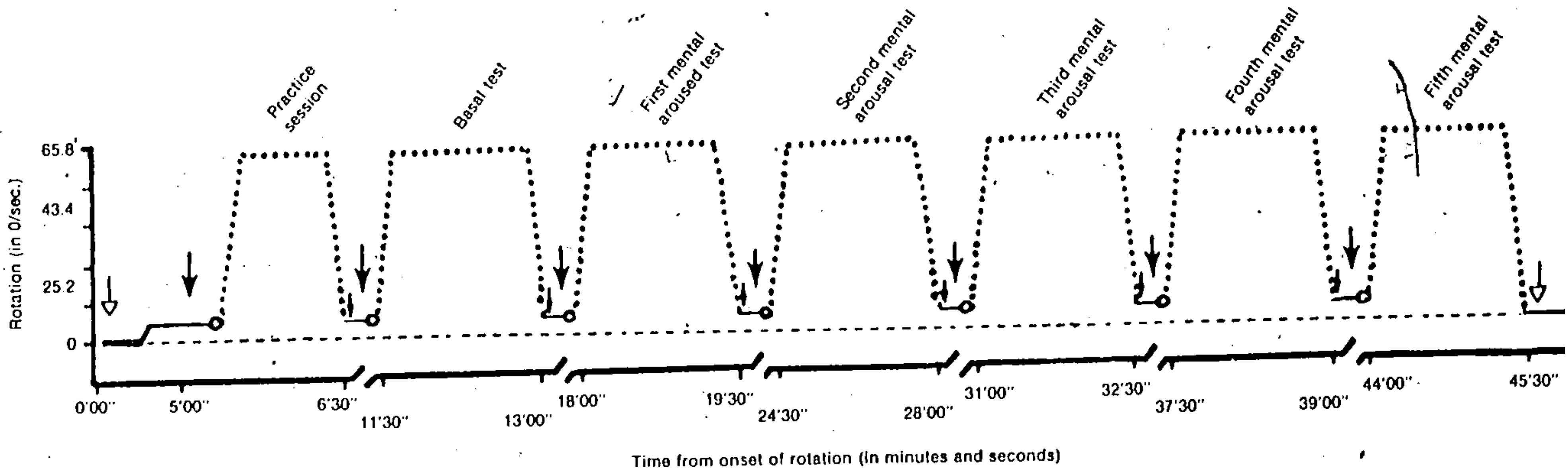
Table 2 (cont.-)

Order[a]	Description of Task	Apparatus S Interacts with
5	Mental arithmetic (MA) Instructions: Respond verbally to questions Calibrating eyes Begin Rotation[b] CV rotation of 1^{o}/sec Stop task Wait quietly for next task	 Switch, LEDs FM transmitter
6	Sense of rotation (SR) Instructions: Indication when begin rotation and thereafter every 90^{o} Calibrating eyes Begin Rotation[b] CV rotation of 1^{o}/sec Stop task Wait quietly for next task	 Switch, LEDs Buttons
7	Temporal reproduction (TR) Instructions: Reproduce the length of tone heard Calibrating eyes Begin Rotation[b] CV rotation of 1^{o}/sec Stop task Wait quietly for next task	 Switch, LEDs Button
8	Reverie (R) Instructions: Place self in reverie Calibrating eyes Begin Rotation[b] Stop rotation Stop task	 Switch, LEDs
9	Closing remarks (Lights in room gradually increased)	

Note. The full transcript can be found in the Appendix 1b.

[a]The actual order of items 4 through 8 is determined by a random order from Table 1.

[b]Rotations consist of acceleration, constant velocity (CV), and deceleration respectively (refer to Figure 5).



Time sequencing:

Acceleration —	7 seconds
Constant velocity —	76 seconds
(except practice session which lasts 45 seconds)	
Deceleration —	7 seconds
Rest period —	5 minutes

Symbols:

- Initial & closing remarks.
- Onset of instructions.
- O Calibration of eyes.

Figure 5 — Timing sequencing of stimuli presentation.

(Miles, 1940; Coats, 1972). There is a voltage difference that is generated in the retina, with the positive pole at the front and the negative pole at the back. This polarity potential originates in the photosensitive elements of the retina. (Recent indications are that it is at least in part due to extraretinal elements.) This eye potential changes with biochemical changes due to adaptation to darkness. Under constant illumination of 5 milliamberts (ml) the average potential is $1.10 \pm .03$ millivolts (mv). When the illumination is reduced to .001 ml, this potential drops to $0.99 \pm .02$ mv after ten minutes of adaptation to darkness (Miles, 1940). Changing back to the 5 ml illumination causes the potential to rise to $1.25 \pm .04$ mv after five minutes. For ENG recordings the level of illumination must be held constant. When the eye adjusts from conditions of darkness to light (.001 to 5 ml), its polarity potential increases very slowly in the first three minutes, with an accelerated rise in the 4th and 5th minute, and a continued slow rise to an equilibrium value at ten minutes. The literature has established that five minutes of dark adaptation is a sufficient length of time. Calibration of the eye immediately prior to rotation is necessary for making any required adjustments related to inter-individual differences in potential level and rate of adaptation. This change in potential during the 35 seconds of recording is considered negligible.

The length of time between rotational stimulations (Wendt, 1951) is considered critical because this interval allows the vestibular system to return to its homeostasis. As discussed in Chapter I, Section 4, one component of the response is secondary nystagmus which may last anywhere from three to ten minutes after stimulation is stopped. The consensus given in the literature is that five minutes is the proper length of time between stimulations. If secondary nystagmus does extend beyond this time, its interference with current responding is insignificant.

In this study, nystagmus testing took place for one hour at any time between 0800 to 2100 hours. Time of day was found not to influence nystagmic output (Ferneyhough, 1974), though it did affect the perception threshold of rotation which is highest in the morning hours (Eckel, Kuipers & Wendt, 1963).

Previous nystagmic research (Ferneyhough, 1974) found that volunteer subjects remained on-task throughout all experimental conditions. This high compliance rate was judged to be the result of the volunteer subjects' great intrinsic interest in the subject matter being investigated, as found by Rosenthal (1970) and others (Edgerton, Britt & Norman, 1947; Martin & Marcuse, 1958; Rosen, 1951; Wallin, 1949), and their great need for approval (Marlowe & Crowne, 1961; Riggs & Kaess, 1955; Rosenthal, 1970). The subject is assumed to comply with the experimental instructions and, therefore, a secondary measurement confirming this compliance is not used for the current study. Any possible non compliance by a subject is felt to be minimal and would have a non significant effect on the results when a large subject pool is used.

Habituation, or a long lasting response reduction over repeated stimulation, which is not found in this study, has been extensively reviewed (Collins, 1973; Crampton, 1964; Dodge, 1923; Fernandez & Schmidt, 1962; Pfaltz & Piffko, 1970; Wendt, 1951). This phenomenon differs from the temporary state of fatigue where brief intervals of rest are sufficient for recovery of response. Wendt (1951) cites factors which inhibit habituation. An inward orientation of attention, or low arousal, would account for nystagmus reduction whereas an environment directed orientation, or higher arousal, would restore nystagmus or prevent its decline. In this study only one (reverie) of five subjective mental states is low enough in arousal to promote habituation. The order of presentation will be considered in the data analysis to evaluate the effect of this approach. Wendt, as well as others (Pfaltz, Collins and Crampton), have documented that visual fixation is an essential factor for the occurrence of habituation. Using the condition of darkness to eliminate fixation has proven to be the most effective method of nullifying habituation.

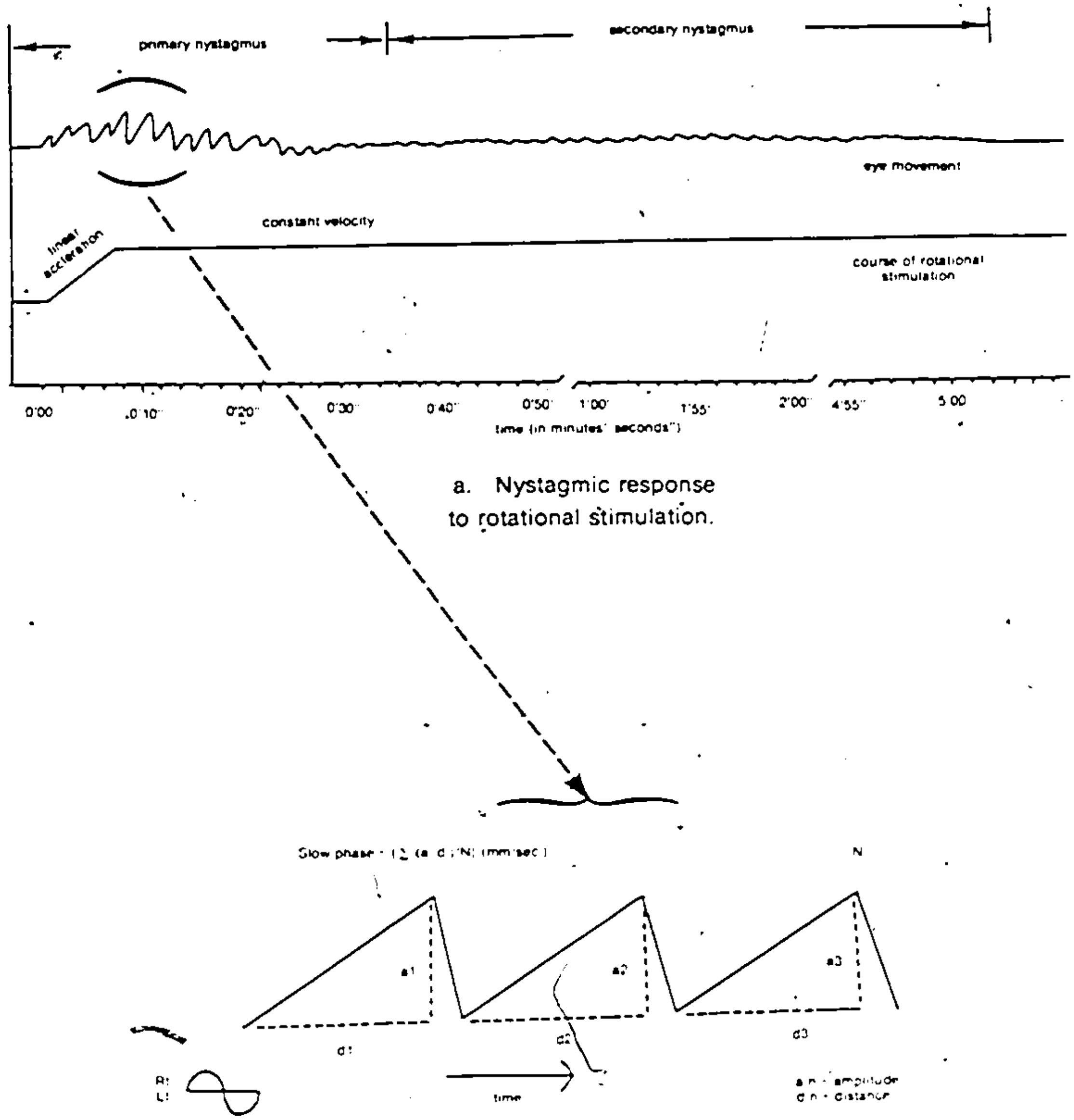
4. Analysis of the Data

This section provides a detailed description of the manual method used to measure the recorded slow phase, primary nystagmic velocity. The statistical procedures for testing the hypothesis, as stated at the end of Chapter I, are given and the controversy of repeated measure design is discussed.

A. Measurement of Recordings

The dependent variable being investigated is nystagmus which is defined as a slow, linear drift of the eyes in one direction interrupted by a fast return movement. This compensatory drift must be contiguously paired to rotational vestibular stimulation. The specific component of nystagmus being evaluated is the slow phase, nystagmic velocity.

All raw score, nystagmic data were reduced by hand measurement as follows: (Please refer to Figure 6.) The



a. Nystagmic response to rotational stimulation.

b. Measurement technique.

Figure 6 — Measurement of slow phase, primary nystagmic velocity.

vertical magnitude of the slow phase sweep of each primary nystagmic beat was measured first in millimeters for each second segment of the recording and then converted to degrees for each second. Since the paper speed was held at 10 mm per second for all recordings, a special protractor could be used to greatly simplify the calculations. To minimize the effects of random fluctuations in the recordings, the arithmetic average of nystagmic velocity over a 2.5 second period was computed. Fourteen 2.5 second blocks in recording from the onset of the rotational stimulation were measured.

The datum used for statistical analysis of the hypothesis was a "difference score" between the highest nystagmic velocity response obtained (usually at the cessation of linear acceleration) during basal testing and the highest response during each mental arousal state. Since the absolute level of nystagmic change between arousal states within each subject is what is evaluated, and since there is a large variation (Ferneyhough, 1976) between individuals of the same personality group (i.e., introvert, ambivert or extravert) in their actual level of nystagmic response for the same basal condition, the technique of difference score is utilized.

To counteract scorer's bias, each recording was evaluated without the knowledge of the subject's position on the extraversion scale. To validate the scorer's methodology nine independent judges were chosen, on the basis of their total lack of knowledge in the area of eye movements or personality, to score random, totally unmarked, nystagmic recordings. The judges had no knowledge of the dependent and independent variables of this study; they were only told that they were measuring the slope of lines that had a saw tooth configuration.

B. Statistical Analyses

In order to test the hypothesis as stated at the end of Chapter I, an analysis of variance technique was used to establish the significance of an interaction between the three levels of extraversion (introverts, ambiverts, and extraverts) and the five levels of mental arousal (including: reverie, temporal reproduction, sense of rotation, mental arithmetic and complex choice tasks). Each subject was tested at all levels of mental arousal.

A two factor analysis of variance with repeated measures on one factor was used to test for the interaction effect. Subjects were assigned to the experimental groups of extraversion (factor A) according to their score on the Eysenck Personality Inventory, and each group was rotated under all levels of subjective mental arousal (factor B). The interaction effect of A x B was the main concern.

