RESULTANT AROUSAL LEVEL AFFECTED BY PERSONALITY VARIABLES OF EXTRAVERSION-INTROVERSION WITH MENTAL SET

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CURRICULUM STUDIORUM

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CHAPTER I

REVIEW OF THE LITERATURE

A. Introductory Statement

Perception of most phenomena is not only composed of incoming stimuli but also of the disposition of the perceiver. Therefore, a gross change in conditions varies the overall recorded output from subjects in the same direction, at a varying rate between subjects. This intra-individual variance is usually overlooked in the evaluation of physiological data.

Inter-subject variations of vestibular nystagmus due to the effects of physiological conditions of the body are well documented throughout the literature. Manipulation of such variables as sleep deprivation, emotional states, mental set, and drug ingestion all show a marked ability to alter the nystagmic reaction. The main variable throughout these conditions is arousal level. Arousal is a highly significant variable in eliciting nystagmic response (Griffith, 1920; Mowrer, 1934; Wendt, 1951; Collins, 1962, 1963; Collins, Crampton & Posner, 1961; Collins & Poe, 1962; Jun-Ichi, 1970). Under many conditions eye movements (Kestenbaum, 1957) give a better indication of a subject's state of alertness than do encephalographic patterns (Collins, 1962;

Pendleton & Paine, 1961). Foremost in the consideration of nystagmus is that it can be used as a tool in the study of mental arousal without confounding the resultsby motor and sensory arousal as was done in many past studies (Freeman & Hovland, 1934).

Intra-subject variations of vestibular nystagmus, with one exception (Dunstone, et al., 1964), are never considered in the evaluation of data. However, certain inconsistencies are noted by Collins (1962) and Brown and Crampton (1964) in their nystagmic recordings. Collins found a greater inter- and intra-subject variation of nystagmic responsefor tasks of a lower mental arousal than of a higher arousal; Brown and Crampton also deal with this variation but do not state which mental sets produce greater differences. For many other studies a larger variance of scores for differing mental sets are reported without further comment. Using mental set as one independent variable, Collins found that a number of subjects, while in the state of reverie, showed the expected large decline in nystagmic response even to the point of appearing completely absent. For some subjects, however, the decline between mental arousal and reverie was negligible. Collins suggested that subjective interpretation of relaxing and day dreaming would differ for each subject and confound actual arousal levels. An equally plausable explanation would be that individual physiological composites react differentially to environmental stimulation.

Eysenck's neurophysical basis of personality differences is found to be an excellent model from which to explain individual differences in nystagmic response. The interlocking variable for both positions of nystagmus and personality is the level of arousal. In Eysenckian terms extraverts are cortically inhibited, while in introverts the excitatory process dominates. Introverts are tonically in an aroused cortical state because their reticular formations have a lower threshold than those of the extraverts (Eysenck, 1967). If introverts are higher on excitation/arousal than extraverts, the two groups should react differently to changes in conditions. Studies by Bakan (1963), Hogan (1966), and Colquhoun and Corcoran (1964) have shown that introverts perform significantly better than extraverts in tasks of vigilance over extended periods of time. Colquhoun and Corcoran (1964) proposed an inverted-U relationship between performance and arousal. Since introverts are more cortically excited than extraverts, under conditions of low arousal states introverts should perform better. Under high arousal states, however, the extravert's deficit in excitation is negated and there should be no significant differences in performance between subjects.

Within this context, the present research is designed to consider the following general area: do introverts and extraverts differentially react to vertibular stimulation across varying mental sets? What is hypothesized from the previous mentioned studies is that there is an interaction of the cortical excitation/inhibition of an organism with arousal level on the resultant nystagmic response.

(1) In organisms of high cortical excitation (cf. introverts) there is not a significant difference to resultant arousal levels (primary slow phase nystagmus) between mental sets of low arousal versus high arousal mental sets.

(2) In organisms of low cortical excitation (cf. extraverts) there is a significant interaction between mental sets.

A further consideration is the initial basal rate nystagmus of introverts and extraverts.

(3) Organisms of high cortical excitation are physiologically set to produce indications of a higher arousal level than organisms of low cortical excitation, providing that the organism is maintaining a resting state.

B. Nystagmic Response

Animals with eyes facing forward have developed an area in the retina (the fovea) which has a high density of photoreceptors. To achieve high visual acuity, the incoming visual image must move to maintain itself on each fovea. The oculomotor systems are those of: smooth pursuit, saccadic, vergence, and vestibular, and are especially well developed in primates to acquire a visual target and to track it so that its image remains on the fovea. To accomplish this, the systems must overcome the same problems encountered in tracking systems developed by man. For instance, when a tracking device is mounted on a moving platform, as a radar dome on a ship, a coordinating unit is required to stabilize the tracking device against movements of the platform. For the eye movements this function is carried out by the vestibular system. It measures the motion of the head in space and moves the eyes to compensate and maintain the visual axis stable in the environment. Retinal image movement caused by head movement below 30°/ second can be compensated for by the smooth pursuit system; however, head movements can exceed 300°/ second. The vestibular system can compensate for these large velocities, and its short path through the brain stem ensures an immediate reaction (Robinson, 1968).

To stabilize eye position, angular head velocity about any axis in space is resolved from three components (obtained from the three semicircular canals on each side of the head) and then applied in the correct combination to the three pairs of antagonist muscles of each eye to counterrotate them about the same axis. The outcome is the creation of a sawtooth pattern of eye movements, which is called nystagmus. Nystagmus is the rhythmic movement of the eyes, that consists of slow movement of the eyes in one direction, followed by a quick return movement in the opposite direction. The slow movement is called the slow phase of nystagmus, and the recovery movement in the opposite direction is the fast phase. Since it is the quick component that is so conspicuous, the nystagmus is named according to the direction of that movement. Therefore, nystagmus to the left would have its slow phase in the right direction and its fast phase in the left. By definition a right eye movement for the right eye would be in the direction of the nasal region to the temporal, and for the left eye of the temporal region to nasal; a left eye movement would be in the reverse direction.

C. Vestibular Anatomy

All physiological visual tracking systems depend on visual information through movement of the head, except the vestibular system, which obtains its information from the vestibule of the inner ear. Figure 1 shows the bony labyrinth of the internal ear, a series of intercommunicating spaces, which is situated within the temporal skull, and contains the membraneous or true labyrinth, a membraneous sac. The vestibule, the central chamber of the bony labyrinth, lies between the cochlea, a coiled tube, and the semicircular canals. The bony labyrinth is filled with a fluid of low specific gravity, the perilymph, in which the entire membranous labyrinth floats. Through a small tube, opening into the subarachnoid space, the perilymph is provided with a means of escape and communication with the rest of the cerebro-spinal fluid. The membraneous portion of the labyrinth within the vestibule consists of a closed membraneous sac, divided into the utricle and the saccule, and is filled with a gelatinous fluid (endolymph) of high specific gravity.

The three semicircular canals are placed at right angles to each other in three different planes (Figure 2). The superior canal lies in a plane halfway between the frontal and the sagittal, with the outermost portion placed anteriorly and continuing inward and backward. The posterior canal also lies in a plane halfway between the frontal and sagittal, however, the outermost portion is placed posteriorly and the plane continues forward and inward. The superior canal of the right ear and the posterior canal of the left ear are situated in parallel planes, and the superior canal of the left ear and the posterior canal of the right ear occupy parallel planes. The horizontal canal lies in a plane inclined 30° from the horizontal and continues anteriorly and posteriorly. When a person sits with his head inclined 30° forward, the horizontal canal is in a plane parallel to the

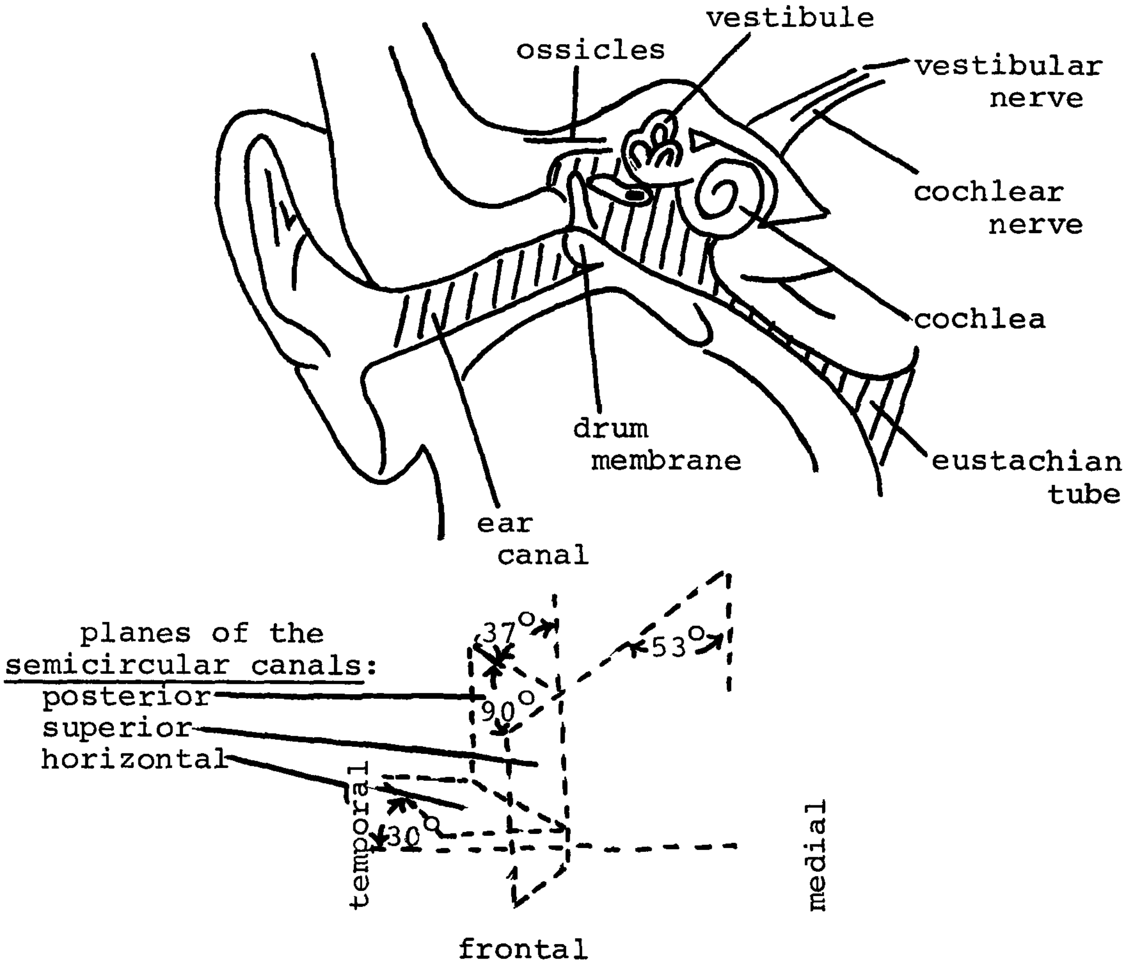

Figure 1. The anatomy of the human ear.

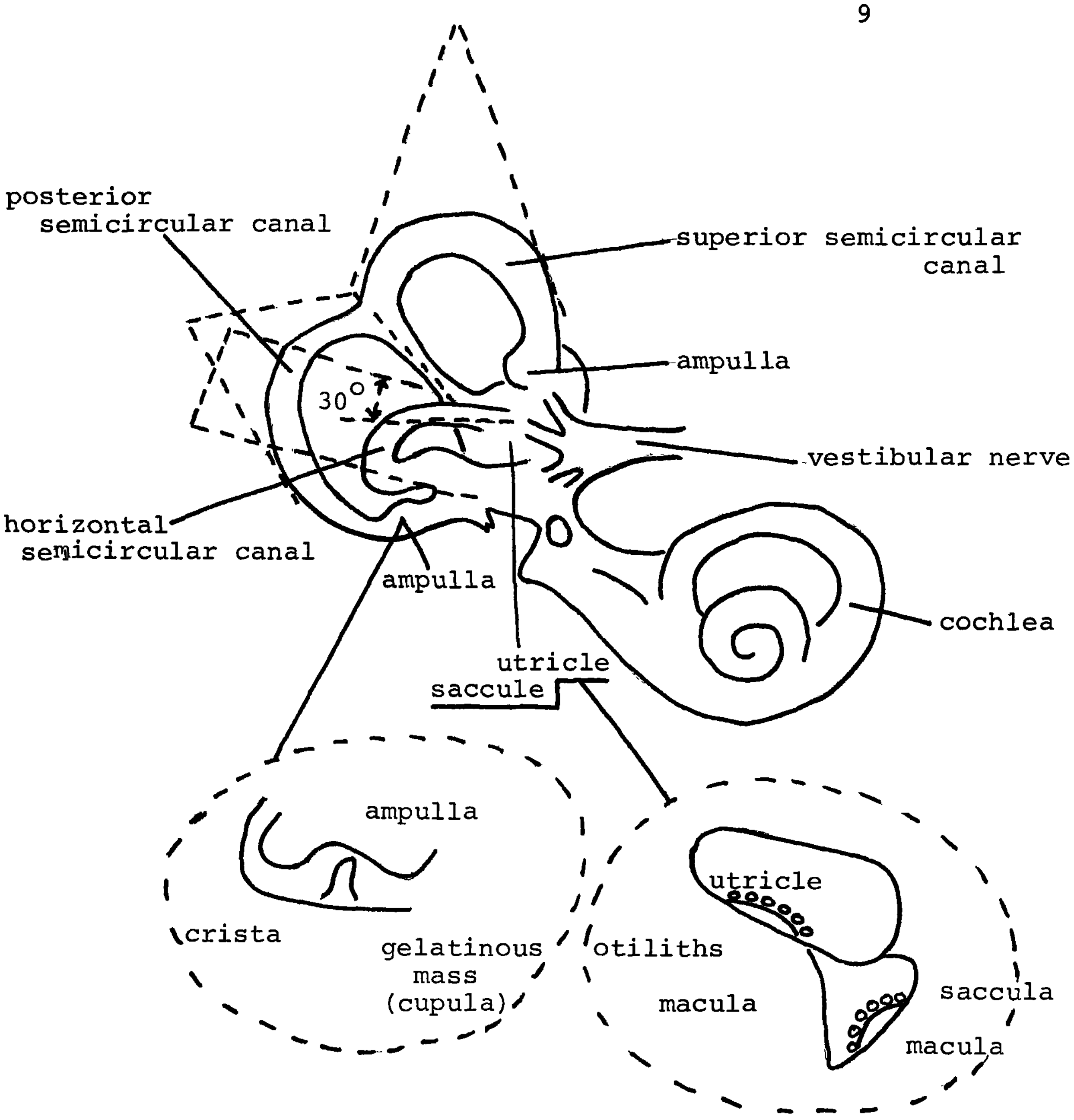

Figure 2. The anatomy of the vestibular of the right ear.

floor, and the superior and posterior canals are nearly at right angles with the floor. (It is important to remember that this position of the head is used in the rotational nystagmic test.) The semicircular canals connect with the bony vestibule and are filled with perilymph. Suspended within each semicircular canal is a membraneous duct that contains endolymph, and which communicates with the utricle. At the base each semicircular canal widens into a bulb-like enlargement, the ampulla.

