RESPONSE SPEED AND EYSENCKIAN EXTRAVERSION: PREDICTORS OF INTELLECTUAL FUNCTIONING IN THE OLDER ADULT

by Mary E. Garke

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Mary Elaine Garke, c.pp.s., was born December 8, 1935, in Coldwater, Ohio. She received the Bachelor of Science in Education degree from the University of Dayton, Ohio, in 1961, and the Master of Psychology degree from the University of Ottawa, Ontario, in 1971.

INTRODUCTION

Many studies which have compared young adults with older persons have indicated that there are relatively few psychological functions on which they differ significantly. The differences that are noted are often found related to speed tasks and arousal levels. It appears that there may be some factors which are not significantly influential in the performance of the young, but which may be so in the performance of the elderly. Factors which depend upon optimal neurophysiological organization and structural integrity are likely to express their influence as injuries to the cortical-subcortical areas accumulate, or as growth factors no longer mask existing deficits. And so, as age increases these factors become not only more apparent, but also more important in explaining individual differences.

Birren (1970, 1974) has suggested that one such factor is the speed of response. He states that response speed assumes the role of an independent variable because it reflects a basic change in the time with which it takes the central nervous system to process information. In effect, this processing time is a limiting factor in the performance of the older adult.

Observation clearly indicates that older people exhibit a wide behavioral variation in the daily interaction with their environment. The Eysenckian model of personality postulates a biological basis for these individual differences (Eysenck, 1967). The dimension of introversion-extraversion is attributed to cortical excitation-inhibition balance, or the level of arousal in the cortical areas. The hypothesized neurophysiological antecedents, which may be susceptible to aging influences, suggest that this personality dimension may be a significant variable in the prediction of the older adult's performance.

This research, then, proposes to investigate the significance of extraversion and response speed as predictor variables in the performance of the elderly. The particular performance under consideration in this study is intellectual functioning.

Chapter one presents the review of the literature, focusing on the use of reaction time as an index of psychomotor integrity, reflecting the efficiency of central nervous system processing. It presents the Eysenckian model of the personality dimension of extraversion, and some particulars which this concept offers when applied to the older adult. A model of intelligence which incorporates developmental considerations is presented, and the final section gives the hypotheses which this study will test.

Chapter two presents the research design employed in this investigation and includes a description of the subjects, tools, procedures, and statistical operations utilized in the collection and treatment of the data.

And finally, chapter three gives the results of the investigation in terms of the hypotheses, and discusses them in terms of the objectives of the research and the theoretical background.

CHAPTER I

REVIEW OF THE LITERATURE

This review begins by presenting reaction time as an index of psychomotor efficiency, reflecting the general processing of the central nervous system. The literature, here, centers on the interplay of the peripheral and central factors in the Reaction Time Experiment, and underlines the primacy of the central components. Section two outlines Eysenck's concept of the personality dimension of extraversion-introversion and presents the literature pertinent to extraversion and the older adult. In section three, Cattell's model of intelligence is presented distinguishing the two second-order factors of fluid and crystallized intelligence. Finally, in section four a summary is made and hypotheses formed.

1. Psychomotor Integrity

This section presents speed of response as an index of psychomotor performance reflecting the structural integrity and/or the functional efficiency of the central nervous system.

The adverse effect of age on speed of response is one of the least disputed propositions in psychology. Jarvik and Cohen (1973), in their review of psychobiological changes occurring with age, have noted that a decline in performance on speed tasks is by far the most consistent modification of behavior accompanying advancing age. Talland (1965) has generalized to the point of stating "no matter how the task is defined, latency tends to increase with age (p. 528)." This decline in speed of response has been referred to as the "classic aging pattern" (Botwinick & Storandt, 1973, p. 1123). Birren (1970) has seen "slowness of behavior as the independent variable that sets limits for the older person in such processes as memory, perception and problem solving (p. 126)."