The repeated measures analysis of variance design is widely used in research in the behavioral sciences because a major concern of psychology is behavioral change; however, many researchers warn against the use of an analysis of repeated measures design (Huck & McLean, 1975; McCall & Appelbaum, 1973). In addition to assumptions concerning normality and homogeneity of variance within cells, the repeated measures analysis requires homogeneity of co-variances between repeated assessments. This type of analysis of variance is not robust enough to deal with violations of covariance assumptions which produce artificially large F values relative to the appropriate critical value. This bias results in rejecting the null hypothesis more often than should be the case for the stated significance level.

Corrections for the use of the conventional analysis of variance design have been suggested by Greenhouse and Geisser (1959) and McCall and Appelbaum (1973). The distribution of the conventional univariate F statistic can be adjusted for the covariance assumption.

Adjustments for the violation of covariance in the conventional analysis of variance design are made by reducing the degrees of freedom (Greenhouse & Geisser, 1959). This is completed by multiplying the degrees of freedom for both the numerator and denominator by a function of the degree of heterogeneity of the variances and co-variances. The greater the heterogeneity, the smaller the function and the greater the F value must be to reject the null hypothesis.

McCall and Appelbaum (1973, p. 406) explain the use of an alternative computational technique called the "lower bound estimate" which is suggested by Greenhouse and Geisser to expedite the computation of the above adjustment. In this most conservative of tests the degrees of freedom become one and one minus the number of levels of the repeated factor being considered. The resultant critical value becomes almost twice the size of the critical value found in the conventional analysis.

A Scheffé Test is used to test for simple effects comparing the differences among group means. This test is used, instead of a Duncan's Multiple Range Test or a Tukey, since it is more stringent and thus the probability of a Type I error is lower.

To further evaluate the possible findings of an interaction effect between personality and arousal variables a test of linearity of regression is completed. Eta and Spearman Rank-Correlation (rho) is computed for each personality grouping of introverts and extraverts on their respective, resultant slow phase, primary nystagmic velocity at each of the five arousal levels. The F test of linearity (Guilford, 1965, p. 314) is used to interpret if the change in nystagmic velocity across increasing arousal levels is linear or nonlinear. When the actual regression is linear, the difference between eta and rho computed for the same data is nearly the same. Eta is found to be larger numerically when the actual regression is nonlinear.

The Pearson Product-Moment Coefficient (r) is typically used in the calculation for the F test of linearity; however, W. J. Conover (personal communication, January 27, 1984) advises that Spearman rho is closely equivalent to the Pearson r and can, for practical purposes, be substituted when using ordinal instead of interval measurements. The use of rho as an approximation of r is confirmed by many statisticians (Guilford, 1965, p. 307; Mendenhall & Ramey, 1973, p. 309; McGuigan, 1968, p. 169).

To determine the type of equation which would best describe any possible nonlinear results found by an F test of linearity a test for trends [described by Bruning and Kintz (1977) on pages 143-168] will be computed. This test will be used to determine whether the equation is linear, quadratic or a higher complex relationship.

CHAPTER III

PRESENTATION OF RESULTS

The beginning of this chapter describes the subjects obtained for the study and their nystagmic output. The main body of this chapter deals with the analysis of the extraversion by arousal interaction. The several most pertinent variables considered to have possible confounding effects upon the results are also reviewed and systematically discussed.

1. Characteristics of the Subjects

The subjects are extremely homogenous with regard to age. Over 40% of the group is nineteen years old, and over 65% is between the ages of eighteen and twenty. Subjects younger than eighteen and older than twenty-five account for less than 13%. The ratio of males to females is 40% to 60% respectively. The age distribution in the personality grouping of introvert, ambivert and extravert is non significant (X^2=3.66, df=4, p=n.s.).

When considering the internal distribution of the personality variables of the introvert, ambivert and extravert across the L and N scales, time of day tested and day of the study when testing occurred, the only variable which is disproportionally weighted across personality groups (χ^2=9.94, df=2, p<.01) is the day testing occurred. The variable measures the number of subjects tested during the first twenty days of the experiment versus those tested during the last fifteen days. Twice as many ambiverts were tested in the first twenty days as in the last portion of testing and twice as many extraverts were tested in the last portion of the study as in the first portion. However, "day tested" was found to have no significant effect (F=0.37, df=4/111, p=n.s.) across extraversion when measuring nystagmic output.

2. Characteristics of Nystagmus

In looking at the trends that the nystagmus responding took, three different variables in the nystagmic response were evaluated across personality types; they are the time lapse from the onset of acceleration until the highest nystagmic response was achieved, the duration of the response from the onset of the acceleration until the last nystagmic eye movement, and the difference between nystagmic slow phase velocities at the height of nystagmic output between differing instructional task conditions. The variables of time lapse and duration of response do not differentiate personality groups. Duration of response is, as expected, influenced by arousal levels such that high arousal states induced significantly

(F=21, df=6/702, p<.001) longer nystagmic responding than reverie.

The presentation order of the subjective mental states was systematically counterbalanced to ascertain possible order and carry-over effects. Results of an analysis showed no order effect (F=0.23, df=4/420, p=n.s.) as shown in Table 3.

Examples of nystagmic output taken at maximum velocity for each personality group are shown in Appendix 3. The tabulated data across time for all speeds are given in Appendix 4. The validity of the scoring technique was tested by using nine independent raters who scored a 2.5 second portion of the highest nystagmic responding for each personality type, at each speed of stimulation, across all arousal states. (Twenty-one recordings in all were presented.) The specific recording used was randomly chosen by computer from the total possible records from each group. The judges were a group of nurses who had no knowledge of the experiment or the significance of the recordings. The Kendall's Coefficient of Concordance for raters and the initial scorer is 0.89 which indicates a non significant difference in scoring technique among all judges.

Table 3

Analysis of Variance
Evaluating Effects of Presentation Order

Source	SS	df	MS	F	P
Between subjects	5691.97	119	-	-	-
Extraversion (ES)	306.76	2	153.38	6.04	<.003
Arousal (Ar)	2022.28	4	505.57	19.92	<.001
ES X Ar	698.61	8	87.33	3.44	<.002
Error	2664.32	105	25.37	-	-
Within subjects	11919.11	480	-	-	-
Order (Or)	23.29	4	5.82	0.23	n.s.
Or X ES	76.74	8	9.59	0.37	n.s
Or X Ar	493.07	16	30.82	1.20	n.s.
Or X ES X Ar	527.53	32	16.49	0.64	n.s.
Error	10798.48	420	25.71	-	-
Total	17611.08	599	-	-	-

3. Evaluation of the Hypothesis

The results of the two factor analysis of variance with repeated measures on one factor found a significant interaction effect, at $p<.05$, for the nystagmic output between extraversion groups and mental arousal states. (These results have been adjusted for covariance, as described in section 4 of Chapter II, using the "lower bound estimate" of correction.) The conventional analysis of variance is presented in Table 4.

If the main effect of levels of extraversion (factor A) only was evaluated, the erroneous conclusion that there were no differences among introverts-extraverts would be drawn. The significant interaction effect in the analysis is a signal to look further for differences among means (A) at specific levels of the other treatment (B). Therefore, the results of simple effect testing are presented in Table 5.

As predicted by research studies presented in sections 3 and 4 of Chapter I, a significant difference in nystagmic output between arousal states for introvert, ambivert and extravert groupings was found. The influence of different arousal states on slow phase, primary nystagmic velocity has been well documented since the 1960's. However, the effect across these groupings at each level of arousal state was different. At higher arousal states

Table 4

Analysis of Variance
Evaluating Factors of Extraversion and Arousal

Source	SS	df	MS	F	P
Between subjects	10411.49	119	-	-	-
Extraversion (E)	202.13	2	101.06	1.16	n.s.
$Error_b$	10209.36	117	87.26	-	-
Within subjects	7568.23	480	-	-	-
Arousal (Ar)	2099.27	4	524.82	51.98	<.001
(E) X Ar	743.40	8	92.93	9.20	<.001
$Error_w$	4725.56	468	10.10	-	-
Total	17979.72	599	-	-	-

Table 5

Simple Effects Evaluating Factors of Extraversion and Arousal

Source[a]	SS	df	MS	F	P
Between subjects					
Extraversion (E)					
at CC	384.66	2	192.33	7.53	<.001
at MA	278.64	2	139.32	5.46	<.005
at TR	206.45	2	103.23	4.04	<.025
at SR	13.18	2	6.59	0.26	n.s.
at R	62.82	2	31.41	1.23	n.s.
Within cell	14935.05	585	25.53	-	-
Within subjects					
Arousal (Ar)					
at I	727.43	4	181.86	18.01	<.001
at A	575.20	4	143.80	14.24	<.001
at E	1539.64	4	384.91	38.11	<.001
E X Ar	743.40	8	92.93	9.20	<.001
Ar X subject within groups	4725.56	468	10.10	-	-
Total	17979.72	599	-	-	-

[a]Abbreviations: CC=complex choice; MA=mental arithmetic; TR=temporal reproduction; SR=sense of rotation; R=reverie; I=introvert; A=ambivert; and E=extravert.

there was a significant difference in nystagmic production depending if the subject was an introvert, ambivert or extravert; at lower arousal states no significant differences were found. A Scheffé Test (Table 6) was calculated to further explore this effect. The results of Table 6 are discussed in Section 1 of Chapter IV.

The obtained interaction effect of extraversion by arousal was hypothesized, in Chapter I, to be the result of the difference in linearity of the relationship between the two personality groups of introverts and extraverts, and the differences in level of arousal. Specifically, changes in the nystagmic output during the increasing mental arousal states vary linearly for extraverts and curvilinearly for introverts. These findings were confirmed by the following method.

For introverts, the results of the F test of linearity show that the difference between eta and rho is so great as to leave no doubt of nonlinearity ($F=7.47$, $df=3/195$, $p<.001$) in changes in nystagmic output across increasing arousal levels. For extraverts, however, the obtained F indicates ($F=1.73$, $df=3/195$, $p=n.s.$) that this change is linear. The tendency for introverts' responses to deviate from a straight line to a curvilinear form ($F=19.95$, $df=1/195$, $p < .001$) is seen in a trend analysis presented in Table 7.

Table 6

Scheffé Test for Difference Score
Evaluating Factors of Extraversion and Arousal

	E.R	A.R.	I.R.	A.TR	E.TR	A.MA	I.CC	E.MA	A.SR	A.CC	E.SR	I.TR	I.SR	I.MA	E.CC
E.R = -2.94	-	0.13	1.70	2.51	3.25	3.71	4.20	4.47	4.71	5.26	5.58*	5.89*	7.40*	7.40*	8.42*
A.R = -2.83		-	1.59	2.40	3.14	3.60	4.09	4.36	4.60	5.15	5.47	5.64*	5.78*	7.29*	8.31*
I.R = -1.24			-	0.81	1.55	2.01	2.50	2.77	3.01	3.56	3.88	4.05	4.19	5.70*	6.72*
A.TR = -0.43				-	0.74	1.20	1.69	1.93	2.20	2.75	3.07	3.24	3.38	4.89	5.91*
E.TR = 0.31					-	0.46	0.95	1.22	1.46	2.01	2.33	2.50	2.64	4.15	5.17
A.MA = 0.77						-	0.49	0.76	1.00	1.55	1.87	2.04	2.18	3.69	4.71
I.CC = 1.26							-	0.27	0.51	1.06	1.38	1.55	1.69	3.20	4.22
E.MA = 1.53								-	0.24	0.79	1.11	1.28	1.42	2.93	3.95
A.SR = 1.77									-	0.55	0.87	1.04	1.18	2.69	3.71
A.CC = 2.32										-	0.32	0.49	0.63	2.14	3.16
E.SR = 2.64											-	0.17	0.31	1.82	2.84
I.TR = 2.81												-	0.14	1.65	2.67
I.SR = 2.95													-	1.51	2.53
I.MA = 4.46														-	1.02
E.CC = 5.48															-

I =introvert
A =ambivert
E =extravert
CC=complex choice
MA=mental arithmetic
TR=temporal reproduction
SR=sense of rotation
R =reverie

*p<.05

E.R A.R I.R A.TR E.TR A.MA I.CC E.MA A.SR A.CC E.SR I.TR I.SR I.MA E.CC

Table 7

Trend Analysis of Evaluating the Nonlinear Relationship of Nystagmic Output with Increasing Arousal Level

Source		SS	ms	F	P
Between levels	1815700	4	453930	7.31	<.01
Linear	409984	1	409984	6.60	<.025
Quadratic	1239663	1	1239663	19.95	<.001
Cubic	3036	1	3036	0.05	n.s.
Quartic	162989	1	162989	2.62	n.s.
Within levels	12116000	195	62131	-	-
Total	13931000	199	-	-	-

Chapter IV

DISCUSSION OF RESULTS

The first section of this chapter restates the findings of the present study and discusses the interaction between levels of extraversion and levels of arousal as they reflect Eysenck's model. This section proposes the conceptual explanation of transmarginal inhibition for the inverted-U function found between arousal and nystagmic output. The last section suggests directions for future research which would consider a multidimensional arousal system's effect on the individual's processing of information.