The membraneous layrinth is the seat of the actual sense organs. The end-organ of the cochlea consists of a basilar membrane with special cells with hair-like extensions. These hair cells, called the Organ of Corti, extend throughout the cochlea. Basal structures, the maculae, are also contained in both the utricule and the saccule (Wersall, et al., 1967; Lowenstein, 1967). The macula of the saccule is an oval spot, extending across its floor in the frontal plane of the head. The macula of the utricle extends into the antero-posterior plane of the head, and, therefore, is at right angles to the saccule. A gelatineous membrane extends over these maculae, containing a number of tiny particles, the otiliths, formed by a calcium compound. The otiliths are heavier than the material in which they are immersed and rest on the hair-like endings of the maculae. When the body is a rest, the otiliths, by their pressure on the maculae

of the saccula and the utricle, give information as to the position of the body. If the body moves forward or backward in a linear direction the otiliths above the macula of the utricle lag behind; if the body moves sideways the otiliths above the macula of the saccule lag behind. Linear movement in a vertical direction is detected by both, the utrical and the saccule. Within each ampulla is a gate-like protuberance called the crista, that with its ciliated structures extends into a gelatinous material called the cupula. These ciliated structures serve as the sensory apparatus and are stimulated by movements of the endolymph. The flexible cupula projects into the ampullar cavity and is capable of bending like a swinging door. Angular acceleration of the head causes the endolymph to lag behind, and this inertia of the fluid deflects the gelatinous cupula. The nerve cells that are lying beneath sense its deflection, and alter their rate of discharge proportionately. The cristae's function is dependent upon the direction of the stimulation. Utriculopetal (towards the utriculous) deviation of the cupula in the horizontal ampulla evokes a stronger reaction than utriculofugal (away from the utriculous) deviation, whereas, in the vertical ampullae (superior and posterior canals) the utriculofugal deviation evokes a stronger stimulation.
Single unit recordings of the electrical activity in the afferent ampullary nerve show that utriculopetal dislocation of

the hair bundle of the horizontal canal increases the impulse frequency from a preexisting resting state. Utriculofugal displacement of the hair bundle from its resting position inhibits the firing of the nerve impulse. The deflection of the cupula is proportional to the force of the turn. The canals respond to acceleration, rather than to speed of movement. At a constant velocity the endolymph, and thus the cristae, returns to their resting states. Therefore, the utricle is concerned with the static maintenance of position or linear directional movement, and the semicircular canals recognize and analyze angular motion.

D. Vestibular Pathways

The hair cells of the maculae of the saccule and utricle, the cristae of each semicircular canal, along with the end-organ of the cochlea, make up the vestibular filaments of the eighth crainal nerve. The filaments from the saccule and the posterior semicircular canal unite to form one bundle which enters Scarpa's ganglion, and the filaments from the utricle and from the superior and horizontal canals unite to form another bundle which enters Scarpa's ganglion. The VIII cranial nerve consists of two bundles, a cochlear portion and a vestibular portion, which extend from Scarpa's ganglion to its entrance into the brain-stem at the junction of the medulla oblongata and pons, where it breaks again into a cochlear and vestibular portion. Reference to Figure 3 will facilitate understanding of the different pathways.

Most of the fibers of the vestibular nerve end in the vestibular nuclei which are clustered in the lateral part of the floor of the fourth ventricle (Gatz, 1966). The vestibular nuclei are composed of the medial vestibular nucleus (of Schwalbe), the lateral vestibular nucleus (of Deiter), the superior vestibular nucleus (of Bechterew), and the spinal vestibular nucleus (Inferior). A few of the vestibular nerve fibers pass the vestibular nuclei and go directly to the cerebellum, ending in the cortex of the flocculonodular lobe. Connections are made inside the cerebellum to the nucleus fastigius which gives rise to the fastigiobulbar nuclei in the brain stem. As they pass from the cerebellum they loop around the superior cerebellar peduncle to form the uncinate fasciculus. The vestibular fibers which pass to and from the cerebellum lie on the medial side of the inferior cerebellar peduncle and constitute a portion of the peduncle called the juxtarestiform body.

Two vestibulospinal tracts arise from the vestibular nuclei. The lateral tract (uncrossed) comes from the lateral vestibular nucleus. The medial tract (with both crossed and uncrossed fibers) comes chiefly from the medial and spinal vestibular nuclei. Both tracts pass down the

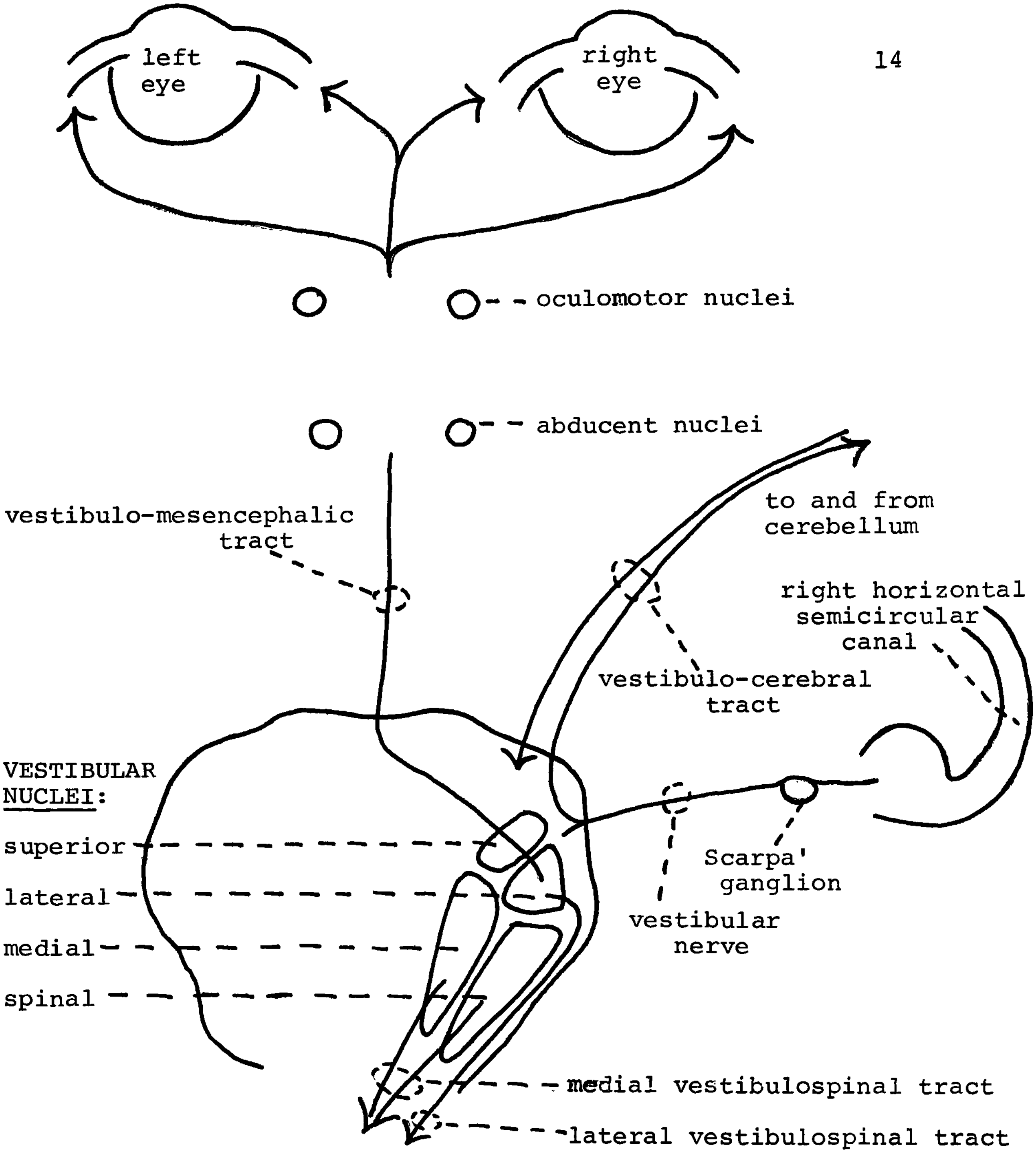

Figure 3. Neurological tract for Vestibular Nystagmus.

spinal cord in the anterior funiculi to end on lower motor neurons of the anterior horns. Impulses descending in these tracts assist the local myotactic reflexes and reinforce the tonus of the extensor muscles of the limbs.

Fibers from the superior and medial vestibular nuclei are carried rostrally in the medial longitudinal fasciculus. These fibers constitute the vestibulomesencephalic tract which is distributed to the motor nuclei of the cranial nerves, supplying the ocular muscles that control the position of the eyes. Turning the head to the right (Figure 4) produces a flow of endolymph (lymphokinesis) in the horizontal semicircular canals which is directed to the left. This lag is created by the inertia of the fluid in the right horizontal canal. The utriculopetal stimulation causes vestibular impulses to be carried by the medial longitudinal fasciculi to the left abducent nucleus (VI ocular nucleus) and to the right oculomotor nucleus (III ocular nucleus). The III ocular nucleus of the right side causes contraction of the internal rectus of the right eye. The VI ocular nucleus of the left side produces contraction of the external rectus of the left eye. The result is a left conjugate deviation of the eyes. Turning the head to the left (Figure 5) causes utriculofugal stimulation of the right horizontal canal by the flow of the endolymph to the right. Vestibular stimulation is carried to the abducens nucleus (VI oculomotor nucleus) of

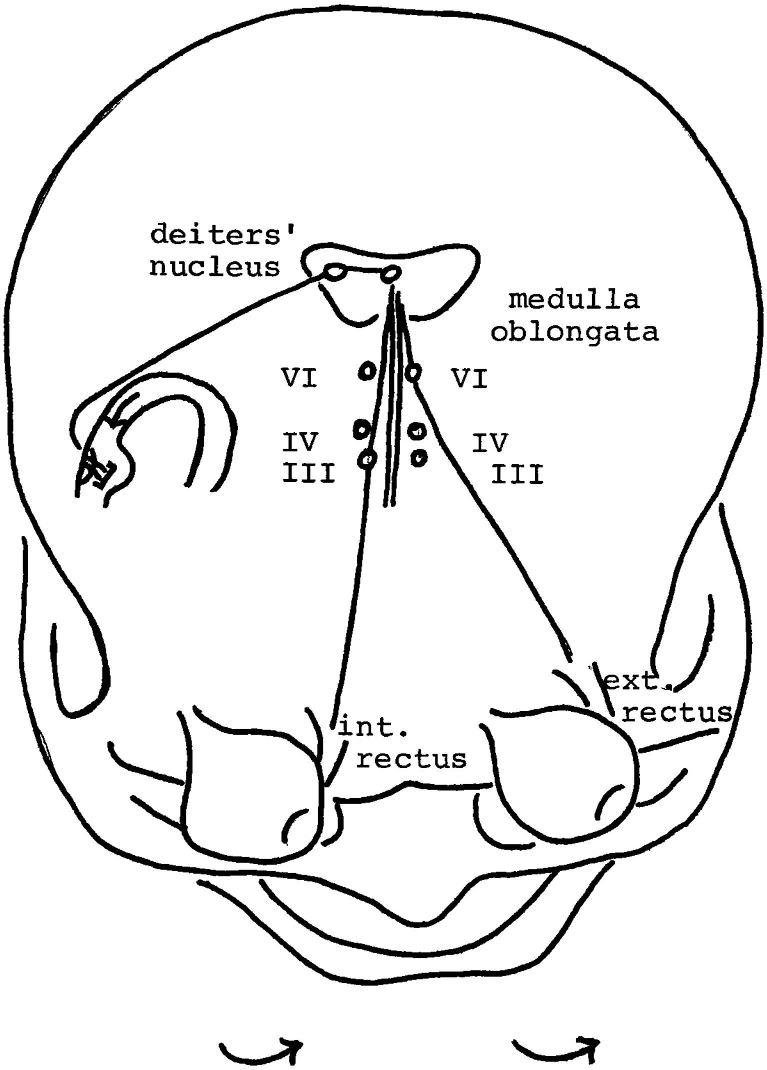

Figure 4. Effect on the vestibular system when the head is turned to the right.†

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† I. H. Jones, Equilibrium and vertigo. Philadelphia: J. B. Lippincott Company, 1918, p.141.