Simple reaction time (RT) being low on the scale of behavioral complexity appears to be an extremely sensitive neurophysiological indicator which adeptly reveals any changes beyond the normal physiological and behavioral range (Surwillo, 1968; Talland, 1965). Simple reaction time involves both exteroceptors and effector operations, and their efficient coordination. It tests the organism's capacity in the speedy execution of an act of controlled behavior. Aging impairs this capacity. The studies investigating the slowing in old age focus either on peripheral factors or on central nervous system factors.

A. Peripheral Factors

Under the heading of peripheral factors, studies of nerve conduction velocity, synaptic delay, organ sensitivity, and motor time are reviewed.

Studies of conduction velocity in the human motor nerve have shown that the speed of transmission of the nerve impulse is slowed in old age. Wagman and Lesse (1952) reported preliminary observations which indicated that the maximum conduction velocity of the motor fibers of the human ulnar nerves was lower in subjects (Ss) older than 60 years of age than in young adults 20 to 30 years of age. Mean conduction velocity was 58.4 m/sec in Ss aged 20 to 30 years, 51.4 m/sec in Ss aged 60 to 82 years, and the difference between the two velocities was statistically significant. Norris, Shock and Wagman (1953) applied an electrical stimulus to the left arm over three separate points of the ulnar nerve, namely, at the wrist, elbow and 5 cm below the axilla. One hundred and seventy-five males ranging in age from 20 years to 90 years were the Ss. The maximum conduction velocity showed age-relatedness, 58-59 m/sec for Ss in their thirties and 48-49 m/sec for Ss in their eighties. This difference was significant at the .001 level. They calculated that this reduction in the motor nerve conduction velocity accounts for 4% of the observed changes in reaction speed between 30 and 80 years of age. The importance of these changes is the implication that similar changes may be occurring in other nerve tissue. Birren and Botwinick (1955) hypothesized that if age changes in the peripheral pathways were primarily involved in the slowing of responses, then it would be expected that the reaction time of the foot with its long pathways would be disproportionately slow compared with the finger or jaw. Reaction to an auditory stimulus of a 1000-cycle tone presented through earphones was made by separate response keys attached to the foot, finger and jaw. Young Ss ranged in age between 18 and 36 years and elderly subjects between the ages of 61 and 91 years. The elderly Ss were significantly ($p < .01$) slower than the young Ss for all locations, foot, finger and jaw, reaction times. Age difference accounted for 27, 21 and 29 per cent, respectively, for the speed change in finger, jaw and foot. In contrast to the age difference, no significant difference was found between finger and foot, jaw and foot, or finger and jaw reaction time in the same age group. The conclusion from this study was that the increment in reaction time for the elderly group is a constant, related to age but not correlated with the path length of the peripheral nerves. Talland (1965) reported a variation of Birren and Botwinick's (1955) study in which direct stimulation of the sensory nucleus in the thalamus was made through an electrode. The manual responses elicited were no faster than for visual or auditory signals.

Wayner and Emmers (1958) thought that the general slowing found in aging might be due to prolonged excitation at synapses. They devised an experiment to compare the delay in transmission of the monosynaptic flexor hallucis longus reflex in young and aged rats. Using four groups of rats varying in ages of 117, 276, 445 and 822 days old, a stimulating electrode was attached to the exposed afferent root, L_5DR. The reflex discharges in the ventral root, L_5VR, were recorded. The synaptic delay was obtained by subtracting the conduction time to and from the spinal cord. Synaptic delay increased progressively and significantly over this age range from a mean value of 0.97 msec in the youngest group to a mean value of 1.36 msec in the oldest group. A one-way analysis of variance of Group I-IV resulted in an $\underline{F}$ of 54.180 with a $\underline{p}$ of $<.001$. An analysis in terms of $\underline{t}$ tests indicated that although the differences between the means of successive groups were small, each was significant and that synaptic delay increased with age. However, age differences in synaptic delay, less than .5 msec, accounted for a small percentage of the slowing response in senescence. Birren (1955) found a 20 msec difference in the startle reaction to a loud auditory stimulus or to an electric shock in rats, with the oldest rats being significantly slower. If this is taken as the norm for increased response latency for older rats, then synaptic delay accounts for less than 2% of the slowing.