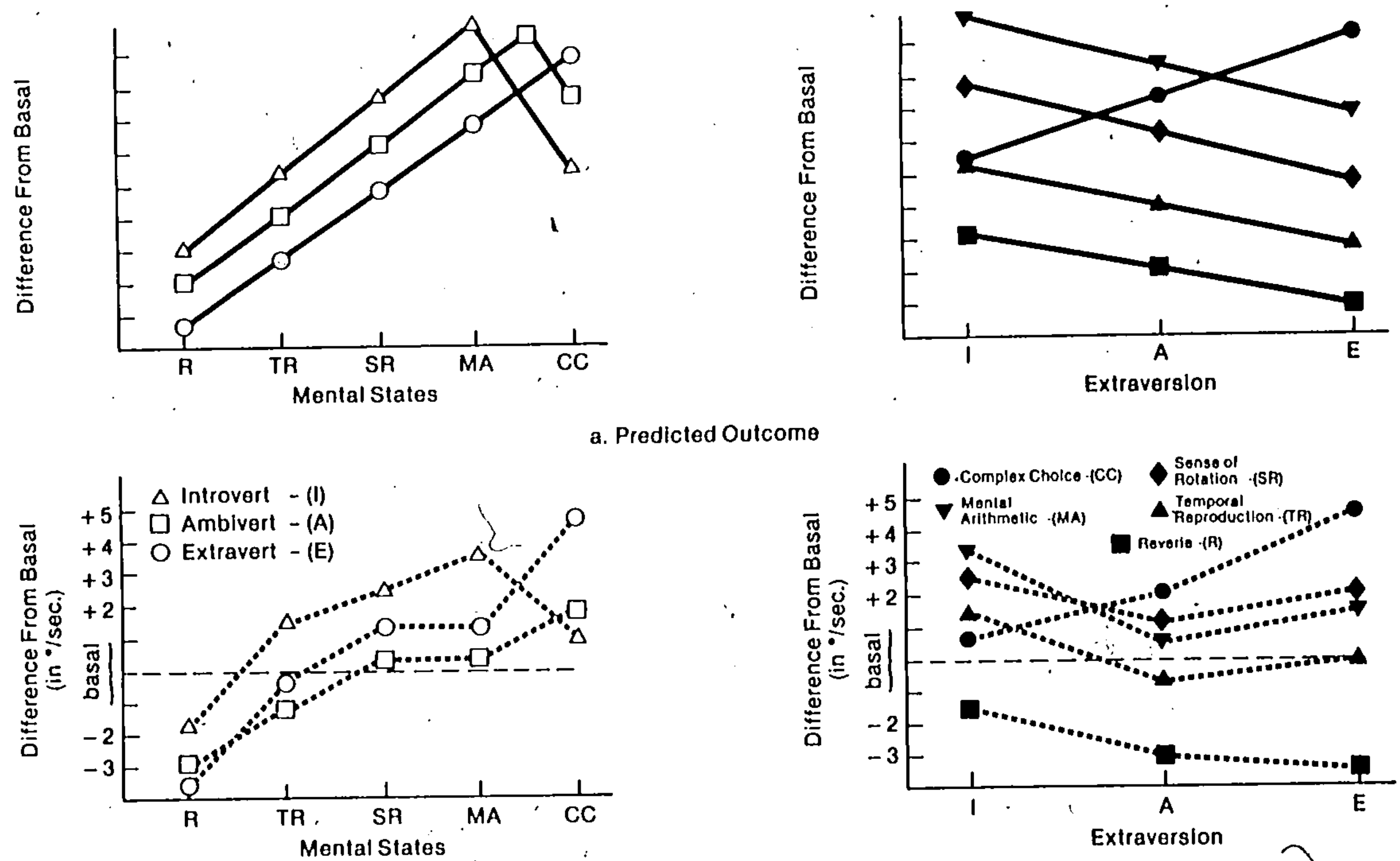
1. Interpretation of the Present Findings

A statistically significant interaction was found between levels of extraversion (as defined by Eysenck) and levels of arousal, as they reflect in slow phase, primary nystagmic velocity (refer to Table 4). Significant differences in nystagmus with changes in arousal levels were found across all levels of extraversion (found in Table 5). Nystagmic changes within levels of extraversion, however, differed depending on the level of arousal. At low arousal levels, no significant differences were found across extraversion levels. At higher arousal levels, significant differences were found (reviewed in Tables 5 and 6).

Except for one instance--introverts during the temporal reproduction task--no significant differences in nystagmic output between personality type were found at each of the three arousal levels. In the two highest arousal levels, however, significant differences were noted. During mental arithmetic, introverts' velocity was greater than ambiverts or extraverts', while during the complex choice task extraverts' responding was significantly higher than either of the other two groups. (Refer to Table 6). This interaction effect was predicted as diagrammed in Figure 7a. The actual outcome of events, shown in Figure 7b, closely approximates the hypothesized results.

This interaction between personality groupings and cortical arousal is tentatively explained by the course of nystagmic velocity change with increasing arousal. As confirmed by computing the F test of linearity, for the extraverted grouping there is a linear change in nystagmus with increasing arousal levels and for introverts there is a nonlinear change. This nonlinear change was found to be curvilinear in nature, as viewed in Table 7b.

The above factors are consistent with the inverted-U relationship previously suggested by Colquhoun and Corcoran (1964) who explain their findings in terms of excitation-inhibition taken in conjunction with a curvilinear relationship



a. Predicted Outcome

b. Actual Outcome

Figure 7 — Predicted compared to actual outcomes of various mental states across levels of Extraversion.

between arousal and performance. Their argument followed that arousal has been shown to be low in the morning which would place introverts in an optimal position in their performance on a letter cancelling task. A general rise in arousal in the afternoon would shift extraverts into the favorable position. If varying mental states replace the time of day variable in Colquhoun and Corcoran's study and nystagmic output replaced letter cancellation, then a relationship approximating Figure 8 would result.

Once concept which might explain the phenomenon of the inverted-U relationship has been identified as trans-marginal inhibition. To restate this concept, trans-marginal inhibition is an impairment in the efficiency of performance at high levels of arousal, whether the high level of arousal is induced by the presentation of an ultra strong stimulus, the protracted application of a stimulus of moderate intensity or frequent presentations of stimuli of moderate intensity at time intervals short enough to allow summation of the excitation. Individuals high in the dimension of arousability, such as introverts, respond at a lower intensity, a lower duration, or a lower frequency of stimulation than individuals low in this dimension, such as extraverts.

When contrasting Figure 8 and Table 6 with the literature

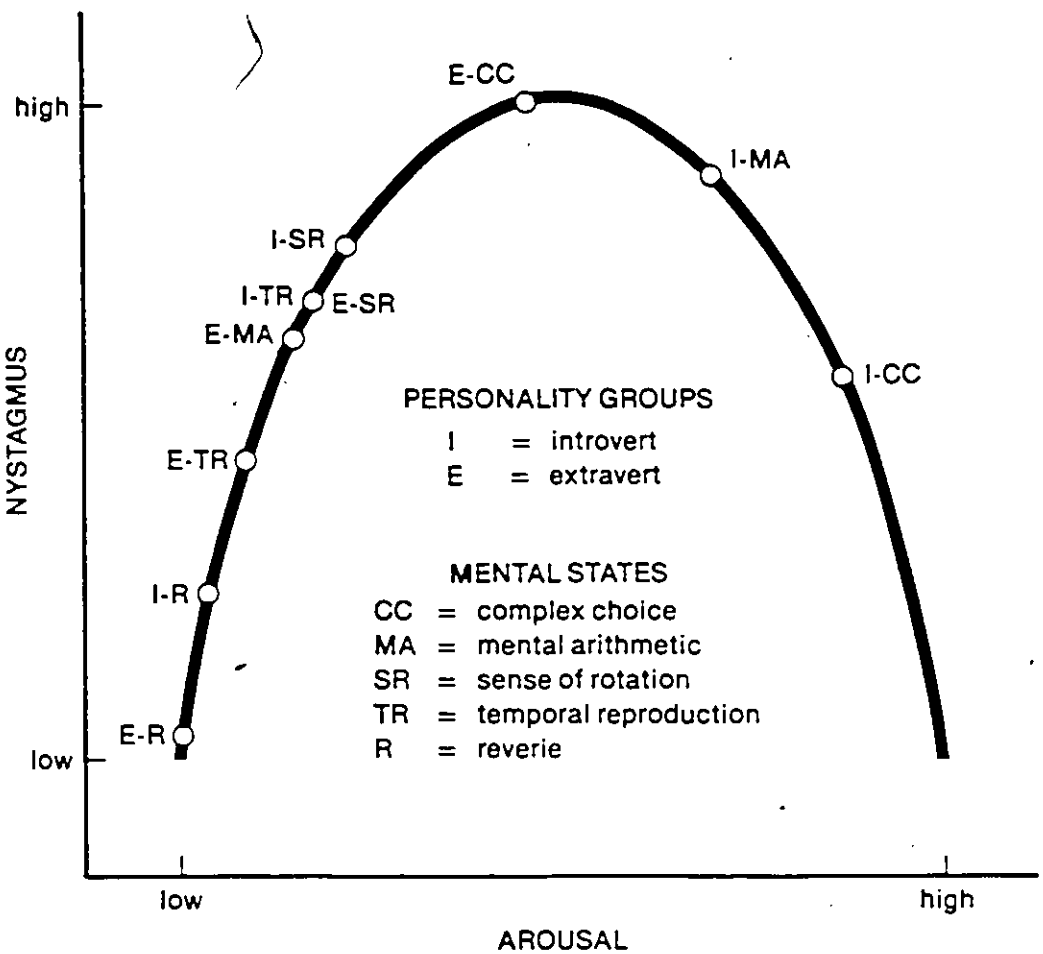
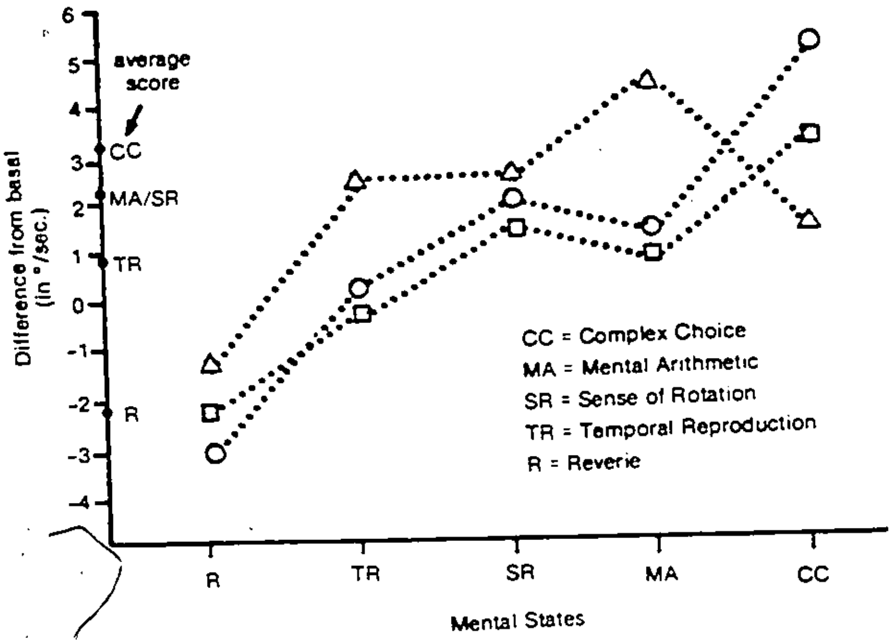


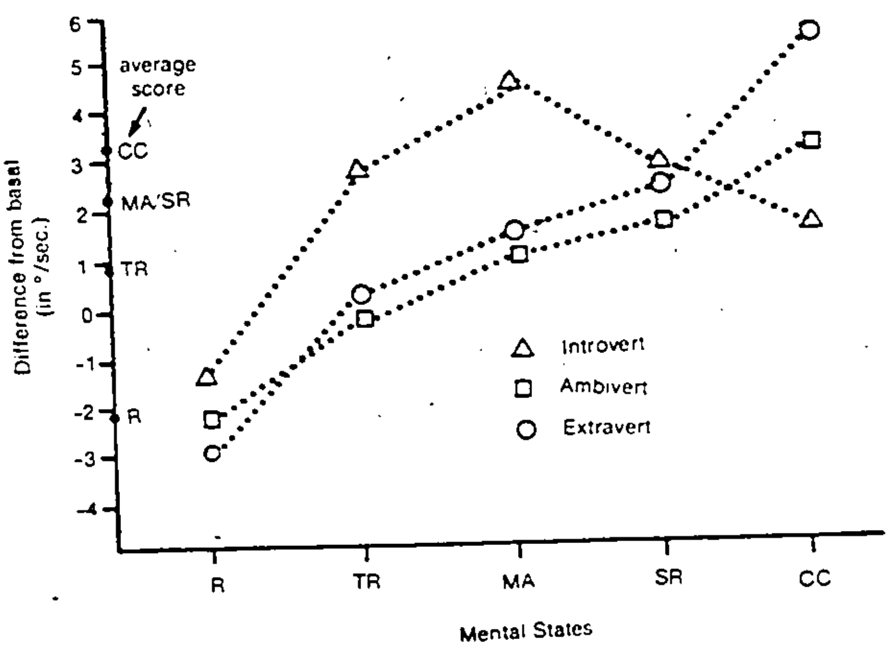
Figure 8 — Inverse-U relationship between Extraversion and arousal reflected in nystagmus.

reviewing the quantitative positions of nystagmic responding to various instructional tasks, as found in Section 4 of Chapter I, an interesting conflict arises. Previous studies (Brown & Crampton, 1964; Collins, 1962, 1963, 1964, Collins, Crampton & Posner, 1961; Collins & Guedry, 1962, 1967) report that the sense of rotation task is a less arousing condition than the mental arithmetic task. The present results, nevertheless, indicate both tasks are not significantly different in eliciting cortical excitation. Unlike the past research, however, the present study separates subjects by personality grouping and, thus, offers further information.

This conflict might be explained by reversing the ranked positions of the two tasks. This switch is based on the interaction effect between personality grouping and arousing conditions. If it is true that changes in slow phase, primary nystagmus vary linearly for extraverts and curvilinearly for introverts than Figure 9 shows graphically why sense of rotation might be a more arousing state than mental arithmetic and less arousing than complex choice. Figure 9b, the tentatively suggested positioning of the instructional tasks, enhances the curvilinearity of responding of introverts and the linearity of responding of extraverts. Table 8 presents the results of a trend



a. Placement found by past researchers



b. Suggested placement from present study

Figure 9 — Placement of sense of rotation task in arousal continuum.

Table 8

Trend Analysis of Nystagmic Output with Arousal Level Evaluating the Tentative Ranked Positions of Instructional Tasks

Source	SS	df	ms	F	P
Between levels	1815700	4	453930	7.31	<.01
Linear	256806	1	256806	4.13	<.05
Quadratic	1503775	1	1503775	24.20	<.001
Cubic	44935	1	44935	0.72	n.s.
Quartic	10204	1	10204	0.16	n.s.
Within levels	12116000	195	62131	-	-
Total	13931000	199	-	-	-

analysis for the introverted group based on the ranked positions in Figure 9b; compared to Table 7, the enhanced curvilinear responding is shown statistically ($F=24.20$, $df=1/195$, $p<.001$) by the current computation. Therefore, depending on the personality type of the subject pool on which the study is based, the ranked positions of the mental tasks may vary.