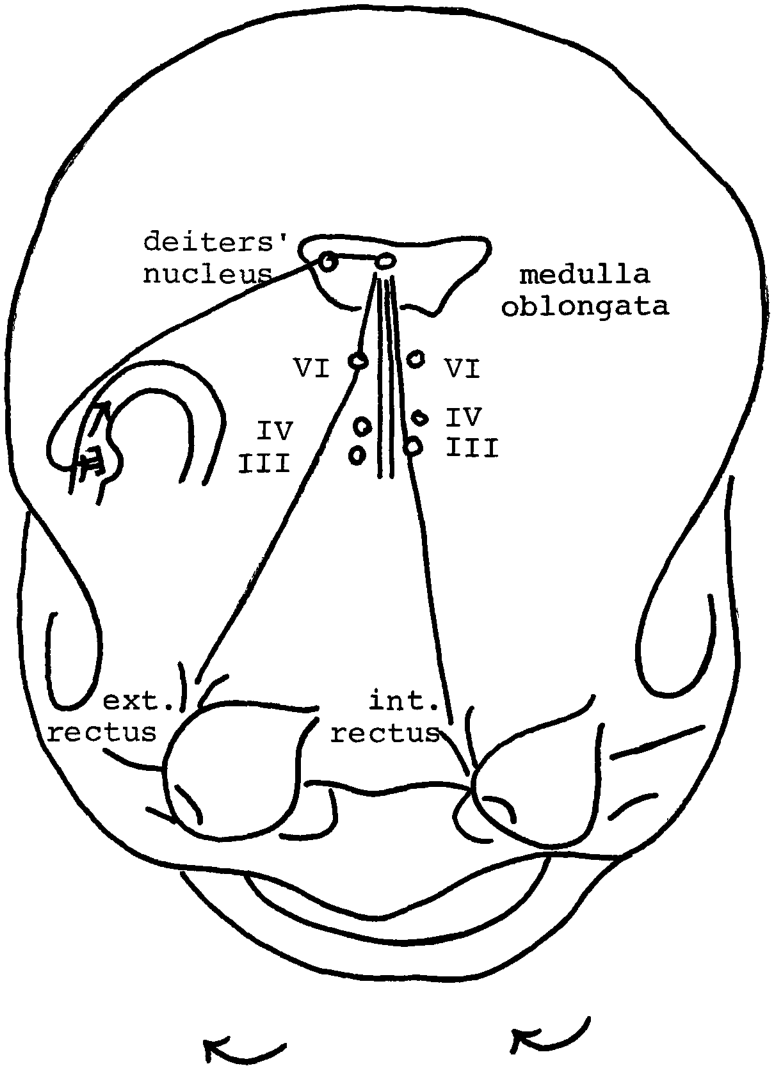


Figure 5. Effect on the vestibular system when the head is turned to the left.[†]

[†] I. H. Jones, Equilibrium and vertigo. Philadelphia: J. B. Lippincott Company, 1918, p.139.

the right side and the oculomotor nucleus (III ocular nucleus) of the left side. The VI oculor nucleus of the right side causes a contraction of the external rectus muscle of the right eye. The III ocular nucleus of the left side produces a contraction of the internal rectus muscle of the left side (Figure 6). The result is a drawing of both eyes to the right. This completes the path of the slow phase movement for the horizontal semicircular canal. Angular movements of the head which stimulate the superior and posterior canals result in impulse transmission to the trochlear nuclei (IV ocular nucleus) and the oculomotor nuclei. The resultant contraction of the proper oblique muscles of the eyes cause slow phase eye rotation to the right or left. The oblique muscles do not produce pure rotary movements, but rather cause the cornea to turn outward and downward, while the inferior oblique muscle causes the cornea to turn outward and upward.

Evidence suggests that the vestibular centers operate as if in a balance (Shimaga, 1972). Afferent impulses from the vestibules to the ocular muscle nuclei are continuous. As long as this activity is equal in all nuclei the eyes do not move. Stimulation that raises or depresses the activity of one side of the system results in eye movement.

The mechanism responsible for the quick component of nystagmus is not yet understood (McCabe, 1965), but evi-

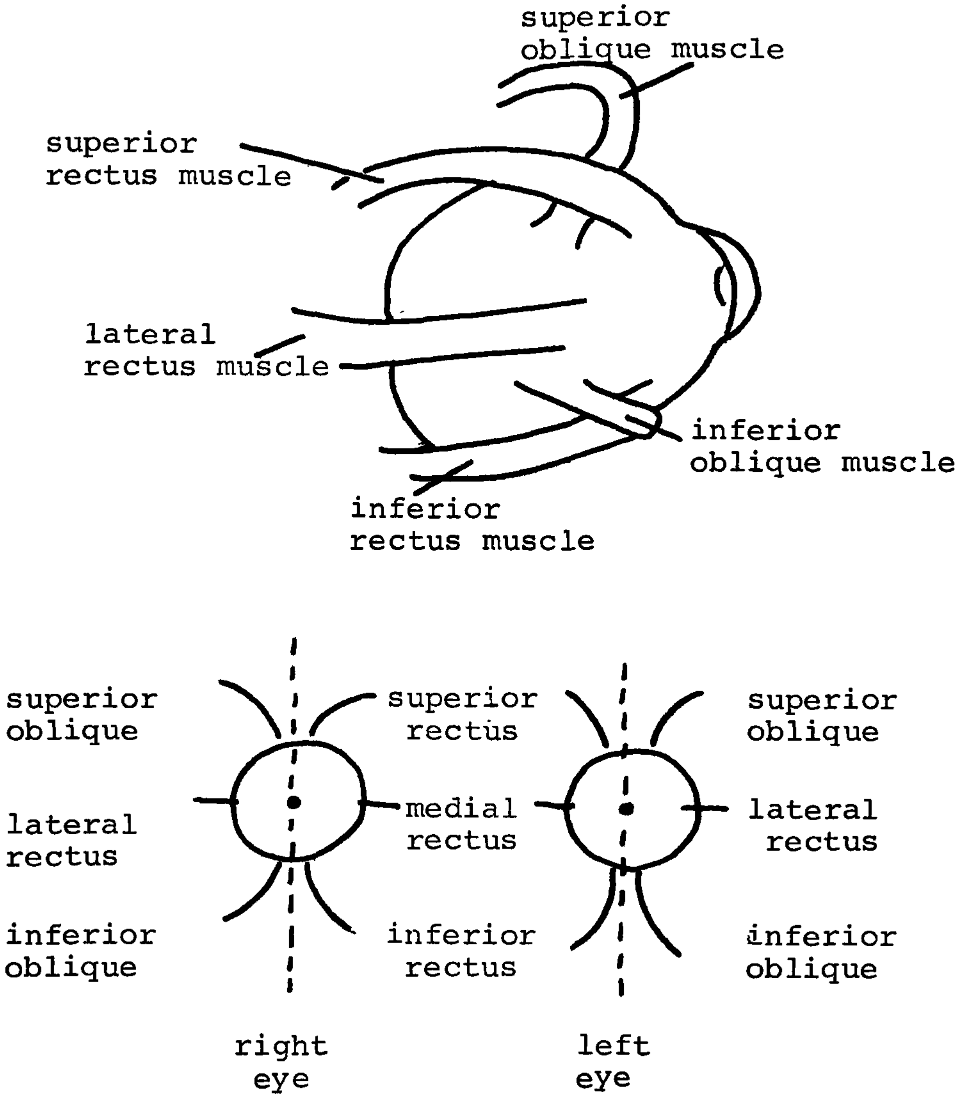


Figure 6. Muscles of the human eye.

dence points to a cerebral center. The two pathways travel down through the internal capsule into the uppermost portion of the posterior longitudinal bundles at the point where the crura cerebri unite to form the pons. The fibers are then distributed by means of the posterior longitudinal bundles to the various eye muscle nuclei. The quick component of nystagmus to the left seems most likely to be controlled by a center in the right cerebral hemisphere, and the left cerebral hemisphere probably controls the quick component of both eyes to the right.

Stimulation of the vestibular nerve activates extensive parts of the recticular formation (RF). Few primary fibers end in the reticular formation of its most dorsolateral medullary part, but secondary vestibular fibers to the reticular formation arise from all four main vestibular nuclei. Each of the main nuclei has its particular pattern of distribution of fibers within the reticular formation. The majority of the vestibular efferent end in the nucleus reticularis pontine caudalis (Brodal, 1972). Little is known of the routes alone which impulses, ascending from the reticular formation, reach the vestibular cortical area of influence stations in the optic pathway.

E. Classification of Nystagmus

Nystagmus can occur spontaneously in the absence of any observable stimulus or can be induced and clearly related to a particular stimulation. Spontaneous nystagmus occurs when the eyes of a person are closed and in the midline position. Nystagmus occurring when the eyes are rotated 20° to 30° away from the midline, vertically or horizontally, is called gaze nystagmus. Gaze nystagmus and spontaneous nystagmus are abnormal conditions and must be distinguished from end-point nystagmus that occurs in normal eyes to extreme eye deviations of 40° or more.

Induced nystagmus can be classified as rotational, positional, caloric, or optokinetic nystagmus. Induced nystagmus, except for the optokinetic form, is the result of an imbalance in the nervous system of the two vestibular labyrinth that is caused by the flow of endolymph (see page 15). Rotational, positional, and caloric nystagmus differ only in the mechanisms responsible for this flow. Rotation of the body in space at an accelerating velocity, for instance, or head turning produces rotational nystagmus, but when assuming a particular body position positional nystagmus is induced. The body positions used to test for this form of nystagmus are the sitting, supine, right-lateral, left-lateral, and head-hanging positions. Through the directional movement of the head when assuming each position, the endolymph flows in a corresponding direction, thereby stimulating each of the three semicircular canals. Temperature alterations in the vestibular labyrinth, caused by the irrigation of the external auditory canal with water warmer or cooler than body temperature, result in caloric nystagmus. Most effected is the lateral semicircular canal because it is closest to the stimulus. Therefore, nystagmus occurs predominantly in the horizontal plane and this response can be exaggerated by specific positioning of the head. Repetitive visual stimuli moving in one direction induces optokinetic nystagmus. For clinical purposes the subjects fixate on a rotating cylinder with alternating black and white stripes. The cylinder is rotated at a constant speed in a single direction for each stimulation.

F. Electronystagmography

Electronystagmography (ENG) is the graphic recording of nystagmus. It is based on the presence of a voltage difference generated in the retina (Figure 7), with the positive pole at the front and the negative pole at the back. This polarity potential was first thought to originate in the photosensitive elements of the retina, however, recent indications are that it is at least in part due to extraretinal elements. The human eye shows an average potential of about

1.10 millivolts under a constant illumination of 5 milliamberts. However, when the illumination is reduced to a value of about .001 milliamberts this potential drops to .99 millivolts after 5 minutes of dark adaption, and to .88 milliamberts after 10 minutes (Miles, 1940). Thus, for ENG recordings the level of illumination must be held at a constant level. The head conducts electricity. Therefore, when the eye rotates, electrodes placed in the plane of rotation will pick up a voltage change (eye rotation will cause the positive pole at the front to move to one electrode and the negative charge closer to the other electrode). This change of electrical potential is graphed by a dynograph (illustrated on page 86). By convention an upward deflection on the graph indicates an eye movement to the right, and a deflection downward indicates a left movement. To record horizontal eye movements of both eyes, electrodes are placed lateral to the eyes' outer canthi (this is usually the only measurement of eye movement taken in most studies). However, both eyes usually do not move in an exact conjugate manner (see Figure 8). Disconjugate eye movement of equal amplitude can theoretically cancel on the summated record (Wolfe & Wendt, 1967). Detection of independent eye movements can be obtained by the placement of additional electrodes on the inner canthus of each eye; however, the intra-ocular variance is usually not great and is rarely considered, since fre-

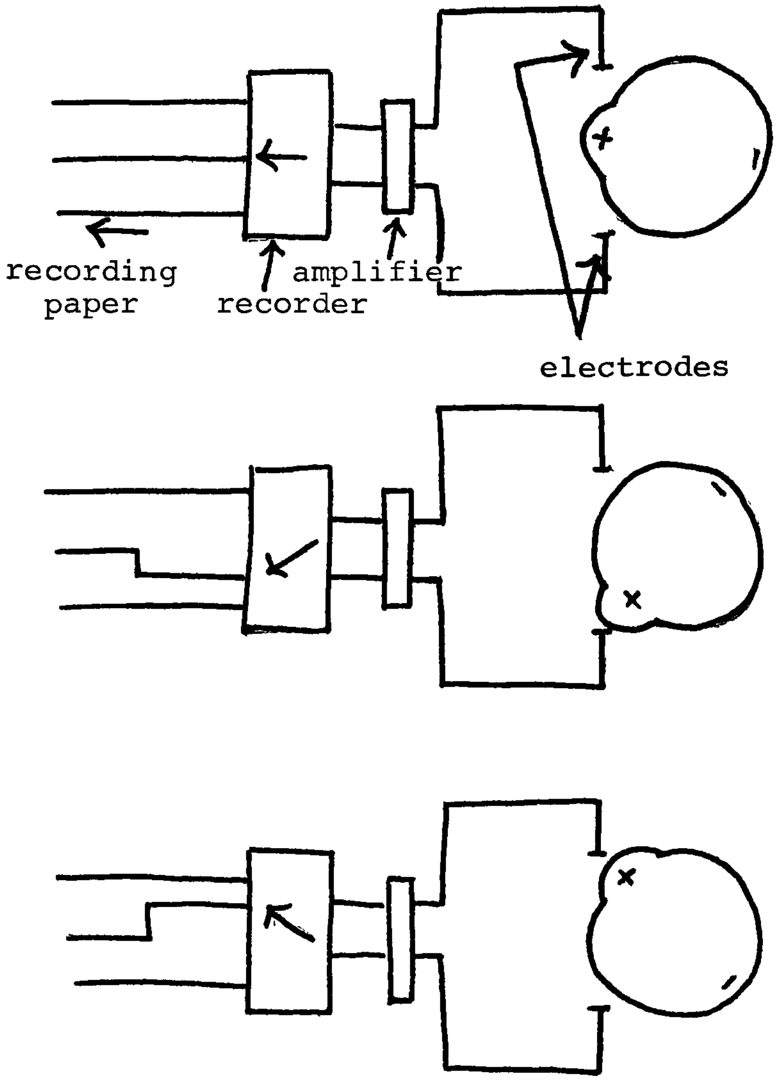
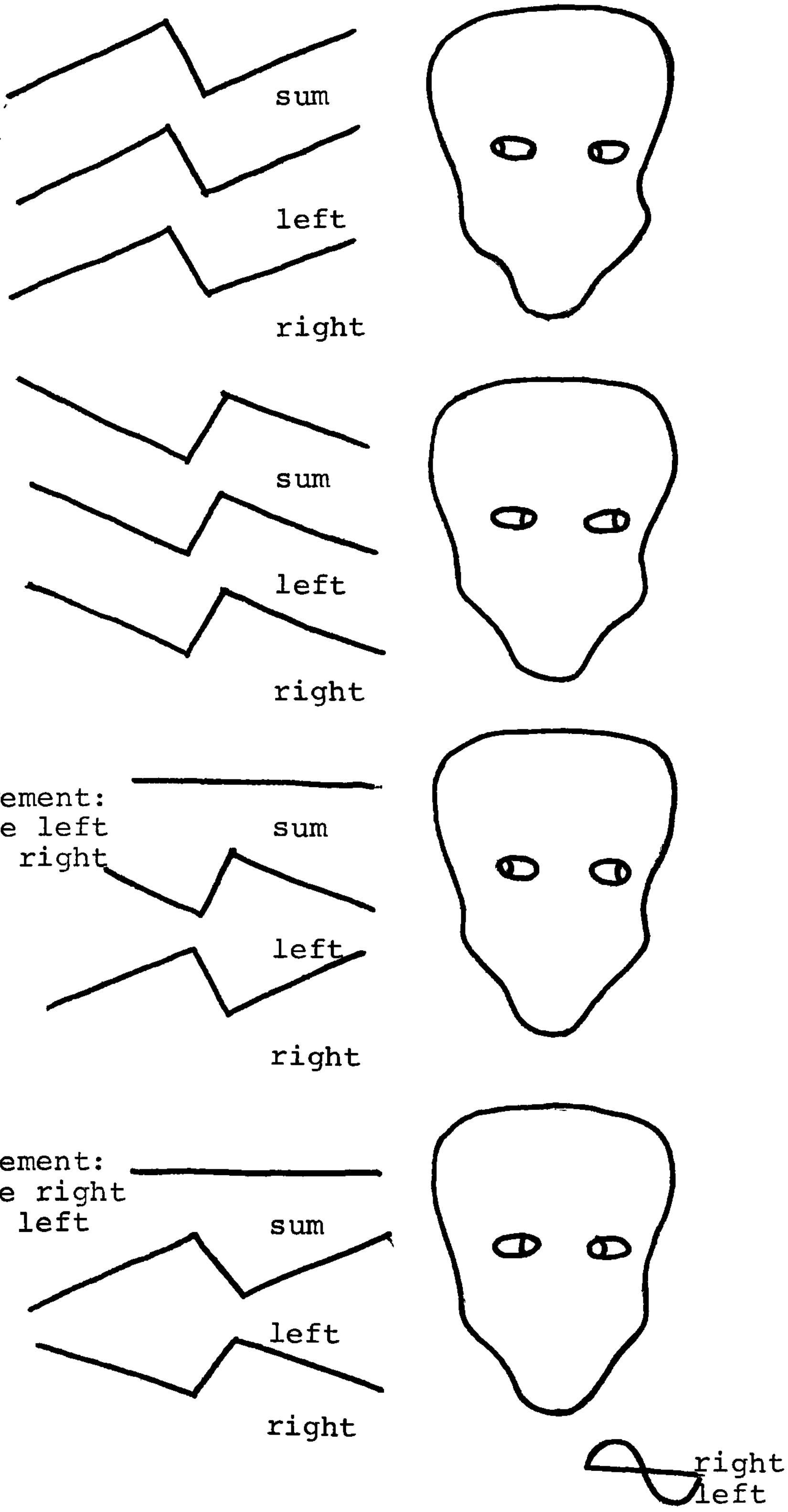