Longer response latency of old age might result from a slower activation of the sense organ concerned with the initiating stimulus. Weiss (1956a) designed an experiment to determine whether there were age differences in the latency of response of the retina. Latency of the A-wave of the electroretinogram (ERG) was recorded as an index of retinal functioning. Two groups of Ss, one aged 18-37 years and the other 66-76 years, were studied, using five different intensities of light as stimulus. The findings showed no significant differences in the latency of the A-wave of the ERG between young and old Ss. Kumnick's (1956) study of pupillary constriction in response to light and sound stimulation remained unchanged with age over a nine-decade range.

Motor time, defined as the delay or time interval between the electrical activity of the muscle as recorded by an electromyogram (EMG) and the mechanical response, has been investigated as a possible source of the longer response latencies associated with aging. Weiss (1956b) investigated the motor component of RT by recording EMGs from the exterior muscle of the forearm while S responded by lifting his finger as quickly as possible to an auditory stimulus of a 1000-cycle tone. The motor time of 14 young and 10 old Ss proved to be almost constant. Surwillo (1968) re-investigated the relationship of motor time and age because the number of Ss in Weiss's (1956b) study was small and he (Surwillo) had results from previous research which suggested a greater variability in motor time than that given by Weiss. Surwillo used 100 males, aged 28-99 years. They were tested in a RT experiment in which the S responded to a 250-cycle tone by pressing a button with the thumb. A pair of electrodes was attached to the radial side of the palmar surface of the hand and EMGs were recorded. Average value of the group was 48 msec, with a range of 21-108 msec. Considerable variation in the motor time was obtained; however, the motor time was not related to age. A Pearson product-moment correlation between age and average motor time was only 0.092, not significant. This study confirmed Weiss's (1956b) earlier findings, that motor time contributed little, if any, to the slowing of RT in senescence. Botwinick and Thompson (1966) and Weiss (1965) have corroborated this conclusion.

The evidence from the studies on nerve conduction velocity, synaptic delay, sensory organ sensitivity and motor time has shown that age differences in the various peripheral processes cannot account for the slowing of RT observed in the elderly. The peripheral processes do contribute, but only minimally. Many investigators (Birren, 1965, 1970; Talland, 1965; Weiss, 1965, Botwinick & Thompson, 1966; Surwillo, 1968; and Thompson & Marsh, 1973) have suggested that psychomotor slowing reflects reduced fidelity of the central nervous system functioning.

B. Central Factors

Investigations of central nervous system (CNS) components and/or functions have not been conclusive as to specific structures responsible for psychomotor slowing in the older adult. Much of the evidence is indirect; the strength of the CNS involvement comes from the accumulation of such evidence. This review presents the biological characteristics of the aged brain, some functional similarities between brain-damaged people and the older adult, and the studies of electrophysiological correlates with psychomotor slowing.

Vogel (1969) characterized the biological features of the nervous system that render it prone to progressive dysfunction. In contrast to most somatic cells, the neuron is incapable of mitotic division. It is only in the embryonic stage and in the subependymal region that the neuron shows any propensity for mitotic division. As the neurons mature and differentiate into cortical material they acquire stability and longevity, but lose the potential for self-replication. This developmental characteristic may be most significant. Inherent in this inability of mitotic division is the progressive loss of function which accompanies the neuronal depopulation. In addition, the population of neurons experiences the accumulated effects of internal and environmental insults. The effects basically are a quantitative loss; depopulation of cells occurs at different rates in different individuals but it is an inescapable phenomenon. Another developmental characteristic is the capacity loss of glial cells in the CNS for remyelinization (Yakolev, 1959). Myelinization facilitates conduction speed through the axons. Accurate assessment of myelinization, or the lack, in the CNS has not been made as the neural dysfunction in the aged brain.