Unfortunately, quantitative nystagmic studies have not considered individuals' personality type when selecting subjects. If a high preponderance of the experimental subjects found in the previous studies were introverted than sense of rotation would have been found to produce a lower velocity nystagmic response than the mental arithmetic task.

2. Suggestions for Future Research

The present study supports the inverted-U relationship described by the Yerkes-Dodson Law. According to this law arousal can be regarded as a unidimensional construct where levels of arousal represent quantitative variations along continuum. However, the validity of this single, arousal based system has been placed in doubt by previous research (Lacey, 1967; Pribram & McGuiness, 1975) which differentiates two or more qualitatively different physiological compositions distinguishing arousal from activation states. Research by Broadbent (1971) and Thayer (1970) suggests that two arousal dimensions may exist. The lower arousal mechanism suggested by Broadbent's upper arousal system and Thayer's activation domension B are affected by intense, external stimulation; Broadbent's upper arousal system and Thayer's activation dimension A is affected by less than optimal arousal.

M. W. Eysenck (1982) postulates that there is a division between arousal produced as a result of the active, cognitive involvement of the individual in a task, and arousal produced by passive, non-task stimuli, such as noise or drugs. The two arousers used together interact with each other in determining performance whereas the same two arousers applied separately will produce different patterns of results. The effort of only single arousers on task performance can be greatly effected by small alterations in task parameters (M. W. Eysenck, 1982, p. 186).

Eysenck has suggested the course of future research to be in determining how different arousal states and task demands produce specific processing strategies in individuals. Only with this knowledge will the effects of a single arouser on task performance be understood. As seen by the present study, slow phase, primary nystagmic velocity could be used as an excellent dependent measure in research which would be divised to examine the above question. The sensitivity of the nystagmic response to arousal changes is very important since a finding of most studies is that arousal manipulations have smaller effects on many dependent measures than would have been expected (M. W. Eysenck, 1982, p. 66).

SUMMARY AND CONCLUSION

H. J. Eysenck (1967) has proposed that personality differences may be classified according to a cortical arousal continuum and these differences are reflected on the Eysenck Personality Inventory: Form A (EPI). Evidence has accumulated that there are differences in cortical arousal in these different groups such that their baseline differences may be affected differently by variations in the arousing condition defined by mental tasks. Recently published research suggests that there is a significant interaction of extraversion with varying levels of arousal. Earlier research by Ferneyhough (1976) also suggested the presence of this interaction effect; however, the study only considered the extreme points of the arousal continuum and, therefore, did not provide an explanation for the effects on a continuum of arousing conditions across a continuum of subjects defined at different points on the EPI. This present study, based on measurement of nystagmus as a measure of cortical excitation, addresses the question of a significant interaction between these groups.

One hundred and twenty undergraduate, unpaid volunteers were randomly chosen from a pool of 188 subjects who met six preconditions which assured their normal labyrinthine functioning. The subjects were equally assigned to the introvert, ambivert and extravert grouping depending if they scored below 10 or above 15 on the E scale of the EPI.

Equipment was devised to produce angular rotation, resulting in stimulation of the subjects' horizontal semicircular canals. This produced nystagmic responding which was the dependent variable. The independent variables were the five mental, instructional tasks the subjects maintained while they rotated. Each instructional task was described immediately prior to the subjects' performance of the task. The presentation order of the mental tasks was counterbalanced between subjects. The different instructions were modeled after mental tasks commonly found in the literature. The parameters for each task are: (1) Reverie- maintaining a state of daydreaming with eyes open in the dark; (2) Temporal Reproduction - duplication of the duration of a tone; (3) Sense of Rotation - indicating the onset and cessation of rotation, as well as each 90 degree turn; (4) Mental Arithmetic- simple addition, subtraction and multiplication problems; and (5) Complex Choice- a decision making task requiring identification of the last highest tone. Before experiencing rotation with the above five mental tasks, the subjects were rotated while they counted from one forward, as a practice session, to acquaint them with the experimental situation.

They were then rotated while they sat quietly to record their basal, baseline response.

Beckman electrodes were applied to the outer canti of the subjects' eyes and their heads were restrained so that their horizontal, semicircular canals were in the plane of rotation. Seven, seven second, clockwise rotations of $9.4°/sec^2$ were administered followed by a 76 second period of constant velocity. Five minutes between rotations elapsed to allow the vestibular system to return to homeostasis. During these rest periods the subjects continued to be rotated at a constant velocity of one degree per second. Throughout each acceleration and constant velocity periods of 66 degrees per second the subjects continued to perform their assigned mental task.

Electronystagmic recordings were taken from the onset of acceleration until the onset of deceleration for each trial. All slow phase, primary nystagmic velocities were analyzed by hand measurements. To minimize the effects of random fluctuations, arithmetic averages of nystagmus over 2.5 second blocks were computed for the final analyses. Since large variations in basal nystagmic response between individuals of the same personality group were found in a previous study (Ferneyhough, 1976), a difference score method was used. The difference score for each task consisted of the maximum velocity nystagmic response obtained for that individual during the basal mental task subtracted from the maximum velocity nystagmic response for each specific mental task under consideration. Therefore, the rate of nystagmic change across the mental arousal changes could be equated for all subjects.

A two factor analysis of variance, with repeated measures on one factor, was applied to the data. The main factors considered were the three levels of extraversion and the five levels of arousal elicited by mental, instructional tasks. A statistically significant interaction ($F=9.20$, $df=8/468$, $p\leq.001$) was found between levels of extraversion and levels of arousal, as reflected on slow phase, primary nystagmic velocity. Analysis of the simple effects and a Scheffe test indicate that significant differences in nystagmic velocity between the different personality groups were only found at the higher arousal levels induced by instructional tasks.

The results were assessed by testing differences in linearity of the relationship between personality groups and the differences in level of arousal. For extraverts, the results of the F test of linearity shows that the difference between eta and rho is insignificant and leaves no doubt of the linearity ($F=1.73$, $df=3/195$, $p=$n.s.) in changes in nystagmic output across increasing arousal levels. For introverts, however, the obtained F indicates ($F=7.47$, $df=3/195$, $p < .001$) that this change is nonlinear. A trend analysis of the curve that best describes this nonlinear result for introverts shows that a curvilinear quadratic equation best fits the data.

The findings of this study add support to the theory that varying reactions of individuals to stimulation is a function of psychophysiological typologies. Individuals who are extraverted show that with increasing intensity of arousing stimulation their resultant cortical excitation directly increases in level. For individuals who are introverted, however, increases in intensity of arousal show increases in cortical excitation followed by a decrement in excitation level. This inverted-U phenomenon has been described in the Western literature for extraverts and introverts and by Soviet investigators for weak and strong nervous systems.

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APPENDIX 1

SPECIMEN COPIES OF THE INSTRUMENTS USED

INFORMATION GIVEN TO THE SUBJECTS PRIOR TO TESTING

A. Soliciting Subjects

(Read aloud in the classroom to all students.)

"I am preparing for a research project in experimental psychology to fulfill the requirements for a Ph.D. Your teacher has given me permission to talk to you during the last twenty minutes of this class in order to enlist you as unpaid volunteers. To take part in a research project will help you to understand the background of the research articles that you are required to read. Should you participate in this study you will earn extra credits towards your final grade of this course."

"If you decide to volunteer you will take a short paper-and-pencil test today. Later this week, if you are called, you will be asked to come to the psychology laboratory for one hour at a mutually convenient time. During that hour you will sit in a chair, recording devices will be taped near the temples of your head, and you will be rotated while in the dark. During seven different rotations you will be asked to complete varying mental tasks. I assure you that you will be quite safe. The rotations are not fast and in some instances you might not perceive that you are rotating at all."

"Your teacher will notify you when the study is completed, and at that time you may request your individual results. A full explanation of this study will be provided to you at the reservation desk of the library. If you wish, you may also contact me to discuss the details in more depth."

"A subject in this experiment must meet certain preconditions which I will list in just a minute. The findings of this study might be adversely affected if preconditions are not met by all subjects. I hope you understand how important it is that you exclude yourself from this study if you do not meet them."

"The preconditions you must meet are: first, you should not have a history of inner ear disorder. Secondly, you must not have experienced a high centrifugal force in the past year, (such as an airplane pilot might have), nor should you have been a participant in a rotational experiment. Thirdly, you should not have taken any prescribed or illicit drugs during the past month, and you must agree to continue to abstain from drugs until you have completed this experiment. Fourthly, you must agree to abstain from alcohol for at least fifteen hours, and tobacco, coffee and tea for at least two hours prior to rotation in the laboratory. Lastly, you must also agree to sleep the length of time normal for you during the night before your rotation."

"Everyone who can not or does not wish to participate in this experiment may leave the classroom now. Anyone who is unsure if he or she meets the preconditions I have mentioned should come to the front to discuss his or her questions with me."

(Pass out the <u>Eysenck Personality Inventory</u>: <u>Form A</u>.)

"Please fill out the first two lines of the heading of the test. It includes your name, age, gender, the year you are in at college, and today's date. Also, at the top of the sheet please write a telephone number at which I can reach you."

(Pause.)

"The instructions for this test are found in the middle portion of your sheet. I will read them aloud while you read them silently."

(The instructions are read.)

"As soon as you complete your questionnaire, please bring it to the front immediately. Are there any questions? Now begin."

(A sheet of paper listing items 3, 4 and 5 of the preconditions is handed to the volunteers as they turn in their papers with a reminder of the importance of adhering to the requirements.)

B. On Site Equipment Description and
Demonstration Prior to Nystagmic Testing.

(Read aloud in the room containing the rotational apparatus in the laboratory.)

"Before I begin I will ask you not to discuss with anyone else what you will experience today until after everyone is tested. You had no knowledge about this study before you entered the testing situation, and it is essential that your classmates start with the same level of information. Thank you!"

"I am familiarizing you with the apparatus before testing to allay anxiety you might possibly have about being connected to the equipment and about being rotated. As you can see, this is the chair on the rotating platform in which you will sit. The safety belt will be across your lap, the head holder will keep your head in position, and the front table, with small red lights, buttons, and a switch, will be placed across your lap." (The experimenter points to each section of the equipment.)

"A microphone will be placed around your neck, so that you can talk to me, and headphones are placed over your ears, so that you can hear me. (The microphone and headphones are shown to the subject.) These small electrodes will be taped near your eyes (the outer canthi of each eye is pointed to) and plugged into this box attached to the frame here. Don't worry- you will not receive any electricity through these electrodes: they will only record information from your body." (If the subject asks what is to be recorded, he is reminded that after the study is completed he will receive a full explanation of the research.)

"If you wish to leave the experiment at any time for any reason, you should tell me and you will be freed from the apparatus in less than one minute- even during rotation. I will now show you how the platform rotates. I will rotate it at the fastest possible acceleration you might experience."

(The chair is rotated at $9.4^{\circ}/sec^2$ with the subject standing nearby.)

"Any comments or questions? None? Then let's begin."

(After completing the testing the subject is again reminded not to discuss his or her experience with others until all subjects are tested.)

TAPED INSTRUCTIONS

[Testing of the Apparatus]

"Before we begin, I want to test the equipment. Tones will be given to your left ear and then to the right ear. The tones should both be of the same quality and the same intensity. If you think the tones seem different please tell me. Do you hear this tone in your left ear? (Tone of 510 Hz at 85 dB for five seconds.) Do you hear this tone in your right ear?" (Same tone for five seconds.)

"Now look down with your eyes, only remembering to keep your head in the position I have placed it. Never move your head throughout the experiment; move only your eyes. Look down to the box with two buttons. If you are right handed it is on the right arm rest; if you are left handed it is on the left arm rest. Place your fingers on the buttons. Press the button on the right side. (Pause) Press the button on the left side." (Pause)

"On your left hand rest, in front of the foam padding for your left arm and next to your left hand, is a toggle switch. Place your hand on this switch. It can be moved to the left or to the right. Press it to your left. The small red lights directly in front of you should turn on alternately. If they don't come on please tell me. (Pause) Now move the switch to the right. Both lights should go out. If they don't go out please tell m-." (Pause)

"Thank you. Now we are set to go on."

[Practice Session--PS]

"I want to briefly introduce you to the equipment you are sitting in and then you will have a short practice session which will acquaint you with the procedure we will follow."

"You are sitting on a platform which I can rotate, but don't worry because you will turn very slowly and you may not even feel the rotation. As a precaution please keep your feet flat on the floor at all times. Also, try not to move around excessively. The reason I strapped your head at a forward angle of 30° is extremely important to this experiment so please always keep your head in this position until you are unstrapped and the experiment is over. If you look forward you will see a board with a row of red lights. At certain times I will ask you to follow the flashing lights with both eyes. Move your eyes quickly to the light that is lit. When it goes out move your eyes sharply to the other light. Continue moving your eyes back and forth until both the lights go out. Remember, keep your head in the position I originally placed it. Don't move your head at all, just move your eyes. Beforehand you will be instructed as to the task you must complete after the lights go out."

"The switch which turns these lights on and off is located on the left hand rest just in front of the foam padding. Remember the position of this toggle switch because in a few minutes the room will be darkened until the end of the experiment."

"For some tasks you will be required to press buttons. If you are right handed look at the right hand rest. Remember, don't change the position of your head--just move your eyes to the right. If you are left handed look to the left hand rest. You will see a box with two large red and black plugs and two buttons: a red one on the left side and a black one on the right side. Place your nearest hand on the buttons and press them with your fingers. Remember the position of this box and the buttons because from now on you will be in the dark until the end of this experiment."

"OK, now I will turn the lights out. (The room lights are turned off.) It is time to start your practice session. It won't be as long as the regular trials that will follow, but it will show you that you are safe. From now on it is important that you keep your eyes open when I tell you to and try not to blink. This will only be during the different tasks you will complete. When I tell you to rest for five minutes you may have your eyes open or closed until the next task."