Figure 7. The principle of electrical recording of eye movements. The corneo-retinal potential is illustrated as a "+" (i.e., positive voltage) at the front of the eye and a "-" (i.e., negative voltage) at the back. Eye movement displaces this potential. This displacement is "seen" by electrodes placed in the plane of the eye movement because the head is an electrical conductor.[†]

[†] A. C. Coats, Electronystagmography: A compendium, Houston, Texas: Baylor College of Medicine, 1972, p.3.



Conjugate eye movement: both eyes move to the right in slow phase.

Conjugate eye movement: both eyes move to the left in slow phase.

Disconjugate eye movement: left eye moves to the left and right eye to the right in slow phase.

Disconjugate eye movement: left eye moves to the right and right eye to the left in slow phase

Figure 8. EOG recordings for conjugate and disconjugate eye movements.

quency and amplitude of the nystagmic response vary in a relatively arbitrary fashion (Jun-Ichi, 1970). (Figure 9 shows the electrode placement.)

The most frequently used measurement of nystagmus is the speed of the eye movement in the slow phase. Studies show that the slow phase eye speed faithfully reflects the excitation of the labyrinth and that the fast phase originates in the brain stem and is not related to vestibular excitation. This velocity can be directly measured by dividing the amplitude of the eye movement by the time it takes to reach that amplitude. To minimize the effect of random fluctuations of speed of single nystagmus beats, averaging of a number of beats is obtained. A graphic representation is shown in Figure 10. The advantages of ENG recordings are many. All visual influences to the subject are eliminated by allowing recording of eye movements with eyes closed, or in darkness with eyes open which thereby eliminates eyelid tremors. The recordings gives a permanent record which allows detailed study after testing. More parameters (amplitude, frequency, and velocity) can be determined than just the deviation.

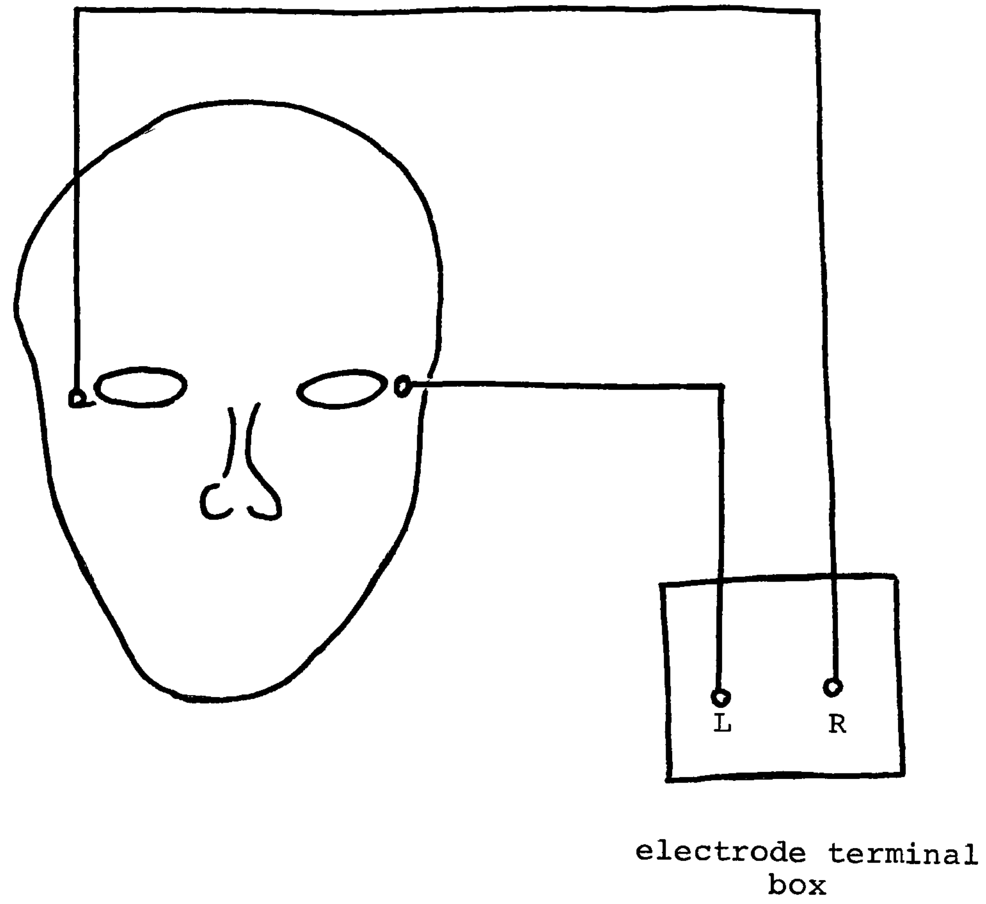
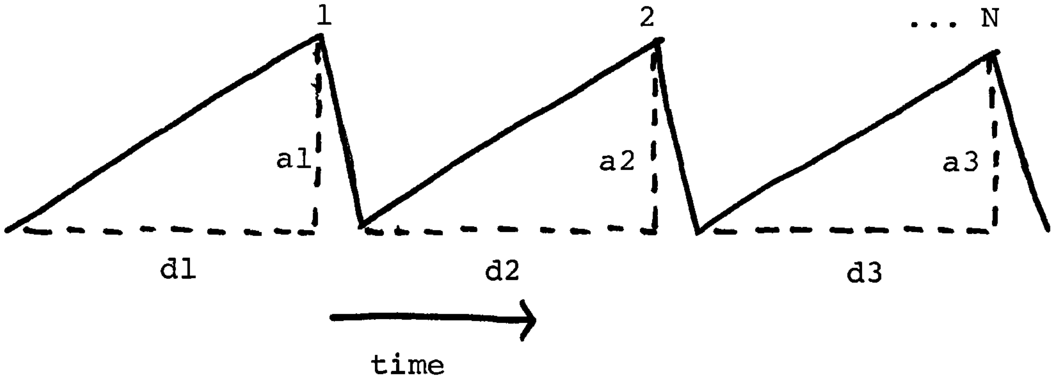


Figure 9. Electrode placement for recording horizontal nystagmus of summated eye movements.

SLOW PHASE



FAST PHASE

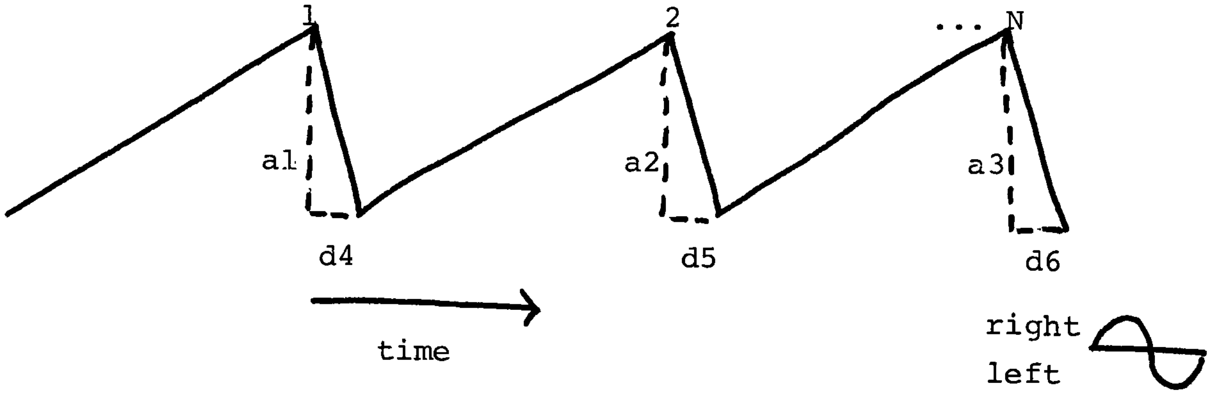


Figure 10. Method to determine the average velocity of the nystagmic response [slow or fast $\phi = \Sigma(a_i/d_i)/N$].

G. Eysenck's Theory of Extraversion and Neuroticism

Eysenck views the task of personality theory as one that describes behavior accurately, quantitatively where possible, and develops a causal theory in which observed behavior patterns are deduced from more fundamental causes. Since man is a biological organism, such factors should be sought in his constitutional endowment. Eysenck's initial formulation of his theory of personality was the result of a factor analysis of a large input of data from military, psychiatric patients (Eysenck, 1947). Two independent dimensions extracted were those of Introversion-Extraversion and Neuroticism-Stability. A hypothetical construct of the excitation-inhibition balance of the nervous system was taken to explain the differences between these two dimensions. Extraverts are cortically inhibited, while in introverts the excitatory process dominates. Introverts are tonically in an aroused cortical state because their reticular formations have a lower threshold than those in the extraverts. This construct is originally a Pavlovian concept. Numerous authors have found various analogies between Eysenck's views and Pavlov's typology of nervous systems (Eysenck, 1966, 1967; Gray, 1967; Strelau, 1970), between Teplov's further development (Teplov, 1972; Teplov & Nebylitsyn, 1969) of Pavlov's theory (Eysenck, 1966, 1967; Gray, 1967), and Gray's

(1970) extension of these theories (Eysenck, 1967; Gray, 1970, 1972; Passingham, 1970). Using Pavlovian terms -- the weak nervous system (cf. introvert) is said to be more sensitive, less stable, and more excitable than the strong nervous system (cf. extravert). The weak nervous system acts to amplify stimulation to the nervous system (the system is generally more aroused), while the strong nervous system acts as if to dampen down stimulation (Gray, 1964; Eysenck, 1967). Although Pavlov theorized that the inhibitory process took place in the cortex, he did not attempt to find the specific neurological mechanisms.

Two sets of neurophysiological loops have been postulated by Eysenck (1967). The first, which explains Extraversion-Introversion, is the cortico-reticular loop. Neural messages going along the ascending afferent pathway relay to the particular projection areas involved in the cortex. Colaterals are also sent into the reticular formation, which in turn sends arousal messages to the cortex to keep it in a state of functional tonus. Depending on the nature of the information transmitted, the cortex in turn instructs the reticular formation to continue sending arousal messages or else to switch to inhibition.

Sokolov's neuronal model (Sokolov, 1960) for the elicitation of the orienting reaction (OR) is essentially the same as the one adopted by Eysenck as a neurophysiological rationale for his introversion-extraversion personality dimension. Both models emphasize the cortico-reticular loop. The only difference between the two is that while Eysenck focusses on differential thresholds of the ascending reticular activating system to explain individual differences, Sokolov concentrates on the functional tonus of the cortex. A graphic outline of Sokolov's model is given in Figure 11. System for Formation of Model found in the figure represents the cortex, especially the association areas for each cortical projection of the various senses. According to the Sokolovian model, novel stimuli arrive at the cortex via the specific pathways from the sense organs. There its properties are analyzed and compared to a preexistent model. According to this conception, incoming stimuli leave traces of all their characteristics within the nervous system and especially in the cortex. These traces are the nervous models. They preserve information about the intensity and duration of the stimuli as well as other more obvious stimulus dimensions. If the properties of the incoming stimulus cannot be matched to a neuronal model in the cortex, excitatory impulses are sent to the reticular formation (line 5). The most important cortical areas which send projections to the reticular formation are in the sensorimotor cortex, superior temporal gyrus and tip, paraoccipital region, and entorhinal cortex. These excitatory impulses

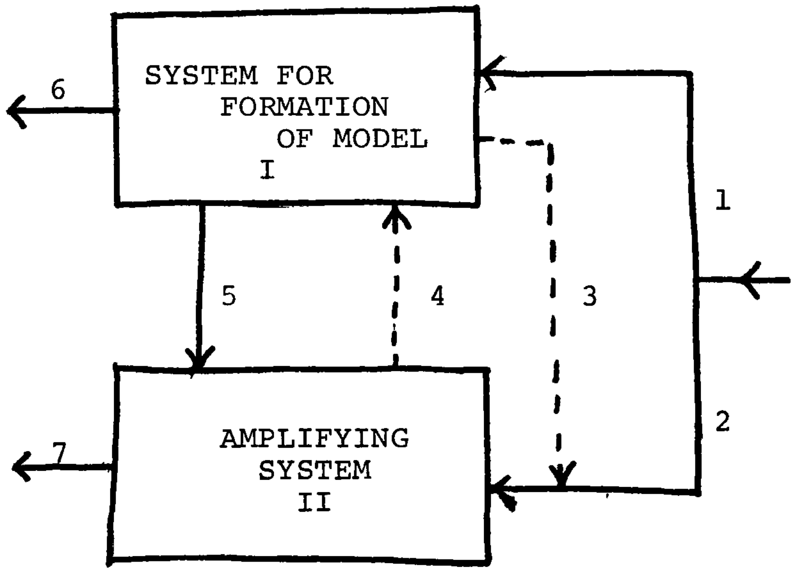


Figure 11. Sokolov's model for the orientation reaction. I: modeling system. II: amplifying system. 1: specific pathway from sense organs to cortical level of modeling system. 2: collateral to reticular formation (represented here as amplifying device). 3: negative feedback from modeling system to synaptic connections between collaterals from specific pathway and reticular formation (RF) to block input in the case of habituated stimuli. 4: ascending activating influences from the RF to the modeling system (cortex). 5: pathway from modeling system to amplifying system (this is the pathway through which the impulses signifying nonconcordance between input and existing neuronal models are transmitted from cortex to RF). 6: specific responses caused by coincidence between the external stimulus and the neuronal model (habitual responses). 7: to the vegetative and somatic components arising from the stimulation of the RF.†

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† H. J. Eysenck, <u>The biological basis of personality</u>, Springfield, Illinois: Charles C. Thomas, 1967, p.250.

from the cortex serve to activate the reticular formation. Such reticular formation activation brings about the central and automatic components of the OR. EEG desynchronization towards waves of higher frequency and lower amplitude takes place as a result of excitatory impulses from the reticular activating system and is reflected in heightened cortical arousal. This is a central component of the OR which occurs via the diffuse thalmic projection system linking the reticular formation to the cortex (line 4). Autonomic components of the OR occur as a result of reticular activation of the posterior hypothalamus (line 7). Both central and autonomic components of the OR have the common purpose of strengthening incoming stimulus so as to facilitate its analysis by the cortex. After repeated presentation of a stimulus, a neuronal model is gradually generated embodying all the dimensions of the particular stimulus. After such a model is present, the cortex transmits inhibitory impulses to the colaterals, transmitting impulses from the sense organs to the reticular formation (line 3). This has the effect of inhibiting stimulus amplification by the reticular formation. The central and autonomic components of the OR disappear, denoting lessened cortical arousal to the stimulus.