The loss of the potentiality for cell replication and the regeneration of myelin does have the benefit of establishing a stable complex network of synapses. By these anatomical connections the CNS becomes an integrated functional whole. This integration is germaine to high cortical functions, such as intelligence (Wang, 1968; Willanger et al., 1968).

Neuronal depopulation occurs as the nonreplicating neurons die. Occlusive vascular disease accelerates depopulation of neurons; however, depopulation does occur independently of cerebral arteriosclerosis. There is some evidence that the variability of neuronal depopulation is controlled genetically, an expression of deoxyribonucleic acid (DNA) (Vogel, 1969). Huntington's chorea and Down's syndrome both support DNA as the prime responsible factor.

Morphological changes of neurofibrillary degeneration, senile plaques and granulovascular degeneration apparent in Down's syndrome, Alzheimer's disease and the aged brain are similar. Vogel (1969) notes that it is unlikely that the morphological and functional changes in Alzheimer's disease and aged brain are expressions of genetic composition and further states "morphology of the lesions, their biochemical composition and the profound functional effect are uniform whereas ostensibly the causation is multiform (p. 261)." Morphological likenesses have been well documented by microscopic studies of Margolis (1959) and Barton (1962).

Thus, while brain changes are known to occur with age, and accompanying dysfunctions can be observed, no single causative factor is known. Time, *per se*, is hardly an appropriate causative factor even though the changes occur with increasing age.

Psychomotor slowing has been shown to be related to the integrity of the CNS. Classification of the brain-damaged individual has been quite general without reference to kind, extent and/or even location of the lesion. Most studies suffer from the inadequacy of this classification; however, a common retardation in psychomotor performance is present in brain-damaged individuals.

Blackburn and Benton (1955) investigated RT characteristics of non-psychotic patients with cerebral disease. Their study was designed to answer the question of significant differences in simple or choice RT between non-psychotic brain-injured patients and patients not suffering from cerebral disorders. Thirty brain-injured patients and 30 non-brain injured were used as *S*s. Patients were given a simple RT task to a visual signal, were rested, and then given a choice RT task to a visual signal. The mean of the simple RT for the non-brain-damaged patients was 208 msec, *sd* of 40 msec; for the brain-damaged patients the mean was 303 msec, *sd* of 140 msec. The difference in mean RT between these two groups was statistically significant ($p < .001$). Further analysis using the median RT of the two groups achieved a 70% screening efficiency. The mean choice RT for the non-brain-damaged was 310 msec, *sd* of .046, and for the brain-damaged 386 msec, *sd* of 102 msec, also significantly different ($p < .001$). Using the same procedure of median RT for the choice task, the screening efficiency was also 70%. This study concluded that brain-damaged patients are significantly retarded as compared with control patients on both simple and choice RTs. These findings have been interpreted to support the generalization that a

> fundamental cerebral function in man is to provide the necessary neural arrangements for the performance of simple high speed tasks and that injury to any part of the brain will result in impairment in such performance (Benton & Joynt, 1958, p. 247).

Benton and Joynt (1958) studied whether localization of the brain lesions within a single cerebral hemisphere showed any differential effects on RT. Assuming that cerebral integrity was necessary for normal RT it was predicted that patients with unilateral lesions would show retardation in simple RT involving both ipsilateral and contralateral sides. Twenty patients with lesions restricted to the right cerebral hemisphere, 20 patients with left hemispheric lesions and 20 control patients comprised the Ss for this study. The simple RT task and the choice RT task were to a visual stimulus following an auditory warning signal. The results showed the mean simple RT of the control group to be significantly different ($p < .001$) to both the right hemispheric lesion group and the left hemispheric lesion group. The two lesion groups did not show a significant difference between their mean scores, 33 msec. On the choice RT task, brain-damaged patients showed differential patterns between right-hand performance and left-hand performance. The findings were interpreted as supporting the concept that simple RT reflects overall cerebral status. "These focal lesions impair a general organismic capacity . . . which is an important determinant of the quality of simple high speed performance (p. 253)," and "focal lesions have both a general bilateral and a specific unilateral effect on reaction time . . . (p. 255)."