"Now keep your eyes open and looking forward. Sharply follow the lights with your eyes. When both the lights go off begin counting from one forward until I tell you to stop. For example, I want you to count out loud: one, two, three, four, and so on. At some point during this period you will be rotated. Let's begin."

"Place your left hand on the toggle switch located just in front of the foam on the left hand rest. Move the switch to the left. Follow the lights with your eyes. (Pause) Now turn the lights off by moving the switch to the right. Neither light should be on."

"Now please begin counting."

[Task]

"Now this task is completed. We both must wait five minutes until the next trial--so just relax, close your eyes if you want to, and I will tell you when the time is up. The next trial begins the experiment in earnest."

[Basal -- B]

"In this task I want you to just sit as you would if you were waiting quietly for an appointment. You will be rotating at some point during this period but please do not attend to this movement. Just pretend you are sitting in a normal chair, placed in a normal room. Always keep your head tilted 30° forward. Keep your eyes open and try not to blink."

"Before this task begins I want you to follow the flashing lights in front of you with both eyes as you did in the practice session. Move your eyes quickly to the light that is lit. When it goes out move your eyes sharply to the other light. Continue moving your eyes back and forth until both lights go out. This time, when they go out, follow the instructions just given to you about sitting quietly."

"Place your left hand on the toggle switch located just in front of the foam on the left hand rest. Move the switch to the left. Follow the lights with your eyes. (Pause) Now turn the lights off by moving the switch to the right. Neither light should be on."

"Now pretend you are sitting quietly waiting for an appointment."

[Task]

"OK, you can stop now. Again we both must wait five minutes until the next trial--so just relax, close your eyes if you want to, and I will tell you when the time is up."

[Complex Choice--CC]

"In this task you will hear a series of four changing tones (designated in this script by numbers: tone "one" at 500 Hz, "two" at 1.05 kHz, "three" at 2 kHz and "four" at 3.70 kHz) in both ears (presented at the average decibel intensity of 87dB). However, the tones will vary differently in each ear. For example, in your left ear you will hear this: "1324" (left ear only). In your right ear you will hear this: "3241" (right ear only). Played simultaneously theu will sound like this: "1324 (left ear)/"3241" (right ear). From now on the tones will be presented simultaneously. Your job will be to listen to the last tone in the series and indicate, by pressing buttons, whether the left ear or the right ear heard the highest note: In the last example the highest tone was heard in the left ear. Listen: "1324" (left ear)/"3241" (right ear). Now, if you are right handed place your right hand on the right hand rest and find the box with the two buttons. If you are left handed place your left hand on the left hand rest to find this box. Since the highest last tone heard in the example was heard by the left ear, press the button to the left of the box. If the highest tone was to the right ear, you would press the right side button. Always release the button immediately after you press it."

"Here are three practice sessions. Remember, after the fourth tone pair is presented press the left button if the last highest tone was heard by the left ear or the right button if it was heard with the right ear. "1342" (left ear)"2314" (right ear). The last highest tone was heard with the right ear so press the right button. You try the next practice series. "4312" (left ear)"1234" (right ear). As you can see you must pay strict attention to the tones to be able to make the correct choice."

"You will be rotating at some point during this task but please don't attend to this movement. Just concentrate only on the tones and trying to press the correct button. Before we begin, please look straight ahead and follow the flashing lights with both eyes. When both lights remain out, keep your eyes open and pointed forward. Do not close them until you are told you may. Also, try not to blink. As always, keep your head tilted 30° forward. Do your best."

"Place your left hand on the toggle switch located just in front of the foam on the left hand rest. Move the switch to the left. Follow the lights with your eyes. (Pause) Now turn the light off by moving the switch to the right. Neither lights should be on."

"Let's begin the task."

[Task]

(1)	2314	left ear	(5)	3214	left ear	(9)	2134	left ear
	1243	right ear		1243	right ear		4123	right ear
(2)	1342	left ear	(6)	3214	left ear	(10)	1342	left ear
	1243	right ear		4312	right ear		2314	right ear
(3)	4231	left ear	(7)	4132	left ear	(11)	1432	left ear
	4312	right ear		3214	right ear		2413	right ear
(4)	3124	left ear	(8)	2314	left ear	(12)	2134	left ear
	2341	right ear		2341	right ear		4231	right ear

(Twelve presentations at an average intensity of 76 dB taking five seconds each with a five second period for the subject to respond in.

"OK, you can stop now. Again we both must wait five minutes until the next trial--so just relax, close your eyes if you want to, and I will tell you when the time is up."

[Mental Arithmetic--MA]

"In this task I will ask you very simple mathematical questions and I want you to say the answer out loud as quickly as you can. An example of what I will ask you is: How much is two plus two? and you will answer out loud, four. This task is easy but it does take concentration on your part, so please attend to the question and work quickly and accurately. You will be rotating at some point during this task but please don't attend to this movement."

"Before we begin please look straight ahead and follow the flashing lights with both eyes. When both lights remain out, keep your eyes open and pointed forward. Do not close your eyes until you are told you may. Also, try not to blink. As always, keep your head tilted 30° forward."

"Place your left hand on the toggle switch located just in front of the foam on the left hand rest. Move the switch to the left. Follow the lights with your eyes. (Pause) Now turn the lights off by moving the switch to the right. Neither light should be on."

"Let's begin."

[Task]

(1)	7+1=	(6)	9+1=	(11)	6X3=	(16)	0+2=	(21)	3+9=
(2)	1-0=	(7)	0+0=	(12)	7+8=	(17)	3-1=	(22)	7+3=
(3)	2+8=	(8)	3X6=	(13)	8X7=	(18)	2-8=	(23)	2X2=
(4)	3X4=	(9)	8-8=	(14)	4+7=	(19)	6+3=	(24)	4-1=
(5)	6-1=	(10)	4-0=	(15)	5+6=	(20)	4X5=		

(Twenty-four presentations spoken at an average intensity of 81 dB each taking five seconds to ask the question and the subject to give the answer.)

"OK, you can stop now. Again we both must wait five minutes until the next trial--so just relax, close your eyes if you want to, and I will tell you when the time is up."

[Sensation of Rotation--SR]

"In this task I want you to attend to your rotation. If you are right handed place your hand on the right hand rest and find a box with two buttons. If you are left handed place your left hand on the left hand rest to find this box."

"When you think you have begun to turn, press down any one of the two buttons and then release the button. Every time thereafter, when you think you have rotated 90° I want you to press the button. So you will press the button a total of four times every time you think you feel that you have rotated completely around in a full circle. When you feel that you have stopped rotating press the button and do not press it again."

"Before we begin please look straight ahead and follow the flashing lights with both eyes. When both lights remain out keep your eyes open and pointed forward. Do not close your eyes until you are told you may. Also, try not to blink. As always keep your head tilted 30° forward."

"Place your left hand on the toggle switch located just in front of the foam on the left hand rest. Move the switch to the left. Follow the lights with your eyes. (Pause) Now turn the lights off by moving the switch to the right. Neither light should be on."

"Let's begin the task."

[Task]

"OK, you can stop now. Again we both must wait five minutes until the next trial--so just relax, close your eyes if you want to, and I will tell you when the time is up."

[Temporal Reproduction--TR]

"In this task you will hear a tine in both ears. Pay attention to the length of the tone because when it goes off I want you to reproduce the length of the tone by pressing a button the same period of time. The length of one tone might last one second while another may last for five seconds so please pay close attention."

"Now, if you are right handed place your right hand on the right hand rest and find a box with two buttons. If you are left handed place your left hand on the left hand rest to find this box. Listen carefully and note the length of the tone and when it is finished press any one of the two buttons for what you think is the same length of time as the presented tone. You will be rotating at some point during this task but please don't attend to the movement."

"Before we begin please look straight ahead and follow the flashing lights with both your eyes. When both lights remain out, keep your eyes open and pointed forward. Do not close your eyes until you are told you may. Also, try not to blink. As always, keep your head tilted 30° forward."

"Place your left hand on the toggle switch located just in front of the foam on the left hand rest. Move the switch to the left. Follow the lights with your eyes. (Pause) Now turn the lights off by moving the switch to the right. Neither light should be on.

"Let's begin."

[Task]

(1) 1 second	(5) 5 seconds	(9) 2 seconds
(2) 5 seconds	(6) 4 seconds	(10) 1 second
(3) 2 seconds	(7) 4 seconds	(11) 1 second
(4) 3 seconds	(8) 3 seconds	(12) 5 seconds

(Twelve presentations of a tone of 510 Hz at 86 dB taking five seconds each with a five second period for the subject to respond in.)

"OK, you can stop now. Again we both must wait five minutes until the next trial--so just relax, close your eyes if you want to, and I will tell you when the time is up."

[Reverie--R]

"In this task I want you to sit quietly, completely relaxed with your eyes open. Daydream but do not deliberately pursue any line of thought. Do not think of anything of real concern to you. Let thoughts flow freely into and out of your mind without any effort on your part. Remain as physically relaxed as you can, but keep your eyes open.

You will be rotated at some point during this task but please don't attend to the movement."

"Before we begin please look straight ahead and follow the flashing lights with both eyes. When both lights remain out keep your eyes open and pointed forward. Do not close your eyes until you are told you may. Also, try not to blink. As always keep your head tilted 30° forward."

"Place your left hand on the toggle switch located just in front of the foam on the left hand rest. Move the switch to the left. Follow the lights with your eyes. (Pause) Now turn the lights off by moving the switch to the right. Neither light should be on."

"Let's begin."

[Task]

"OK, you can stop now. Again we both must wait five minutes until the next trial--so just relax, close your eyes if you want to, and I will tell you when the time is up."

[Closing Remarks]

"This experiment is over. Thank you for your cooperation. Please remain seated and I will be with you in a minute to unhook you."

<u>Note</u>: All tones were sinusoidal waves, with a 6% distortion, generated on a non commercial tone oscillator.

APPENDIX 2

DESCRIPTION OF ELECTRONIC EQUIPMENT

APPENDIX 2a

SILICON CONTROLLED RECTIFIER

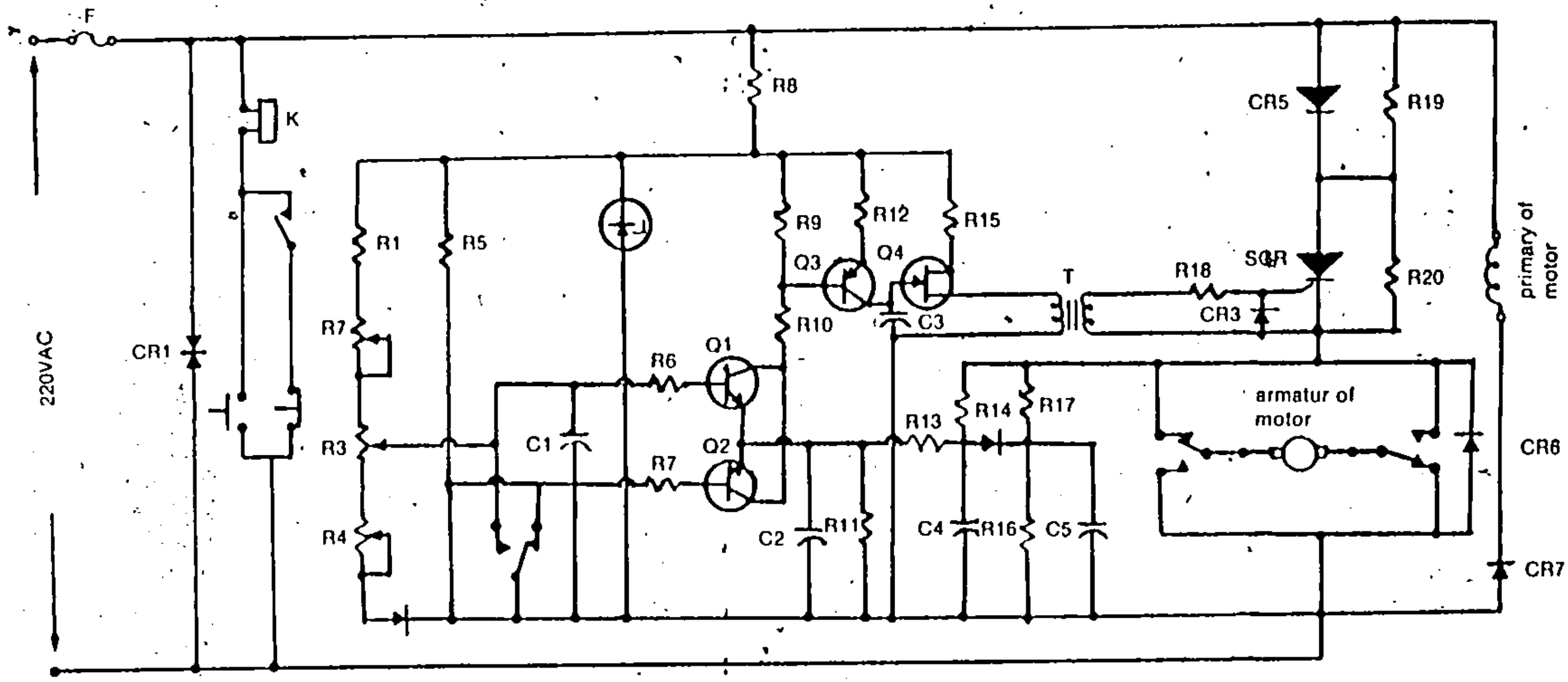
The silicon controlled rectifier (SCR) is a Century Model 76 adjustable speed drive (refer to attached schematic) that converts single phase 220 AC voltage to half wave adjustable DC voltage. The voltage is applied to the drive motor armature to obtain adjustable speed. The voltage is phase controlled to adjust the average output voltage according to the speed setting on the speed adjust potentiometer, and to correct errors and changes detected in the system. The drive functions of the motor are controlled by forward-reverse pushbuttons and a single turn speed potentiometer.

With a constant field voltage, the DC motor output speed is in direct proportion to the applied armature voltage, with rated armature voltage producing rated motor base speed. Under these conditions the motor output torque remains constant and the horsepower capability varies directly with motor speed.