The second loop in Eysenck's model concerns the visceral brain (the hippocampus, amygdala, cingulum, septum, and hypothalamus) and the reticular formation. Messages from the visceral brain also reach the reticular formation via colaterals and have arousing effects on the cortex in a manner similar to that produced by information received via the ascending afferent pathways. The hypothalamus has its own activating functions by direct connection with the cerebral cortex and also through autonomic activities which in their turn activate the reticular system. It is this loop that is concerned with emotion, and in its application to personality differences of Neuroticism-Stability. According to Eysenck, differences in behavior associated with neuroticism are related to differential thresholds of arousal in the visceral brain. Cortical arousal can be produced by sensory stimulation of the cortico-reticular loop, with little autonomic arousal. Thus, emotional arousal can be indexed in terms of cortical arousal, but cortical arousal can take place without any marked degree of autonomic-emotional arousal.

The first loop is related to differential threshold in various parts of the reticular formation, and the second loop is related to differential thresholds of the visceral brain. Cortical arousal can be produced by sensory stimulation or problem solving by the brain, without involving the visceral brain. There is no autonomic arousal, but high cortical arousal is present. A person thinking profoundly could have considerable cortical arousal but little autonomic activity.

H. Arousal Level Effects on Nystagmus and Eysenck's Personality Variables

Griffith (1920) demonstrated that the vestibular response was enhanced if subjects engaged in strenuous physical exercise prior to testing. Mowrer (1934) reported that nystagmus produced by excited subjects differed from that produced by subjects in a tranquil state. Today the effect of mental set upon nystagmic response output is a well established fact. Reverie states result in a decline of nystagmus, whereas, mental altertness maintains a high level of nystagmic output. Collins (1962) has found that under many conditions eye movements give a better indication of a subject's state of alertness than do encephalographic patterns.

Studies of Bakan (1963), Hogan (1966), and Colquhoun and Corcoran (1964) have shown that introverts perform significantly better than extraverts in tasks of vigilance over extended periods of time. Colquoun and Corcoran proposed an inverted-U relationship between performance and arousal, from which can be concluded that at times of low arousal introverts would perform significantly better than extraverts. However, when the subjects are in a high arousal state the performance of an extravert will become better and that of an introvert poorer. In high arousal the performance between introverts and extraverts will not, therefore, differ significantly. If introverts score higher on excitation/arousal than extraverts, the two groups should react differently to changes in conditions.

I. Arousal Level and Mental Set

The choice of the independent variable used to elicit differing levels of arousal is crucial, as is the technique used to define arousal. Although diurnal changes have been used in the past, there is little agreement between mental arousal and the time-of-the-day (Freeman & Hovland, 1934), and they have actually been found to have no correlation at all to mental arousal (Eckel, Kuipers & Wendt, 1963; Ferneyhough, 1974). However, Haas and Eidebenz (1967), using a dependent variable not considered in the above studies, found threshold levels of vestibular stimulation were significantly higher in the evening than in the morning. Many studies which have found a correlation have used an operational definition of arousal which confounds the results. If arousal is measured, for example, by the subject's ability to complete arithmetic problems, sensory and motor arousal are also variables which have been found to correlate with the diurnal cycle (Freeman & Hovland, 1934).

A significant amount of investigation has been done on the effect of drugs on cortical arousal (Efron, et al., 1968). However, the effects of most drugs are wide spread, with differences in inter-subject effects.

Changing the mental set of a subject is another technique used frequently in human research, especially involving nystagmic stimulation. The literature has established a high correlation between changes in mental set and nystagmus (see the introductory section). The greatest advantage of this technique is the ease in which it can be implemented.

J. Statement of the Problem

Experimental work linking nystagmus with individual differences is strangely lacking in view of the observations of inter-subject variations of vestibular response under exact conditions. Eysenck's theory of personality gives a basis for individual differences and is uniquely linked to nystagmus by the variable of arousal level.

The major problem then, is to determine if the effect of change in arousal level in introverts effects their nystagmic response significantly different than it does that of extraverts. A review of studies in the literature shows that arousal level in reverie is lower than in mental activity. Since nystagmic response is positively correlated with the level of arousal of an organism, eye movements recorded in reverie should differ from those recorded in mental activity. Differences between organisms, however, must also be considered. In Eysenckian terms, introverts are higher in cortical arousal than extraverts. The major hypothesis of the present thesis is that introverts give a significantly different velocity nystagmic response than extraverts in reverie, without significant differences in mental activity. Secondarily, if introverts are in general at a higher cortical excitation than extraverts, their nystamic output at low arousal level is significantly different. No differences should be found at high arousal.

CHAPTER II

EXPERIMENTAL DESIGN

A. Subjects

Fifteen female and twelve male college students (age seventeen to twenty-one years old) were studied. No subject had a history of prior labyrinthine disorder nor had they participated in any activity within the past year which subjected them to high centrifical force. They abstained from alcohol for at least fifteen hours prior to testing, from tobacco for at least two hours, and did not take stimulant or depressant medications for at least one week prior to testing. All received their normal amount of sleep the night prior to testing.

B. Apparatus

The rotational nystagmus stimulator was locally constructed (Figure 13). A wooden chair, fitted with a head holder, held the subject in position with his head tilted downward 30° to the horizon. A wooden box, enclosed on all sides except one, was built around the chair. This unit was placed on a platform that was able to rotate 360° in either direction. A twenty pound weight dropping with the pull of gravity powered the pulley attached to the platform to a 3.45°/$sec.^2$ rotation. A micro switch recorded each rotation across time.

Two small calibrating white lights were placed at eye level on a horizontal plane to the subject's eyes. Each light alternated on a one second on-off pattern, each light being one second out of phase with the other.

For eye movement recording a six channel Physiography Six from E & M Instruments was used with high gain preamplifiers. Bechman silver-silver chloride electrodes, size 0.5 cm. were used.

C. Procedure

The testing of each individual was completed on the same day, during the same time-of-the-day (1200-1800 hours). Upon entering the testing situation the subject was briefed as to the testing procedure, and an attempt to make him at ease was made throughout the session. He was led to a separate testing room which was sound proof and well ventilated, and there he completed the Eysenck Personality Inventory: Form A (EPI). At the completion of the experiment all inventories were hand scored for the E scale and the first nine individuals scoring the lowest were placed in the introverted group, the nine individuals scoring the highest were designated extraverts, and the remaining subjects were called ambiverts.

After completing the EPI the subject was brought into the room housing the rotational apparatus. A five millimeter diameter beckman electrode was placed at the outer canthus of each eye (see Figure 9) after the area was scrubed with alcohol. Beckman electrode paste was used to make contact between the skin and electrode. After five minutes electrode resistance was measured by a vacuum tube volt-ohm meter and any electrode contact measuring greater than five Kohm was replaced. A vacuum tube meter was used to eliminate currents at the contact site which would be subjectively detected by the subject and might be painful. The electrode wires were plugged into the physiograph through a second lead which was long enough to allow for the twisting of the wires due to the number of rotations of the apparatus. In between subjects the wires were unplugged and straightened. The subject inserted wax plugs into both external auditory canals of his ears to lessen the amount of auditory cues he might receive from the environment.

After seating the subject in the chair, his head was positioned so that his horizontal semicircular canals were horizontal to the floor. This was achieved by drawing an imaginary line from the outer canthus of the eye to the lowest extremity of the external auditory canal and having this line positioned parallel to the ground (see pages 7 and 10). His head was strapped into position throughout the remaining portions of this experiment. The door to the apparatus was shut so that the subject was unable to receive any outside environmental cues. His eyes were dark adapted for twenty minutes and at the end of this period he began to visually follow two lights which flashed out of synchrony by one second. Calibration for the compensation of the corneoretinal potential, which occurs with dark adaptation (Miles, 1940; Aserinsky, 1955; Kris, 1958; Arden & Kelsy, 1962) was completed at the beginning of every recording. The angle of sweep of each eye from the center to each light was ten degrees. The adjustment for corneoretinal potential change was made on the physiograph by correcting the sweep of the recording electrode to constantly be twenty millimeters in amplitude.

For all subjects the first recording taken was at basal level. While the subject sat quietly with his head tilted 30° forward and his eyes open he was rotated from right to left at a linear accelerating rate from zero to 72°/ second. Figure 14 gives the time course for the rotation. The main mass of the apparatus was distributed at the periphery so as to negate as much as possible the slowing of the apparatus due to friction after linear acceleration. To account for differences in body weight between subjects each subject was weighed prior to electrode placement and his weight differential from 200 pounds was added to the platform, directly under the seat. Following the basal recording the subject rested seven minutes to allow his vestibular system to return to homeostasis. His eyes were calibrated and he was randomly assigned to tasks that put him into a low mental arousal state first and a high arousal state second, or vice versa. The choice was made using a list of random numbers generated on a computer print out. Between the second rotation and the third another seven minute rest period was given.

The directions read to each subject by the experimenter prior to each trial were as follows. For the basal condition:

> Please pretend that you are back in your dorm and that you are sitting quietly in your room thinking of any topic that interests you. Remain as you normally would be in that situation until I tell you that this trial is completed. Remember, your eyes are to remain open at all times. Try to ignore your present surroundings and the fact that you are rotating.

For the low arousal condition:

> This time I want you to relax and keep your mind free of any thought. Allow all your muscles to become extremely relaxed. If any thought flows into your mind do not resist it but let it flow out as quickly as possible. If an unpleasant or threatening thought enters your mind try not to react to it but let it freely leave your thoughts quickly. Try to ignore your present surroundings and the fact that at some time you will be rotating. Keep your eyes open at all times. Again, before you begin this trial follow the two flashing lights.

For the high arousal condition:

> This time you will be verbally given simple arithmetic problems which you will complete

> mentally. I will ask questions, such as: How much is two plus two?, and you will verbally answer: four. Keep yourself alert for my questions and attempt to correctly answer every one. If you cannot answer, however, do not worry since you will not be scored as to your mathematical ability. But please remain mentally active and try to answer to the best of your ability. Remember, your eyes are to remain open at all times. Try to ignore your present surroundings and the fact that you are rotating. Again, before you begin this trial follow the two flashing lights.

The recordings of nystagmus on the physiograph were taken simultaneously with rotation. The physiograph's paper speed was 10 mm/second. The twenty pound weight was dropped and the linear acceleration rotation began. The onset of primary, slow phase nystagmus was usually within the first ten seconds and lasted twenty seconds. The recordings were taken throughout the 21 seconds of linear acceleration and at least the first 60 seconds of the constant velocity phase.

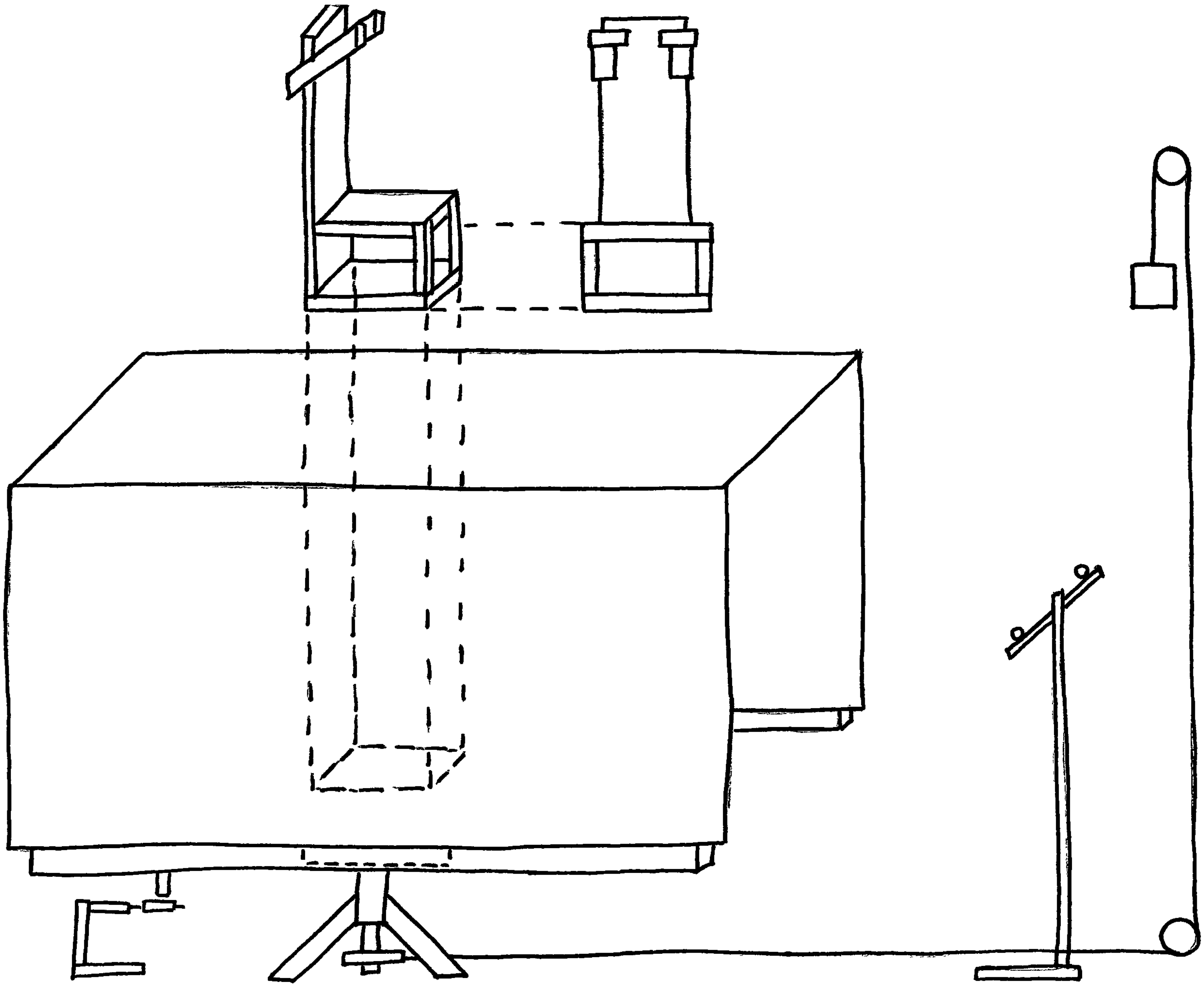

Figure 12. Rotational apparatus.