The motor speed is sensed by comparing motor armature voltage against the portion of the regulated reference voltage at the speed set potentiometer. Any error between the two voltages is signalled to the error sensing amplifier. The amplifier output in turn is signalled to the unijunction transistor firing circuit which adjusts the firing angle of the SCR to eliminate the error.

The SCR is much like an ordinary silicon diode that allows current to pass in one direction only when a sine wave AC voltage is applied at its terminals. It differs from an ordinary diode rectifier in that it has an additional component known as a gate that allows the rectifier to block current in the forward as well as in the reverse direction until a current signal is applied to the gate. The SCR does not conduct until an error gate signal is given to the triggering circuit from the error sensing amplifier. When the signal is applied, the AC wave acts essentially as a short circuit with a constant voltage drop for the remainder of the half cycle and the conducted current is limited only by the impedance of the load.

The point in the cycle at which the SCR is triggered determines the voltage applied to the motor armature. If the firing angle is at or near zero degrees, rated voltage is applied to the armature and the motor operates at rated speed. The average DC voltage output decreases as a triggering angle of 180 degrees is approached. The average DC voltage output is zero when the triggering angle is at 180 degrees.



R1 = 68K Ω	R9, R10 = 6.8K Ω	R16, R17 = 4.5K Ω	C3 = .22 µf	K = 4 PDT	CR1 = KSA11DBE
R2, R3, R4 = 30K Ω	R11 = 680 Ω	R18 = 27 Ω	C4, C5 = 4 µf	F = 10 amp	CR2, CR3 = 1N2069
R5 = 100K Ω	R12 = 470 Ω	R19, R20 = 47 Ω	Q1, Q2 = 2N697	T = 1:1	CR4 = 1N2071
R6, R7 = 4.7K Ω	R13, R14 = 27K Ω	C1 = 68 µf	Q3 = 2N3905	motor = 1/2 HP variable control	CR5 = 12F40
R8 = 10K Ω	R15 = 270 Ω	C2 = 680 µf	Q4 = 2N1671A	SCR = 10RC50	CR6 = 16F80
					CR7 = 1NEVE4

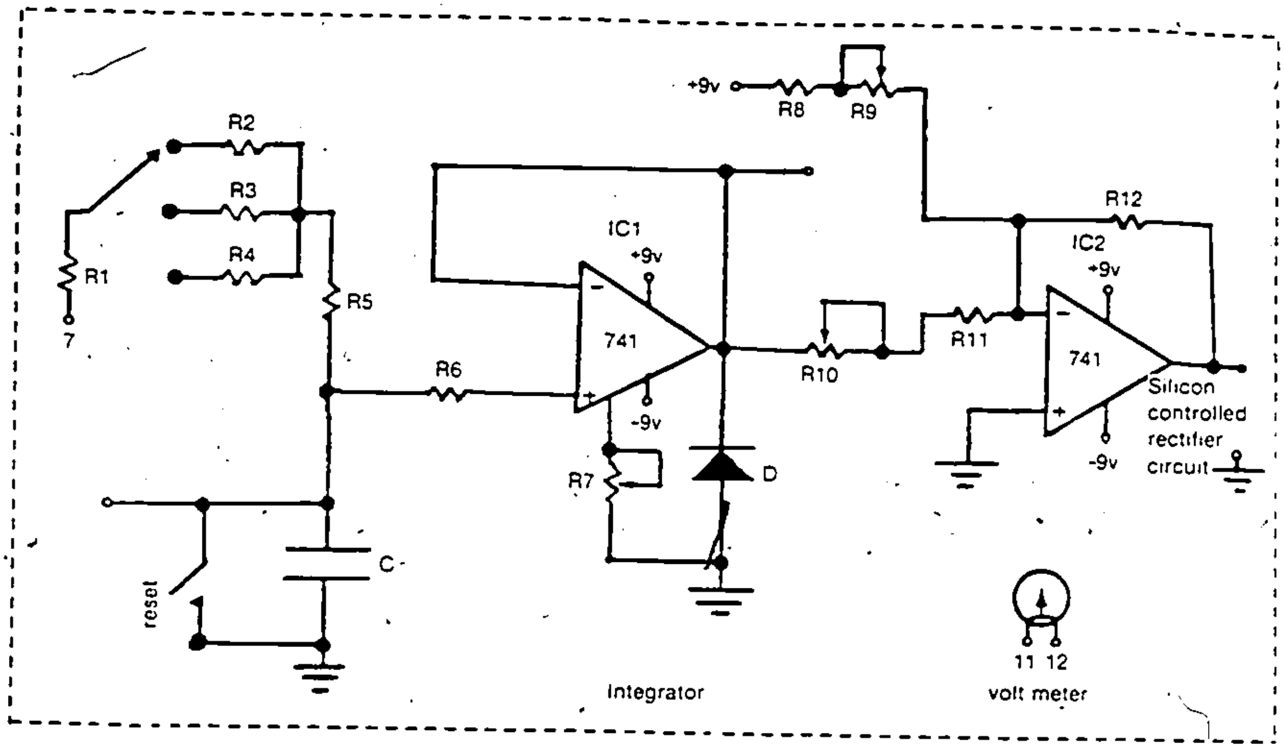
Figure of Schematic of silicon controlled rectifier attached to variable motor and controlled by an integrator circuit.

APPENDIX 2b

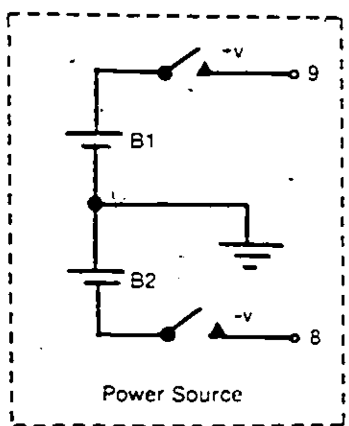
THE INTEGRATOR

The integrator (refer to the attached schematic) is a noncommercial, electronic apparatus designed at the School of Psychology of the University of Ottawa to replace the speed-set potentiometer which is found in series with R2 and R4 in the silicon controlled rectifier (SCR) schematic. The charging and discharging of the capacitor (labeled "C" in the figure) generates the linear positive and negative ramp voltage which is supplied to the SCR through the two 741 preamplifiers. A Lafayette Instrument four bank timer (Model 52010) controls the length of the ramp. Resistors R2, R3 and R4 govern the ramp velocity (refer to the figure). A variation of time and charging/discharging rate results in variations in acceleration and constant velocity.

The length of constant velocity could not be held indefinitely due to the capacitor's leakage. However, this is not manifested at the motor until at least seventy seconds; even then, the voltage drop is insignificant.



R1 = 1502K Ω
R2 = 18.2 Meg Ω
R3 = 11.8 Meg Ω
R4 = 9.2 Meg Ω
R5 = 10 Meg Ω
R6 = 10K Ω
R7, R8, R10, R11 = 1K Ω
R9 = 100 Ω
R12 = 5K Ω
C = 12 μf
D = IN4001
B1 & B2 = 9v
IC1 & IC2 = 741C Op-Amp



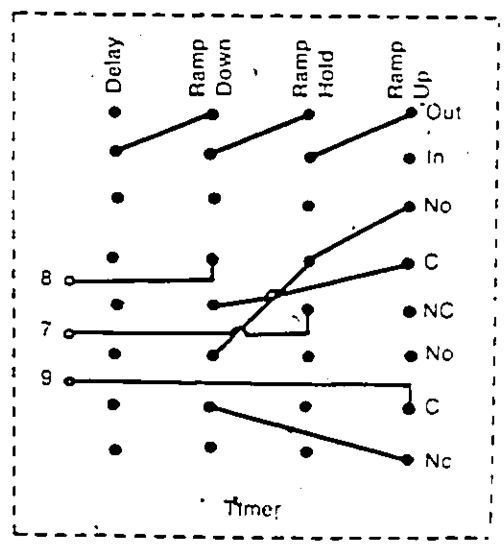


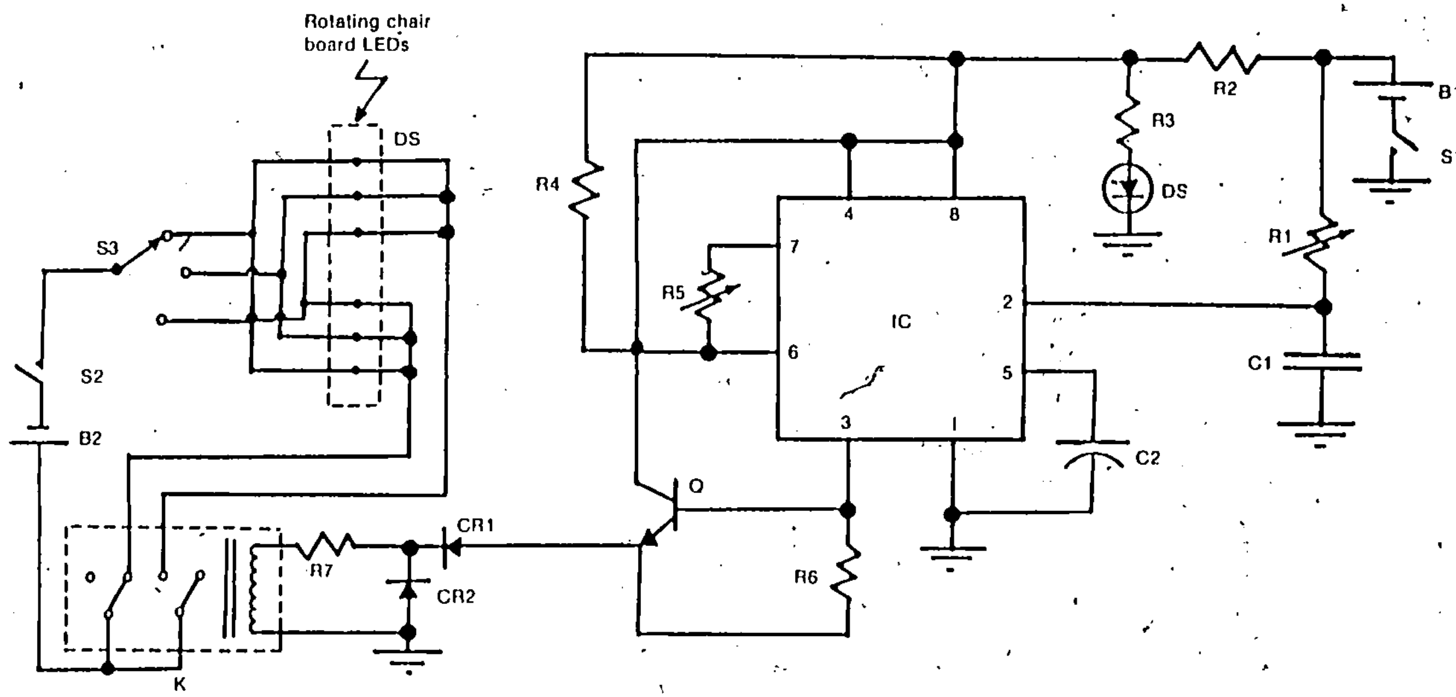
Figure of Schematic of Integrator controlling the silicon controlled rectifier.

APPENDIX 2c

THE EYE CALIBRATION UNIT

The calibration unit is a concommercial, electronic apparatus designed at the School of Psychology of the University of Ottawa. The double-pole, double-throw (DPDT) relay activates one of three pairs of light-emitting diodes (LED) [found on the front table of the rotating chair]. The pair to be activated is selected by a switch (S3 on the attached schematic).

The relay is digitally controlled by the input of a 555 IC timer. During the time the timer's output goes high, the DPDT relay is activated and the selected LED illuminates. When the timer's output goes low, the relay deactivates resulting in the deactivation of the illuminated LED and in the illumination of its paried LED. The timer's duration is adjusted by a variable resistor (RS in the figure).



B1 = 18V DC	DS = Red LEDs	R2 = 100k Ω	R7 = 300k Ω
B2 = 12V D C	IC = type 555 IC	R3 = 300 Ω	S1, S2 = SPST
C1 = 100 mfd, 16v	K = DPDT, 12V D C	R4 = 300k Ω	S3 = 3 position, rotary switch
C2 = 0.1 mfd PC type	Q = RS2030 NPN	R5 = 333 k Ω	
CR, CR2 = 1 amp, 50PIV microminature Diode	R1 = 6.8 k Ω	R6 = 1K Ω	

*all resistors 1/2 watt

Figure of Schematic of alternating timed switch used to calibrate subjects' eye movements.

APPENDIX 3

SAMPLE NYSTAGMIC OUTPUT

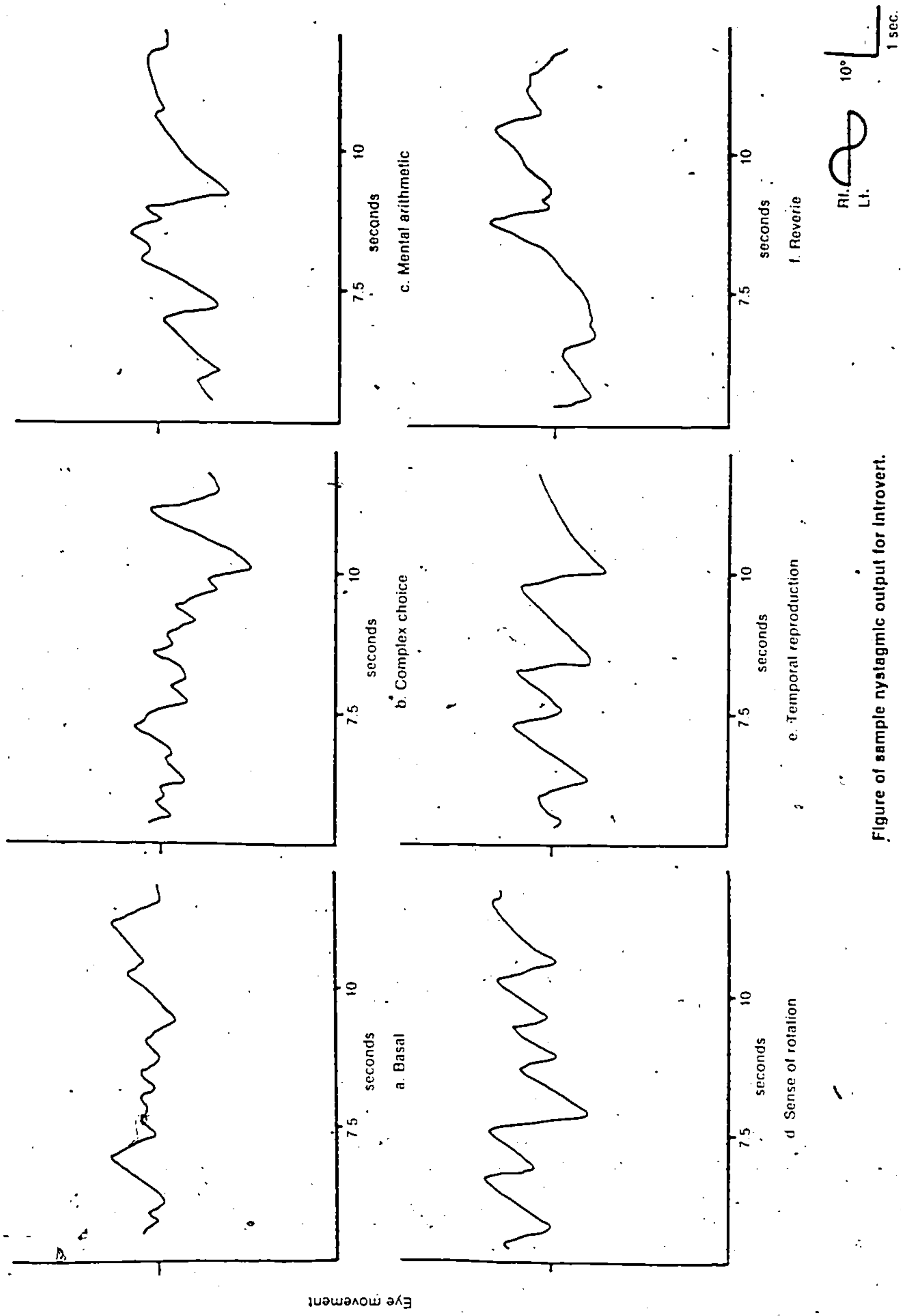


Figure of sample nystagmic output for Introvert.

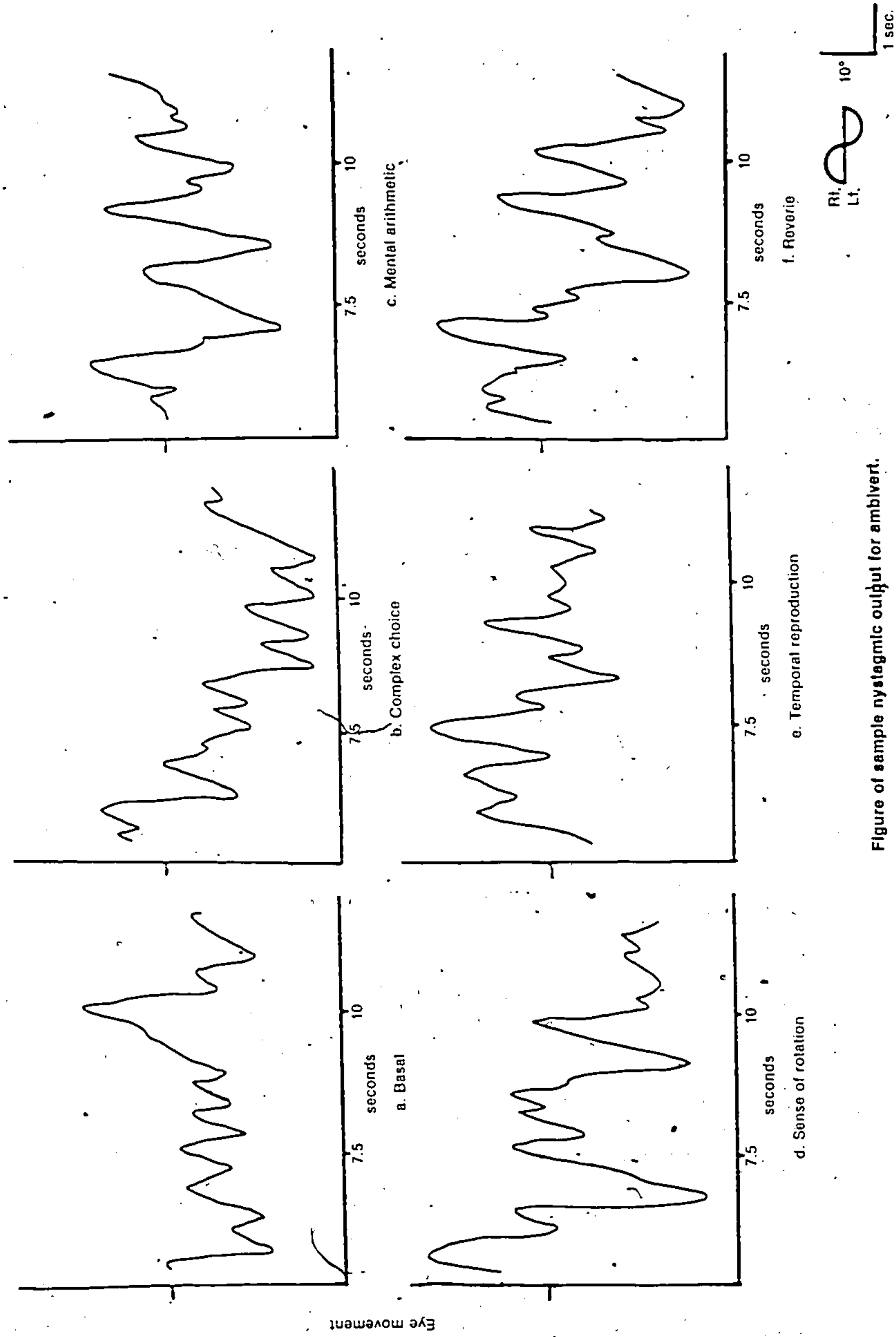


Figure of sample nystagmic output for ambivert.

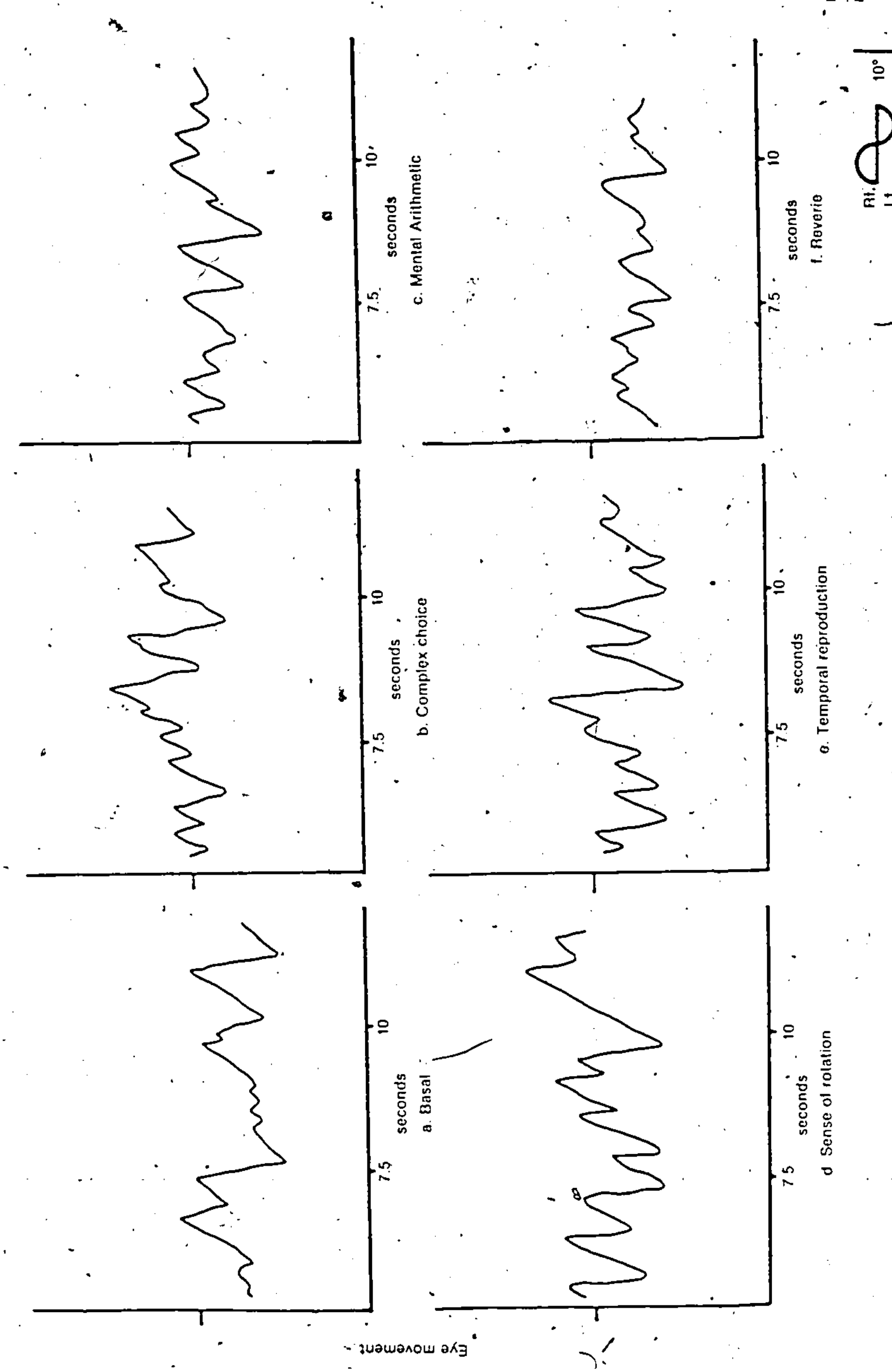


Figure of sample nystagmic output for extravert.

APPENDIX 4

TABULATED DATA OF THE STUDY

Mean Raw Score Nystagmus

Groups[a]	Acceleration 1.3	3.8	6.3	Constant Velocity 1.3	3.8	6.3	8.8	11.3	13.8	16.3	18.8	21.3	23.8	26.3
Introvert = I														
PS	3.4	11.9	18.0	16.6	15.1	13.4	11.6	10.4	9.6	8.5	7.4	6.2	5.3	3.6
B	2.2	9.8	15.2	14.7	13.0	11.7	10.3	9.3	8.0	6.9	5.3	4.2	3.1	2.3
CC	3.6	12.1	17.0	15.4	13.9	12.6	11.2	10.1	8.9	8.0	7.0	5.6	4.4	3.2
MA	3.4	12.6	19.3	17.7	14.7	13.2	11.3	9.7	8.7	7.5	6.2	5.0	3.7	2.8
SR	3.5	12.2	18.4	18.0	16.4	14.5	13.2	12.0	10.6	9.1	8.0	7.0	6.2	4.6
TR	2.8	12.0	17.6	16.7	14.4	12.9	11.6	10.3	8.9	7.1	6.1	4.9	3.6	2.2
R	2.0	9.3	14.2	13.3	11.6	10.3	9.3	7.8	6.4	5.7	4.6	3.4	2.7	2.0
Ambivert = A														
PS	3.4	11.9	17.8	16.6	15.2	13.9	12.8	11.3	9.8	9.4	7.8	6.9	5.7	4.6
B	3.1	10.8	16.5	15.7	13.8	12.1	10.6	9.6	8.4	7.3	6.3	5.4	4.4	3.4
CC	3.4	13.0	19.3	18.1	15.8	13.9	12.2	10.9	9.8	8.4	7.0	5.9	4.6	3.4
MA	3.1	11.8	17.9	17.9	17.0	15.3	13.7	12.8	11.5	10.1	8.7	6.6	5.4	3.9
SR	3.3	12.4	18.7	18.5	16.4	14.7	13.3	12.5	11.4	10.7	8.7	7.9	6.8	5.4
TR	3.1	11.5	16.6	15.9	14.5	13.1	11.6	10.2	9.1	8.1	6.8	5.7	4.4	3.4
R	2.2	9.5	14.5	14.0	12.2	10.6	9.0	7.7	6.6	5.5	4.5	3.6	2.8	2.1
Extravert = E.														
PS	3.2	12.4	19.3	19.3	17.3	15.8	14.3	12.9	11.5	10.1	8.9	7.7	6.6	5.0
B	2.7	11.0	16.5	16.0	14.3	13.0	11.4	10.1	8.8	7.9	6.6	5.2	3.8	2.8
CC	4.3	14.0	22.0	20.4	17.5	15.6	14.2	12.1	11.1	8.9	7.3	5.8	4.3	3.2
MA	3.3	12.8	18.7	17.1	15.7	13.8	12.7	11.2	9.8	8.3	7.3	6.6	5.2	4.1
SR	3.6	12.9	19.0	19.0	17.4	15.9	14.4	12.9	11.7	10.2	9.0	8.2	6.5	4.7
TR	2.8	11.4	17.5	15.7	14.6	13.2	11.9	10.4	9.3	8.0	6.6	5.2	4.2	3.4
R	2.2	9.4	14.0	13.3	11.8	10.5	9.1	7.8	6.7	5.5	4.4	3.2	2.6	1.8
I-A-E														
PS	3.3	12.1	18.4	17.5	15.9	14.3	12.9	11.5	10.3	9.3	8.0	6.9	5.9	4.4
B	2.7	10.5	16.1	15.5	13.7	12.2	10.8	9.7	8.4	7.4	6.1	4.9	3.8	2.8
CC	3.8	13.0	19.4	18.0	15.7	14.1	12.5	11.0	9.9	8.5	7.1	5.8	4.4	3.3
MA	3.3	12.4	18.7	17.3	15.2	13.6	12.3	10.8	9.5	8.2	7.1	6.0	4.8	3.6
SR	3.5	12.5	18.7	18.5	16.7	15.1	13.6	12.4	11.2	10.0	8.6	7.7	6.5	4.9
TR	2.9	11.6	17.2	16.1	14.5	13.1	11.7	10.3	9.1	7.8	6.5	5.3	4.1	3.0
R	2.1	9.4	14.2	13.5	11.9	10.5	9.2	7.8	6.6	5.6	4.5	3.4	2.7	1.9

Note. All scores are in ^{o}/sec.