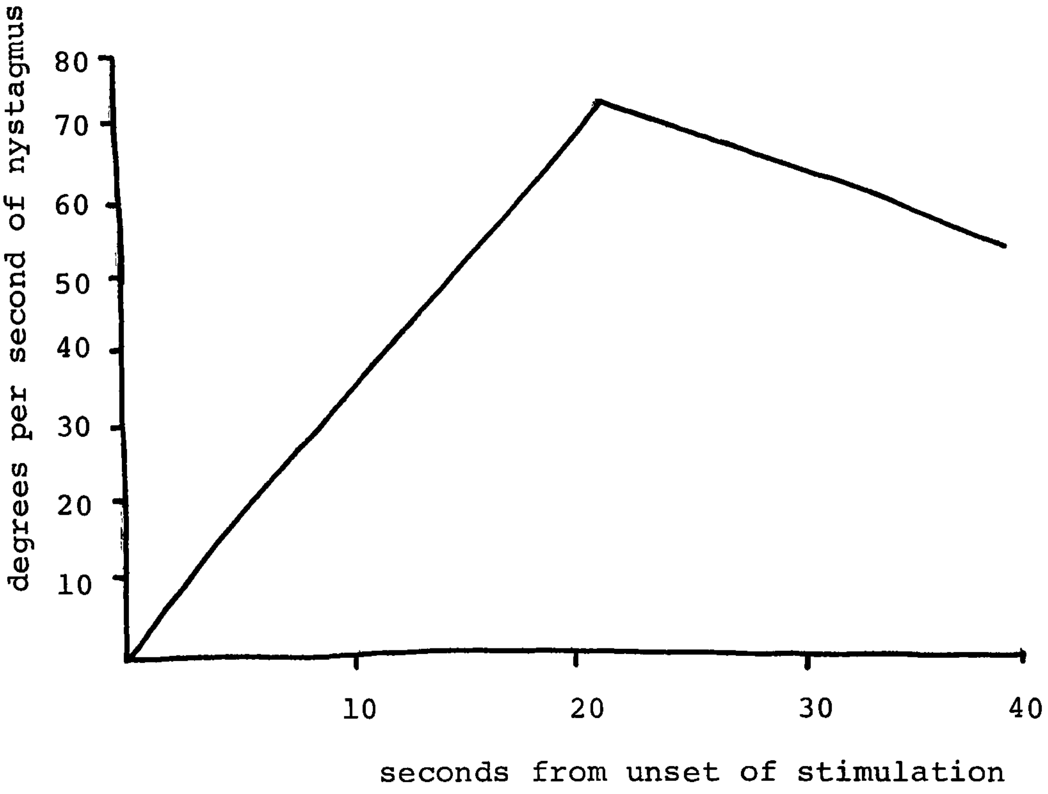

Figure 13. Course of rotational stimulation. The first 21 seconds consist of linear acceleration, with the apparatus rotating freely for the remaining period of recording.

CHAPTER III

PRESENTATION OF RESULTS

Eye velocities were measured by hand. Only primary, slow phase nystagmus of the summated eyes were considered. All measurements were the average of data taken in five second blocks of nystagmus. Care was taken to record only nystagmic responses and not random eye movements. For calculations only the maximum velocity for each stimulation was considered.

On the basis of the <u>Eysenck Personality Inventory</u> subjects were divided into three categories: nine introverts ($\bar{X} = 7.11; \sigma = 1.54$), nine ambiverts ($\bar{X} = 12.11; \sigma = 0.78$), and nine extraverts ($\bar{X} = 16.11; \sigma = 1.05$). The mean and standard deviations of raw score nystagmus under different arousal conditions are given in Table 1.

A noted lack of technique found in the literature is the omission of controlling for inter-subject variation in the basal rate of nystagmus when considering results recorded at manipulated states of arousal. Two techniques shall be explored: first using difference scores and next using raw scores with basal level as a covariate.

The variable of mental set has been found to be nearly linear (Brown & Crampton, 1964). Therefore, subtracting the basal score from low arousal and also from high arousal nystagmus does not change the proportion between arousal conditions within individual scores and allows for an accurate consideration of scores between individuals (Table 1 gives mean difference scores per personality groups). A two-way analysis of variance with repeated measures indicate a significant extraversion scale by mental set interaction ($F=25.21$, $df=1/24$, $p<.001$). Table 2 gives the full analysis. Analysis of the simple main effects between the Extraversion groups and mental set is listed in Table 3, and shown in Figure 15. The conclusion on the basis of this analysis is that the change of arousal conditions caused a significant difference in maximum nystagmus output for ambiverts and extraverts, but not for introverts. Also, only during low arousal condition significant differences in nystagmus level are found between personality types. A Duncan's Multiple Range Test (Figure 16) shows the significance between extraverts and ambiverts, however, both groups are significantly different from the introverts. For high arousal there is no significant difference between introverts and ambiverts, and both groups are significantly different from extraverts.

Table 1

Mean and Standard Deviation of Maximum Nystagmus Velocities Elicited Under Various Conditions of Arousal, with Difference Scores (Condition-Basal Scores)

Group	N	Raw Scores			Difference Scores	
		Basal	Low Arousal	High Arousal	Low Arousal	High Arousal
Introverted	9	28.52 6.05	31.08 5.90	32.42 6.47	2.56 4.05	3.90 4.69
Ambiverted	9	34.59 9.58	31.83 7.58	37.07 8.03	-2.76 3.33	2.48 5.60
Extraverted	9	32.43 8.30	30.66 5.81	39.66 7.05	-1.77 4.35	7.22 6.24

Note: means are the top value and the standard deviations are the bottom numbers.

Table 2

Two-way Analysis of Variance with Repeated Measures for Difference Scores

Source	SS	df	ms	F	P
Between subjects	888.68	26	-	-	-
Personality	118.14	2	59.07	1.84	n.s.
Error_b	770.54	24	32.11	-	-
Within subjects	554.63	27	-	-	-
Arousal	359.60	1	359.60	137.25	<.001
Arousal X Personality	132.10	2	66.05	25.21	<.001
Error_w	62.93	24	2.62	-	-
Total	1443.53	53	-	-	-

Table 3

Analysis of Variance Table for Simple Effects of a Two-way Analysis of Variance with Repeated Measures for Difference Scores

Source	SS	df	ms	F	P
Between subjects	-	-	-	-	-
between Personality at LA	142.94	2	71.47	4.12	<.05
Personality at HA	107.29	2	53.65	3.09	n.s.
Within cell	833.28	48	17.36	-	-
Within subjects					
between Arousal at I	7.54	1	7.54	2.88	n.s.
Arousal at A	123.25	1	123.25	47.00	<.001
Arousal at E	360.91	1	360.91	137.64	<.001
Personality X Arousal	132.10	2	66.05	25.19	<.001
Arousal X subject within groups	62.98	24	2.62	-	-
Total	1443.31	53	-	-	-

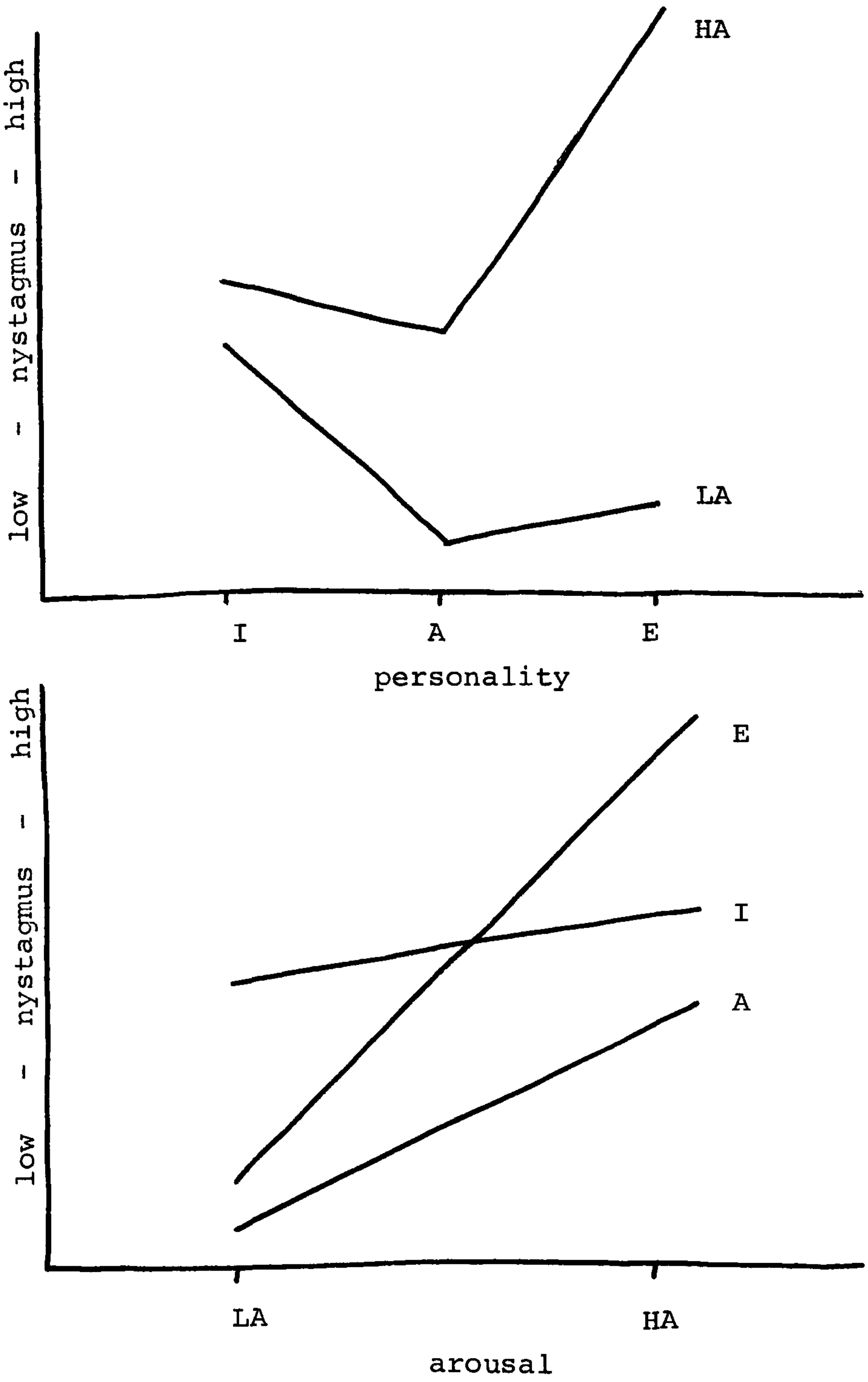

Figure 14. Interaction between treatments of arousal and personality.

Table 4

Duncan's Multiple Range Test for Difference Scores

	A-LA	E-LA	A-HA	I-LA	I-HA	E-HA
A-LA=-2.76	-	.99	5.24*	5.32*	6.66*	9.98*
E-LA=-1.77		-	4.25*	4.33*	5.67*	8.98*
A-HA= 2.48			-	.08	1.42	4.74*
I-LA= 2.56				-	1.34	4.66*
I-HA= 3.90					-	3.32
E-HA= 7.22						-

*p >.05

Many researchers warn against the use of an analysis of repeated measures design (McCall & Appelbaum, 1973; Huck & McLean, 1975). The design is univariate in that there is only one dependent variable, but that variable is measured on the same subject more than once. In computing an analysis of variance the lack of homogeneity of within cell variances is ignored; however, an analysis of variance repeated measures design is not robust enough to handle the additional violation of homogeneity of covariances (correlations) between repeated assessments. Violations of these assumptions, therefore, produce artifically large F values. An alternative approach to repeated measures design is applying the multivariate analysis of variance design which makes no assumptions regarding covariances. Thus, the second way of considering the data is by using the multivariate design as an univariate, partialling out basal nystagmus as a covariate. Again, a significant interaction term was obtained ($F=25.74$, $df=2/25$, $p<.001$). Table 4 lists the results of the analysis and Figure 17 illustrates the interaction.

Possible confounding variables of sex, the order of arousal conditions, and the time-of-the day of testing might influence the outcome of the results and therefore are considered. Using difference scores, the effect of the sex of the subject on his personality ($F=2.38$, $df=1/15$, n.s.) or on arousal level ($F=1.13$, $df=1/16$, n.s.) were found to be non significant (Table 5). Since it was necessary to have equal n's in each cell for this analysis and not every grouping on the E scale had an equal number of males and females, four subjects were randomly dropped from each grouping. Nearly half of the subjects were randomly assigned to first receive the rotational stimulation while in a state of high arousal, while the rest were assigned to low arousal. The effect of the order did not affect (t=0.71, df=25, n.s.) the overall outcome of the results. Also, even though the time-of-the day for testing was restricted, the diurnal change of the body over six hours could influence the results. A partial correlation of the time-of-the day to difference nystagmus scores, with the personality factor partialed out, showed (r=-.08, t=-.40, df=27, n.s.) that this variable held no influence over the total outcome of the results.

Table 5

Multivariate Analysis of Covariance
Using Raw Scores.
The Basal Nystagmus is Partialed Out

Source	SS	df	ms	F	P
Error 1	535.70	23	23.29	-	-
Regression	1668.67	1	1668.67	71.64	<.001
Arousal	364.00	1	364.00	15.63	<.001
Error 2	58.05	23	2.52	-	-
Regression	.81	1	.81	.32	n.2.
Personality	33.17	2	16.59	6.57	<.006
Arousal X Personality	129.92	2	64.96	25.74	<.001

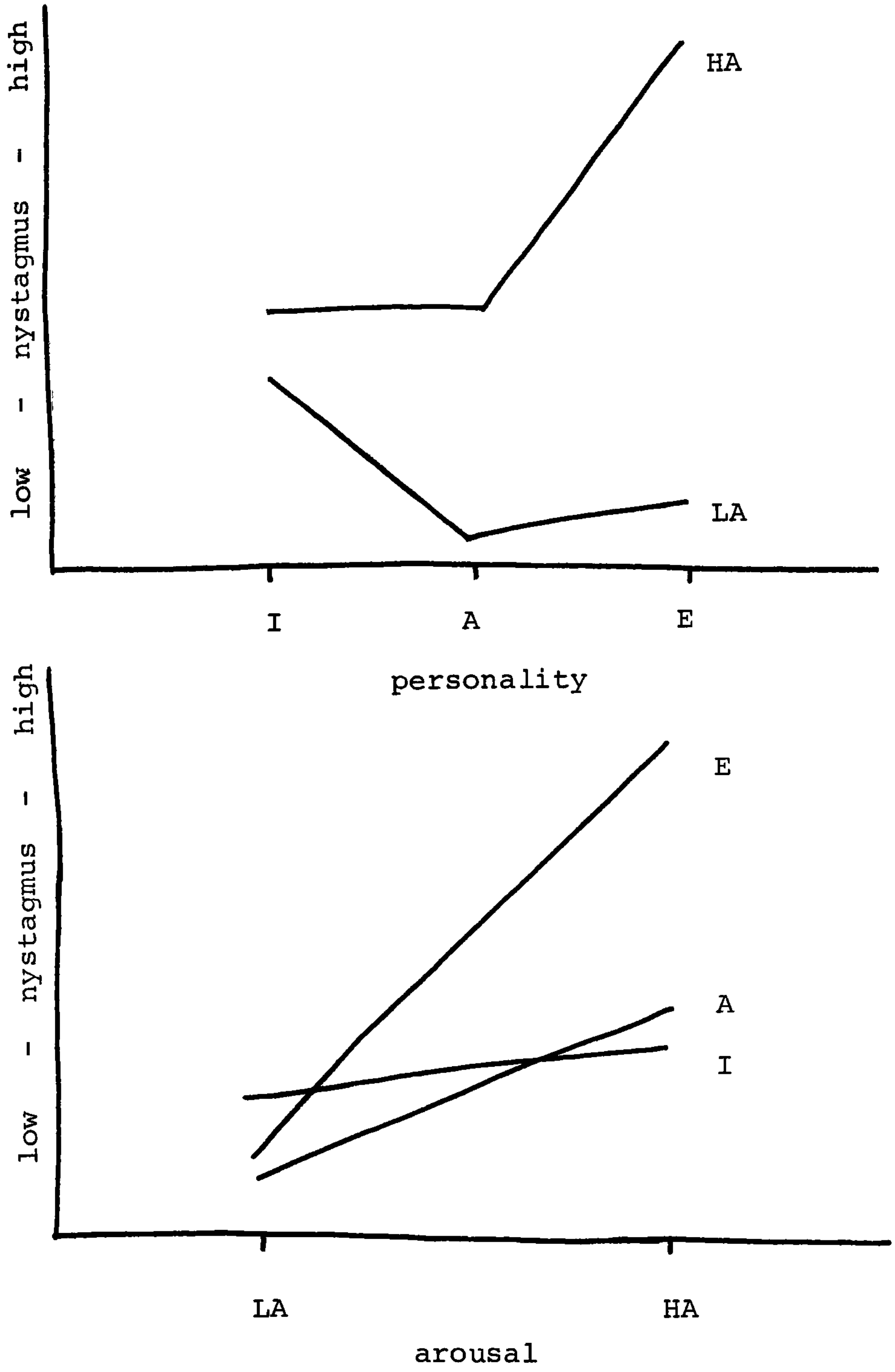

Figure 15. Interaction between treatments of arousal and personality using raw score data.

Table 6

Three-way Analysis of Variance
with Repeated Measures for Difference Scores.
The Variable of Gender Considered

Source	SS	df	ms	F	P
Total	992.75	39	-	-	-
Between subjects	555.38	19	-	-	-
I/E	32.22	1	32.22	1.18	n.s.
Male/Female	19.18	1	19.18	.71	n.s.
Personality/Sex	68.91	1	68.91	2.53	n.s.
Error_b	435.07	16	27.19	-	-
Within subjects	437.37	20	-	-	-
Arousal	273.01	1	273.01	96.81	<.001
Arousal X Personality	107.25	1	107.25	38.03	<.001
Arousal X Sex	3.19	1	3.19	1.13	n.s.
Arousal X Personality X Sex	8.75	1	8.75	3.10	n.s.
Error_w	45.17	16	2.82	-	-

CHAPTER IV

DISCUSSION OF RESULTS

The results of this study showed that groups of introverts, ambiverts, and extraverts varied significantly in their maximum nystagmic output in response to rotational stimulation over varying arousal levels. The critical ratio used as a guideline for accepting or rejecting each hypothesis was set at a five percent level of confidence. In general, the extraverted group produced larger differences in nystagmus between different mental states than either ambiverts or introverts; the introverted group showed the least difference. During low arousal nystagmic output was significantly higher for introverts than for extraverts or ambiverts; however, in high arousal no difference was found between personality types. The predictability of results from the data was not changed whether difference scores or raw scores were used in the calculations.

Both hypotheses presented in this study have been supported by the results. The introverted group gave a significantly higher velocity nystagmic response (resultant arousal level) than the extraverted group in reverie, while with mental activity no significant differences (in resultant arousal level) were found between groups. Secondly, while in reverie introverts produced higher nystagmic velocities than extraverts, with no significant differences in output found under mental activity. The findings of the extravert group, however, presented themselves slightly different than what was expected. The hypothesized ideal interaction between treatments is shown in Figure 18, given the tentative statement that the change in cortical excitation within the Extraversion scale is linear. The actual results show the extraverted group to have a higher rate of change between mental states than what would be predicted, producing a significantly higher nystagmic output than introverts during high arousal. This effect cannot be accounted for.

The question to be asked after reviewing this study is: what subcortical structure(s) could possibly be responsible for the above findings? Put another way: What is a valid operational definition of differing 'strength of the nervous system' which correlates to personality variables? Tentative answers have come from the neuropharmacological work of Dr. Shagass and the neuropsychological studies of Drs. Petrie and LeBeau.

Work on the sedation threshold, begun by Shagass (1954) and continued by him (Shagass, 1956, 1957; Shagass & Jones, 1958; Shagass & Kerenyi, 1958b; Shagass, Muller & Acosta, 1959; Shagass & Naiman, 1955, 1956; Shagass, Naiman & Mihalik, 1956), and others (Claridge & Herrington, 1960,

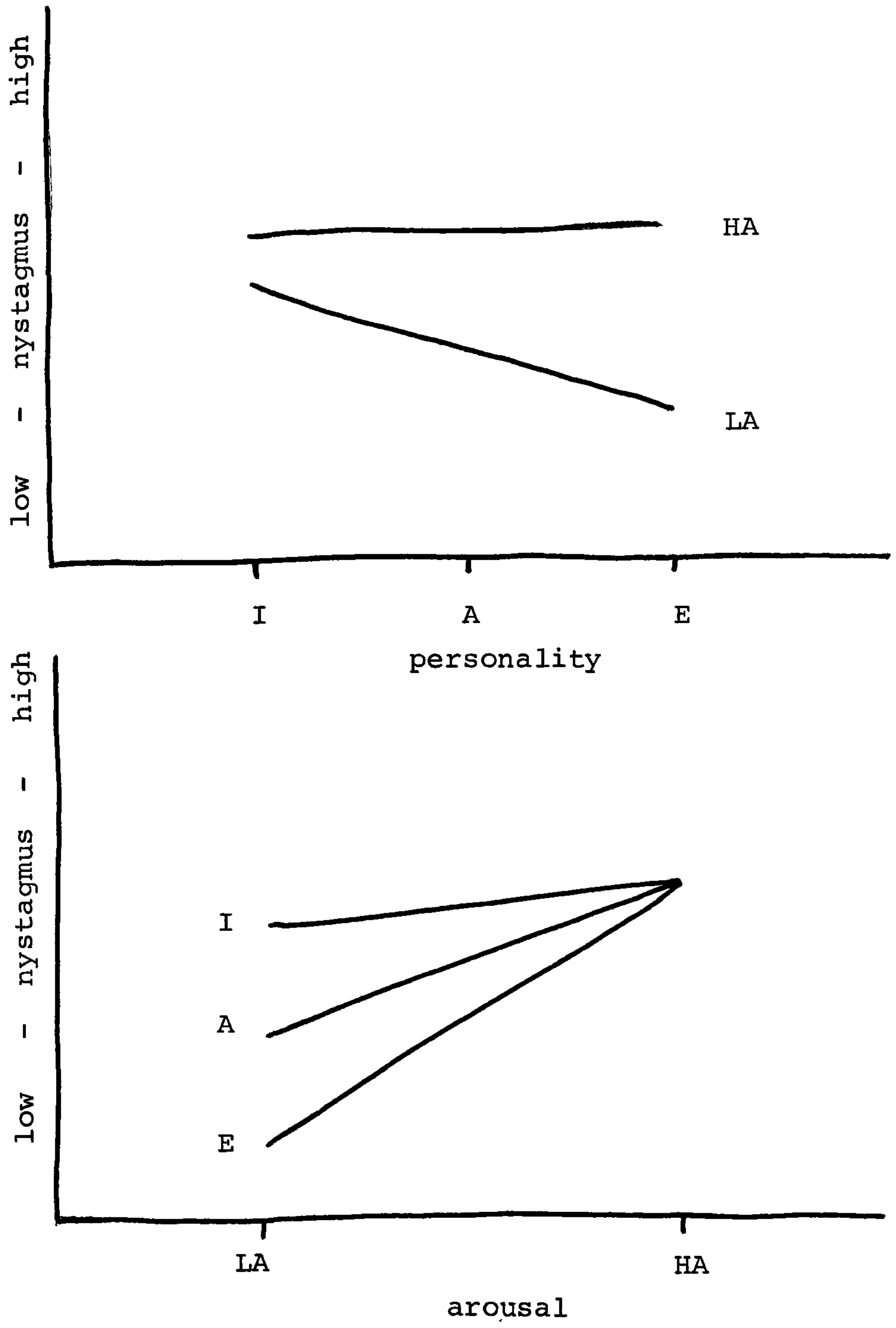

Figure 16. Hypothesized interaction between treatments of arousal and personality.

1963b; Fink, 1958; Nymgaard, 1959; Rodnight & Gooch, 1963) is a method which has been tied specifically to Eysenck's (and Claridge's) theory of personality (Claridge, 1967; Claridge & Herrington, 1960, 1963a; Eysenck, 1967; Rodnight & Gooch, 1963), and of personality in general (Shagass, 1954, 1957; Shagass & Jones, 1958; Shagass & Kerenyi, 1958a; Shagass, Muller & Acosta, 1959; Shagass & Naiman, 1955, 1956; Shagass, Naiman & Mikalik, 1956). A modification of the sedation threshold by Seager (1960) has not only increased the test's reliability but also extended its use to animal research.

The sedation threshold is defined as the amount of a depressant (in mg per kg body weight) required to produce an inflection point in the amplitude curve of frontal 15 to 30 cps electroencephalographic activity. The inflection point is defined as that point which follows an abrupt rise in the curve and precedes a tendency to flatten (see Figure 19 for a better understanding). Extraverts are found to have a lower sedation threshold than introverts. The hypothesized explanation for this is that introverts are higher in cortical excitation than extraverts.

The study of gross surface EEG recordings does not allow one to localize possible structures responsible for the many findings. However, personality changes after psychosurgery do give a clearer picture. A lobotomy is pre-

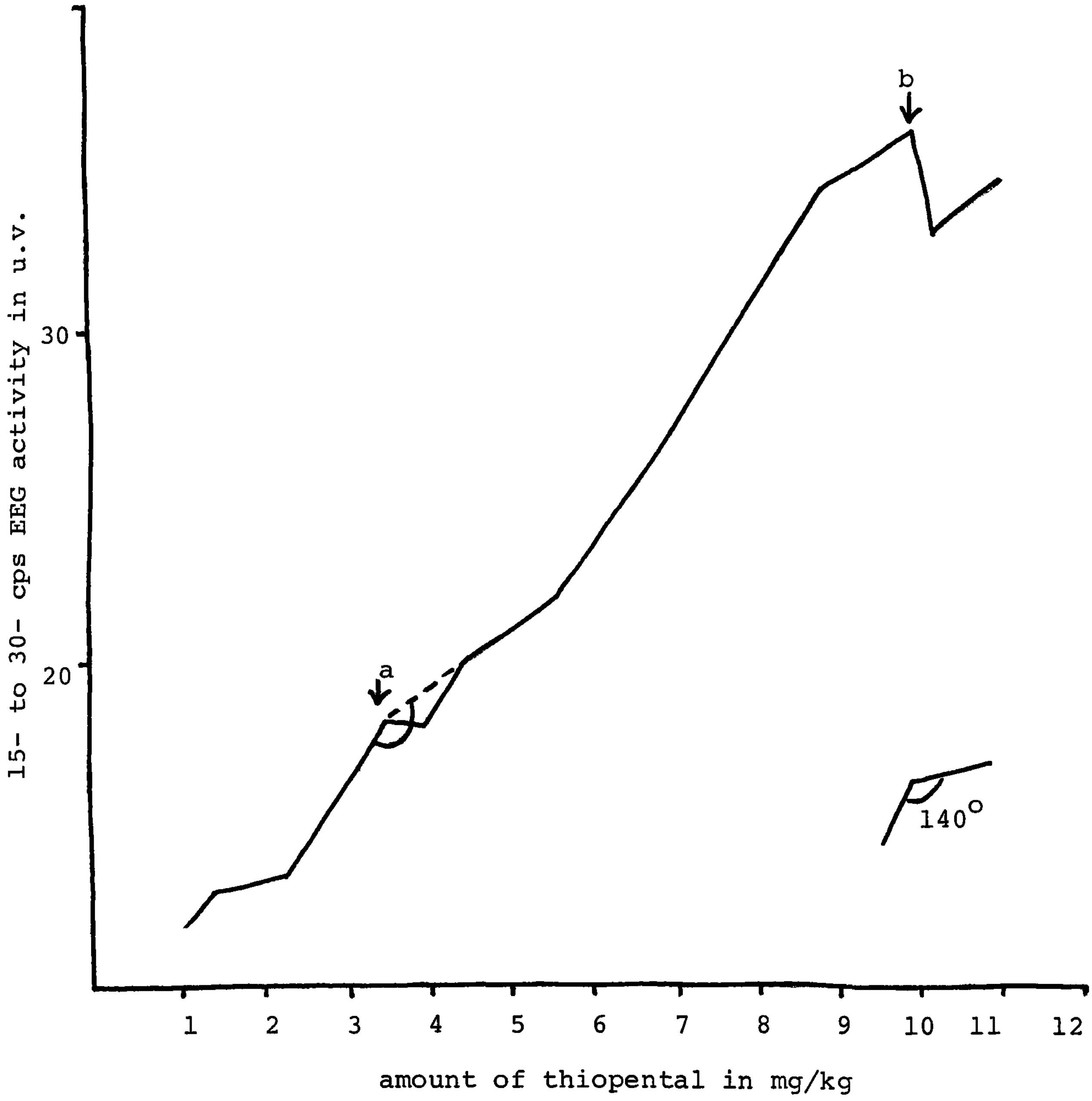

Figure 17. Curve demonstrating sedation threshold. Point a. is one of many inflexion points of a downward open angle of 140 degrees or more. Point b. is the sedation threshold.

formed by cutting the pathways linking the thalamus with those parts of the frontal lobe in the plane of the coronal suture of the skull. The principal tract severed is the thalamofrontal radiation, which arises mainly in the medial nucleus of the thalamus and also in the anterior and lateral portions and goes forward in a compact bundle until it skirts the anterior horn of the lateral ventricle. It then fans out to all parts of the frontal lobe.