[a]Abbreviations: PS=practice session; B=basal; CC=complex choice; MA=mental arithmetic; SR=sense of rotation; TR=temporal reproduction; and R=reverie.

[b]Average times taken in fourteen 2.5 second blocks in recording from the onset of rotational stimulation.

Time[b] (in seconds)

Standard Deviation of Raw Score Nystagmus

Groups[a]	Acceleration			Time[b] (in seconds) Constant Velocity										
	1.3	3.8	6.3	1.3	3.8	6.3	8.8	11.3	13.8	16.3	18.8	21.3	23.8	26.3
Introvert = I														
PS	2.91	4.13	6.39	5.86	5.67	4.98	4.30	4.03	3.86	4.10	4.11	4.29	3.86	3.39
B	1.46	3.82	4.67	4.36	4.29	4.15	4.16	3.76	3.24	3.80	3.70	3.21	3.32	2.82
CC	2.10	4.56	5.08	4.05	4.23	3.79	3.69	3.93	3.98	4.14	4.27	3.58	3.15	3.12
MA	3.24	5.04	5.81	6.21	5.21	5.08	5.15	5.00	4.78	4.92	4.78	4.65	3.86	3.68
SR	2.32	4.38	5.88	6.00	6.08	5.66	5.45	5.23	4.93	4.99	4.76	4.49	4.22	3.69
TR	1.70	3.82	4.73	5.12	4.98	4.22	[illegible]	4.41	4.01	4.30	3.85	3.66	2.95	2.08
R	1.58	3.92	4.49	4.04	3.82	3.73	4.04	3.75	3.41	3.79	3.63	3.33	2.94	2.55
Ambivert = A														
PS	2.00	3.81	5.89	5.20	4.94	4.63	4.53	5.29	4.82	5.01	4.52	4.45	4.04	3.87
B	1.45	3.72	5.49	4.94	4.83	4.82	4.76	4.72	4.27	4.00	3.79	4.12	3.52	2.99
CC	1.65	3.95	5.50	5.75	5.22	4.65	4.89	5.28	4.75	4.74	4.86	4.60	3.83	3.34
MA	1.32	4.18	5.09	4.86	4.82	5.42	5.32	5.00	4.92	4.94	4.89	4.47	4.34	3.50
SR	1.67	4.77	6.71	6.84	6.14	5.91	5.78	5.85	5.43	5.32	4.56	4.82	4.75	4.43
TR	1.54	4.11	5.59	6.15	5.56	5.57	5.69	5.12	5.20	5.17	4.96	4.70	3.94	3.51
R	1.60	4.38	6.16	5.80	5.77	5.73	5.35	4.75	4.93	4.63	4.68	4.06	3.66	3.38
Extravert = E														
PS	2.11	5.09	6.69	6.97	6.64	6.70	6.06	5.83	5.42	5.05	4.83	4.74	4.49	4.07
B	1.45	4.82	5.80	5.46	5.23	4.98	4.63	4.48	4.28	4.47	4.24	3.66	3.41	2.71
CC	4.23	5.21	6.32	5.78	4.92	5.18	5.53	4.94	4.89	3.81	4.01	3.65	3.44	2.89
MA	1.72	4.76	5.65	5.11	5.04	4.69	4.83	4.48	4.19	3.94	3.85	3.92	3.90	3.42
SR	1.90	4.32	5.96	6.64	5.80	5.30	5.19	5.15	5.08	4.65	4.52	4.85	4.22	3.78
TR	1.49	3.79	6.00	5.74	5.10	4.71	4.32	4.68	4.41	4.24	3.93	4.11	3.69	2.98
R	1.45	3.52	4.56	4.44	4.09	3.97	4.03	4.39	3.91	3.90	3.77	3.06	2.94	2.49
I-A-E														
PS	2.36	4.35	6.31	6.14	5.84	5.56	5.11	5.16	4.78	4.75	4.51	4.50	4.14	3.80
B	1.48	4.15	5.34	4.93	4.79	4.65	4.51	4.31	3.94	4.09	3.92	3.69	3.43	2.85
CC	2.89	4.63	5.98	5.61	5.00	4.70	4.89	4.79	4.61	4.22	4.36	3.94	3.46	3.10
MA	2.23	4.66	5.51	5.39	5.01	5.04	5.11	4.86	4.64	4.61	4.54	4.39	4.08	3.54
SR	1.97	4.46	6.15	6.46	5.98	5.62	5.46	5.39	5.13	5.00	4.59	4.71	4.38	3.97
TR	1.57	3.89	5.43	5.66	5.18	4.82	4.71	4.71	4.53	4.57	4.25	4.16	3.54	2.95
R	1.53	3.92	5.09	4.79	4.61	4.53	4.48	4.28	4.10	4.09	4.02	3.49	3.17	2.81

Note. All scores are in ^{o}/sec.
[a]Abbreviations: PS=practice session; B=basal; CC=complex choice; MA=mental arithmetic; SR=sense of rotation; TR=temporal reproduction; and R=reverie.
[b]Average times taken in fourteen 2.5 second blocks in recording from the onset of rotational stimulation.

Mean Difference Score Nystagmus

Groups[a]	Acceleration			Time[b] (in seconds) Constant Velocity										
	1.3	3.8	6.3	1.3	3.8	6.3	8.8	11.3	13.8	16.3	18.8	21.3	23.8	26.3
Introvert = I														
PS	-12.6	-4.0	2.2	0.6	-0.8	-2.5	-4.3	-5.5	-6.3	-7.5	-8.5	-9.7	-10.5	-12.3
CC	-12.4	-3.8	1.0	-0.5	-2.1	-3.3	-4.7	-5.7	-7.0	-7.9	-8.9	-10.3	-11.5	-12.8
MA	-12.5	-3.3	3.7	1.8	-1.4	-2.8	-4.6	-6.2	-7.2	-8.4	-9.7	-11.0	-12.2	-13.1
SR	-12.4	-3.7	2.5	2.1	0.5	-1.4	-2.7	-3.9	-5.3	-6.8	-8.0	-9.0	-9.8	-11.3
TR	-13.1	-3.9	1.7	0.8	-1.5	-3.0	-4.3	-5.7	-7.0	-8.8	-9.8	-11.0	-12.3	-13.6
R	-13.9	-6.6	-1.7	-2.6	-4.3	-5.7	-6.6	-7.8	-9.5	-10.2	-11.3	-12.3	-13.1	-13.9
Ambivert = A														
PS	-14.1	-5.9	0.2	-1.1	-2.3	-3.5	-4.7	-6.2	-7.2	-8.2	-9.6	-10.6	-11.9	-12.9
CC	-14.1	-4.5	1.8	0.5	-1.7	-3.6	-5.3	-6.6	-7.4	-9.1	-10.6	-11.6	-12.9	-14.1
MA	-14.4	-5.7	0.4	-0.5	-2.2	-3.8	-4.7	-6.0	-7.4	-8.8	-9.8	-10.9	-12.1	-13.6
SR	-14.2	-5.2	0.7	1.0	-1.1	-2.8	-4.3	-5.1	-6.2	-6.9	-8.8	-9.6	-10.7	-12.1
TR	-14.4	-5.7	-0.9	-1.6	-3.1	-4.4	-5.9	-7.3	-8.4	-9.4	-10.8	-11.8	-13.0	-14.1
R	-15.3	-8.0	-3.0	-3.5	-5.3	-6.9	-8.5	-9.8	-10.9	-12.0	-13.0	-13.9	-14.7	-15.4
Extravert = E														
PS	-14.2	-5.0	1.9	2.0	-0.0	-1.6	-3.1	-4.5	-5.9	-7.2	-8.5	-9.7	-10.7	-12.4
CC	-13.0	-3.4	4.6	3.1	0.2	-1.8	-3.2	-5.3	-6.3	-8.5	-10.0	-11.2	-13.1	-14.1
MA	-14.1	-4.8	1.4	-0.2	-1.7	-3.6	-4.6	-6.1	-7.6	-9.0	-10.1	-10.8	-12.2	-13.3
SR	-13.8	-4.5	1.6	1.7	-0.0	-1.5	-3.0	-4.5	-5.7	-7.1	-8.4	-9.2	-10.9	-12.6
TR	-14.4	-6.2	0.1	-1.7	-2.8	-4.2	-5.4	-6.9	-8.1	-9.4	-10.8	-12.1	-13.1	-14.0
R	-15.2	-8.0	-3.4	-4.1	-5.6	-6.9	-8.2	-9.5	-10.7	-11.8	-12.6	-14.2	-14.7	-15.6
I-A-E														
PS	-13.6	-5.0	1.4	0.5	-1.0	-2.5	-4.0	-5.4	-6.5	-7.6	-8.9	-10.0	-11.0	-12.5
CC	-13.2	-3.9	2.5	1.0	-1.2	-2.9	-4.4	-5.9	-6.9	-8.5	-9.8	-11.0	-12.5	-13.7
MA	-13.7	-4.6	1.8	0.4	-1.8	-3.4	-4.6	-6.1	-7.4	-8.7	-9.9	-10.9	-12.2	-13.3
SR	-13.5	-4.5	1.6	1.6	-0.2	-1.9	-3.3	-4.5	-5.7	-6.9	-8.4	-9.2	-10.5	-12.0
TR	-14.0	-5.3	0.3	-0.8	-2.4	-3.8	-5.2	-6.6	-7.8	-9.2	-10.5	-11.7	-12.8	-13.9
R	-14.8	-7.5	-2.7	-3.4	-5.1	-6.5	-7.8	-9.1	-10.4	-11.4	-12.3	-13.5	-14.2	-15.0

Note. All scores are in °/sec.

[a] Abbreviations: PS=practice session; CC=complex choice; MA=mental arithmetic; SR=sense of rotation; TR=temporal reproduction; and R=reverie.

[b] Average times taken in fourteen 2.5 second blocks in recording from the onset of rotational stimulation.

Standard Deviation of Difference Score Nystagmus

Groups[a]	Time[b] (in seconds) Acceleration 1.3	3.8	6.3	Constant Velocity 1.3	3.8	6.3	8.8	11.3	13.8	16.3	18.8	21.3	23.8	26.3
Introvert = I														
PS	4.56	4.05	5.67	4.70	5.12	4.84	4.50	4.50	4.73	5.14	5.17	5.09	5.09	4.68
CC	4.24	4.18	4.01	3.50	3.63	3.77	3.80	3.81	3.54	3.76	4.31	3.98	3.97	3.89
MA	3.78	4.97	5.53	4.93	4.64	4.92	5.10	4.87	4.66	5.08	5.05	5.09	4.50	4.63
SR	3.86	3.78	4.53	4.66	4.51	4.46	4.27	4.32	4.28	4.61	4.26	4.38	4.52	4.22
TR	4.63	4.73	5.40	5.42	5.04	5.02	4.93	5.22	4.86	5.20	5.06	5.28	5.04	4.73
R	4.43	5.31	4.90	4.76	4.95	5.14	5.18	4.90	4.48	5.11	5.12	4.71	4.80	4.7[illegible]
Ambivert = A														
PS	5.23	4.67	5.43	4.28	4.73	4.84	5.04	5.32	5.55	5.09	5.35	5.13	5.27	5.33
CC	5.35	5.24	5.83	5.11	5.18	5.38	5.00	5.17	5.63	5.35	5.64	5.64	5.23	4.90
MA	5.11	4.02	3.92	4.00	3.97	4.28	4.41	3.99	3.98	4.58	4.61	4.56	4.92	4.65
SR	5.45	5.97	6.99	6.62	6.13	5.69	5.62	5.65	5.65	5.17	4.84	4.95	4.91	5.12
TR	5.26	5.48	4.83	6.32	6.03	6.15	6.67	6.21	5.92	5.97	5.81	5.29	5.00	4.72
R	4.97	4.68	5.40	5.13	5.14	5.02	4.68	4.53	5.01	4.93	5.34	5.47	5.47	5.42
Extravert = E														
PS	5.40	4.18	5.34	4.53	4.60	4.99	4.53	5.08	4.71	5.00	4.60	4.59	4.68	4.97
CC	6.12	5.04	4.77	5.13	5.30	5.09	5.13	5.17	5.62	5.09	5.55	5.83	5.21	5.18
MA	4.86	4.52	4.43	4.44	4.52	4.14	4.07	4.25	4.44	4.30	4.61	4.19	5.17	4.29
SR	4.69	3.80	3.87	5.65	5.39	5.07	5.51	4.93	5.34	5.21	5.23	5.28	5.17	4.95
TR	5.15	3.99	4.83	4.35	4.16	4.29	4.64	4.81	4.51	4.72	4.72	4.75	4.63	4.96
R	5.54	4.97	4.86	4.79	4.56	4.63	4.81	4.88	5.08	5.52	6.09	5.44	5.47	5.64
I-A-E														
PS	5.09	4.34	5.51	4.66	4.87	4.91	4.71	4.99	5.00	5.05	5.04	4.91	5.01	4.97
CC	5.30	4.83	5.13	4.85	4.82	4.83	4.73	4.75	5.01	4.77	5.21	5.20	4.85	4.69
MA	4.65	4.59	4.84	4.55	4.36	4.45	4.51	4.35	4.33	4.63	4.73	4.82	4.83	4.70
SR	4.74	4.63	5.31	5.67	5.37	5.10	5.17	4.97	5.09	4.96	4.76	4.85	4.86	4.77
TR	5.02	4.83	5.43	5.50	5.14	5.20	5.48	5.44	5.12	5.29	5.19	5.09	4.87	4.77
R	5.00	4.99	5.07	4.89	4.88	4.93	4.93	4.81	5.02	5.21	5.53	5.24	5.27	5.29

Note. All scores are in^{o}/sec.
[a]Abbreviations: PS=practice session; CC=complex choice; MA=mental arithmetic; SR=sense of rotation; TR=temporal reproduction; and R=reverie.
[b]Average times taken in fourteen 2.5 second blocks in recording from the onset of rotational stimulation.