The literature is often contradictory in reporting personality changes after lobotomy. This is largely due to the usual psychotic population used and the faulty experimental approach taken by most investigators. One group of experimenters at the Maudsley Clinic has studied only dysthmics since the 1950's, using highly scientific methods (Petrie, 1949a, 1949b, 1950a, 1950b, 1951, 1952a, 1952b, 1954, 1958; Petrie & LeBeau, 1953, 1956; LeBeau, 1951, 1952a, 1952b, 1953a, 1953b). A general summary of their work shows that post surgery the patients increased in extraversion.

Systems which are involved in both the sedation threshold and lobotomy are the frontal lobes and the reticular formation. In the case of lobotomy the retograde atrophy of the thalamofrontal radiation extends to the complete degeneration of the medial nucleus of the thalamus. This tract, along with other thalamic radiations give and receive collaterals from the reticular nucleus of the thalamus.

For the sedation threshold the main effect of the barbiturate is to the reticular formation. The pathway involved can be visualized as line 4 in Figure 11. All the effects described above can be explained by their interaction with this system. The higher cortical excitation of introverts could be due to either a lower threshold of line 4 fibers to firing or to their greater number of fibers. Thus, an independent variable affecting reticulo-cortical tracts (line 4) at any level should decrease or increase the general cortical excitation of the organism.

The vestibular response is also heavily mediated by the pontine reticular formation. Therefore, the fact that highly cortical excited subjects produce higher velocity nystagmus is predictable. This phenomenon has also been found to exist in sub-human organisms as well. When using rabbits (Ferneyhough, 1975), which were categorized on the basis of their sedation threshold, results very similar to those noted with humans were found when rotational nystagmus was also used as an indication of resultant arousal.

Future suggested routes of experimentation are considered for both animal and human studies. One direction could involve ablation studies in sub-human organisms where pre- and post-tests of both sedation threshold and nystagmic response are taken. Another could involve research on lobotomized humans (following Petrie's techniques) where the above pre- and post-tests are applied.

The question of inter-individual differences in the physiology of cortical excitation and vestibular response is more than just an academic exercise. The functioning of the vestibular apparatus becomes essential when man is taken out of his normal environment and cannot depend on his other senses - particularly visual input; such tasks as flying an airplane or scuba diving are examples. Reports of airplane crashes and divers drowning from becoming disoriented in the water and swimming in the wrong direction instead of to the surface are frequent. Haas and Eidebenz (1967) found thresholds for vestibular stimulation to be higher in the evening than in the morning. Fatigue of the vestibular organ resulting from numerous stimulations throughout the day, was thought to be the reason for this finding. Yet, a change in the organism's physiological mental arousal is also a feasible explanation. Although Haas and Eidebenz did not state the variance of scores of the morning and evening vestibular thresholds, if a greater variance was found in the evening (under lower arousal) than in the morning (under higher arousal), an interaction between cortical excitation (viz. personality) of the individual and threshold level of vestibular stimulation is a possibility and presents an area of further research. The implications of these results would lead to a pragmatic suggestion: Persons showing signs of high extraversion, as measured in Eysenckian terms, should have a greater difficulty piloting an airplane or skin diving when under low arousal conditions than high extraverts would have. Hypothesized results of a study of airplane accidents would indicate that more extraverted than introverted pilots would be involved in mishaps occurring under low arousal conditions (in the evening, when the pilot has ingested a barbiturate, or when he lacks sleep). Under high arousal conditions, however, there would be no significant difference between the numbers of extraverts or introverts.

CHAPTER V

SUMMARY AND CONCLUSIONS

The primary aim of this research was to examine the interaction of individual cortical excitation (viz. personality types) with arousal levels. The inquiry focused on the differences in maximum nystagmic response between groups of high, middle, and low extraversion under two different mental states. There were two phases in this investigation. The first phase identified individuals as being introverts, ambiverts, or extraverts. The second phase tested the differences between these groups in their resultant arousal levels (viz. nystagmic output) over two conditions of mental set: reverie and high mental activity. Two main hypotheses were evaluated.

While subjects maintained themselves in a low arousal state, introverts were found to have significantly higher nystagmus (resultant arousal levels) than extraverts or ambiverts. However, in high arousal states no significant difference was found between groups. The increase in the velocity of nystagmus between mental sets of an individual varied significantly for extraverts and ambiverts, but not for introverts.

Suggestions for future research emerged from the results of this study and from possible neuroanatomical tracts involved with introversion-extraversion and with the nystagmic response. Ablation studies involving superior sections of the reticulo-cortical tracts are hypothesized as affecting levels of general excitation and thus personality.

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Appendix 1

A SPECIMEN COPY OF
THE *EYSENCK PERSONALITY INVENTORY: FORM A*

EYSENCK PERSONALITY INVENTORY

FORM A

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

Name____________________ Age________ Sex________

Grade or Occupation ____________________ Date________

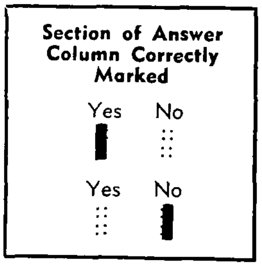
School or Firm____________________ Marital Status________

INSTRUCTIONS

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

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

Section of Answer Column Correctly Marked



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

PUBLISHED BY EDUCATIONAL AND INDUSTRIAL TESTING SERVICE
BOX 7234, SAN DIEGO, CALIFORNIA 92107

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

Appendix 2

TABULATED COMPUTED DATA

APPENDIX 2

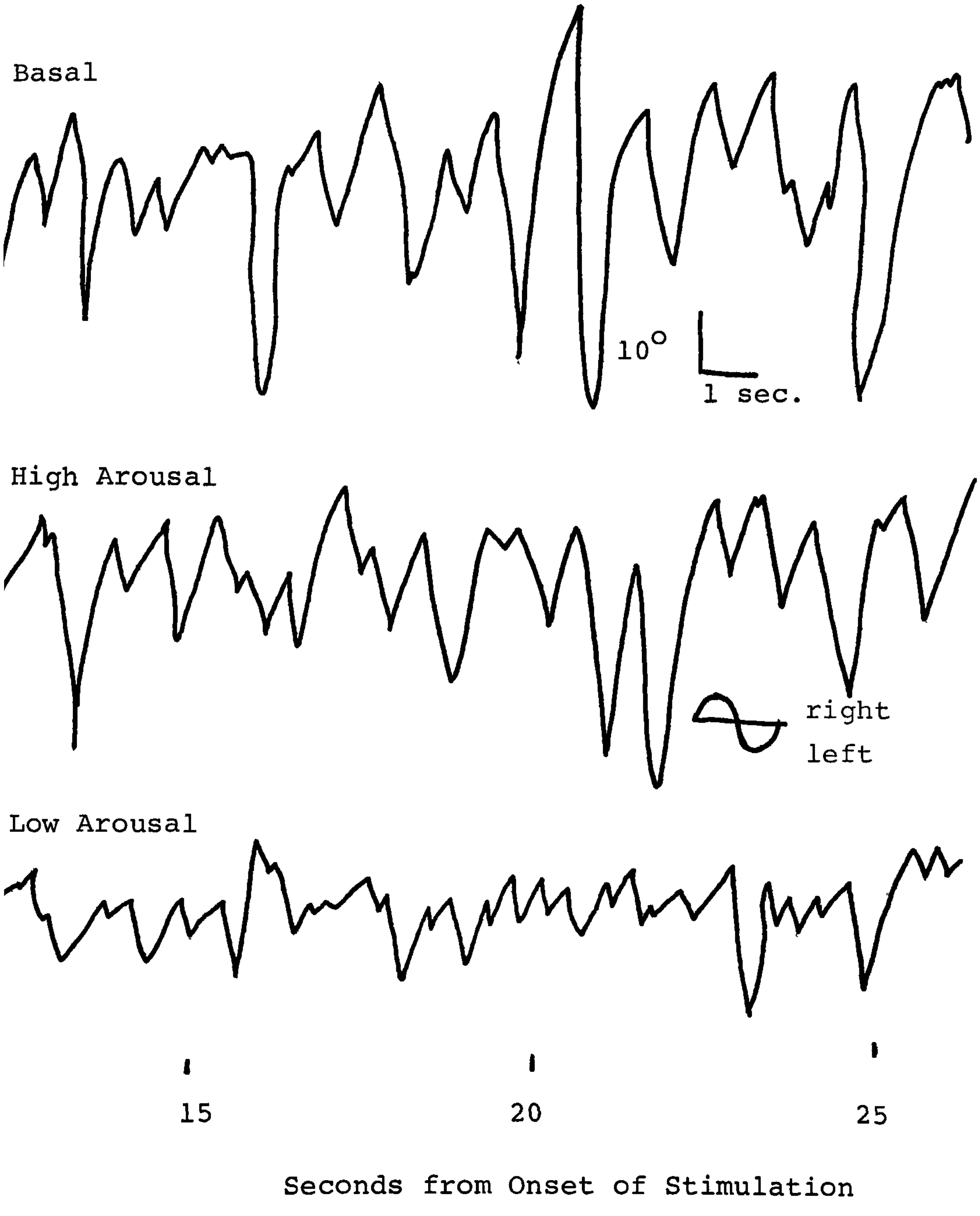
Table I

Computed Statistics for Individuals

Extraversion Score	Sex	Raw Scores			Difference Scores	
		Basal	Low Arousal	High Arousal	Low Arousal	High Arousal
5	Female	29.0	28.3	29.3	-0.7	0.3
5	Female	27.0	35.3	37.5	8.3	10.5
7	Female	23.7	28.8	30.0	5.1	6.3
7	Male	24.0	33.5	36.0	9.5	12.0
7	Female	37.5	39.0	41.5	1.5	4.0
7	Male	18.5	18.3	19.0	-0.2	0.5
8	Male	29.0	30.0	30.5	1.0	1.5
8	Male	32.5	31.5	32.0	-1.0	-0.5
10	Female	35.5	35.0	36.0	-0.5	0.5
11	Female	27.6	24.3	29.0	-3.3	1.4
11	Male	34.7	35.0	36.0	0.3	1.3
12	Male	31.7	28.4	31.8	-3.3	0.1
12	Female	55.0	47.5	51.8	-7.5	-3.2
12	Male	32.0	26.0	32.0	-6.0	0.0
12	Female	37.0	32.3	39.7	-4.7	2.0
13	Female	41.3	39.0	47.3	-2.3	6.0
13	Male	20.7	26.0	28.7	5.3	8.0
13	Male	31.3	28.0	37.3	-3.3	6.0
14	Female	23.0	28.0	35.0	5.0	12.0
15	Male	39.0	34.7	41.5	-4.3	2.5
16	Male	23.3	23.5	28.7	0.2	5.4
16	Female	27.7	27.3	35.7	-0.4	8.0
16	Female	30.8	25.8	38.7	-5.0	7.9
17	Female	46.7	43.3	55.0	-3.4	8.3
17	Female	37.0	32.3	40.3	-4.7	3.3
17	Male	25.7	30.0	41.0	4.3	15.3
17	Female	38.7	31.0	41.0	-7.7	2.3

Appendix 3

ILLUSTRATION OF ENG RECORDINGS



Summated eye movements recorded between the period of 10 to 30 seconds after the onset of rotational stimulation.

Appendix 4

Abstract of

RESULTANT AROUSAL LEVEL AFFECTED BY PERSONALITY VARIABLES OF EXTRAVERSION-INTROVERSION WITH MENTAL SET

ABSTRACT

Although inter-subject variations are well documented for many sensory processes, individual differences in the ability to produce nystagmus is never considered within the evaluation of data. Yet, it is this possible variable which could possibly explain a number of confusing results. Eysenck's neurophysical basis for personality differences is found to be an excellent model from which to explain inter-subject variances in nystagmic response. The interlocking variable for both positions of nystagmus and personality is found to be the level of arousal. It is hypothesized that under low arousal conditions introverts give higher velocity nystagmic responses (an indication of general mental arousal) than extraverts. No significant differences are found in high arousal conditions. Also, the initial basal level of nystagmic velocity of introverts is significantly higher than that of extraverts.

Twenty-seven student volunteers received vestibular stimulation. They were randomly assigned to be tested first or second under high or low arousal conditions. The subjects were grouped as either introverts, ambiverts, or extraverts on the basis of their scores on the _Eysenck Personality Inventory: Form A_. Their nystagmic responses (elicited by linear acceleration to the right) under different mental

arousal conditions were compared. An interaction effect was found, showing that an extravert's and ambivert's nystagmic response in high arousal was significantly higher than their response in low arousal; however, for introverts no differences were obtained. Also, during low arousal condition, significant differences in the nystagmic level were found between personality types.

A neuroanatomical pathway, involving collaterals via the reticular formation, is given to account for this intersubject difference. Further research involving ablation studies is suggested to localize these pathways.