The studies of Costa (1962) and McDonald (1964) have reported similar results of slower simple RTs among the brain-damaged compared to hospitalized controls. Arrigoni and De Renzi (1964) investigated further the effect of localization of the lesion on simple RT. They tested 125 patients with diagnosed unilateral lesions. Patients with right-sided lesions were slower than patients with left-sided lesions. However, it was noted that right-sided lesions tended to be larger than left-sided lesions and that slower

RT may have been a function of size rather than of focus of the lesion. The De Renzi and Faglioni (1965) study supported a greater RT deficit in subjects with right-sided as compared to left-sided lesions.

In more complex psychomotor tasks such as tapping tests and manual dexterity, retardation has been noted by both the brain-damaged and the elderly Ss (Reitan, 1955, 1959; Reed & Reitan, 1962, 1963). Similarity in performance on the Sequin Formboard task (Reed & Reitan, 1962), on the Trail Making test (Reitan, 1958), and the Halstead Battery (Halstead, 1947) may indicate organic changes in the brain of the older Ss. Surwillo (1973) has shown that, as the number of bits of information increases as in complex choice RT tasks, the amount of time required to process the information increased with age. Miller's (1970) work with information processing among the brain-damaged showed similar slowing.

The variables of practice effect and motivation have been studied (Benton & Blackburn, 1957; Blackburn, 1958; Shankweiler, 1959; Farber & Spence, 1956) as to their relationship to RT performance of brain-damaged Ss. The general conclusion from these studies was that the variables of practice effect and motivation do improve the performance of the Ss; however, they do not bring the level of performance up to the performance of normals. Botwinick, Brinley and Robbin (1958) found similar results with older Ss. Older Ss'

RT performance improved under motivating instructions and shock treatment but not to the level of performance of younger _S_s.

Psychomotor slowing has been shown to be related to the integrity of the CNS. Studies of electrophysiological correlates to aging and psychomotor performance are here cited to support CNS involvement. Electroencephalographic changes with age were first reported by Busse and co-workers (Busse _et al_., 1954). In the population of the over-60's approximately one-third have deviant electroencephalograms (EEGs) of the focal type consisting primarily of slow waves. This deviation is greatest over the anterior temporal area and occurs most often on the left side of the brain. These slower waves have been observed in senile psychiatric patients (Obrist & Henry, 1958) and the normal elderly (Busse & Obrist, 1965). In this latter study EEG changes over the adult span of life were investigated. _S_s were separated into three groups: young adult, 20-39 years; middle-age, 40-59 years; and elderly, 60-79 years. The incidence of normal EEG patterns dropped from 85% to 65% to 51% for the groups, respectively. Sex differences occurred for both the middle-age and elderly groups, with women showing excess fast activity ($p < .01$). In 10% of the elderly group, a diffuse slow activity was prominent. Kooi _et al_. (1964) found no evident medical factors responsible for the common types of temporal divergencies as reported by Busse and Obrist (1965). Wang and Busse (1969) concluded that the alpha slowing was probably due to a continued downward trend in alpha frequency with advancing age.

A series of studies have been carried out for the purpose of relating RT to EEG measures. Conclusions based on the studies remain equivocal; some have pointed to such a relationship (Lansing *et al*., 1959; Fedio *et al*., 1961; Dustman *et al*., 1962); others have failed to show the relationship (Birren, 1965; Hermelin & Venables, 1964; Thompson and Botwinick, 1966).

Efforts to relate RT and EEG measures in the elderly have yielded equally equivocal results. Surwillo, in a series of studies, investigated the relationship between RT and EEG measures (Surwillo, 1963a, 1963b, 1964, 1966, 1968, 1973). He showed that simple RT is related to brain wave frequency. In one study (1963a) for a sample of 100 *S*s, a correlation coefficient of .72 was reported between mean RT and average period of the EEG. (Brain wave period is the reciprocal of brain wave frequency; Surwillo reports all correlations and statistics using this unit of measurement since it is linear with respect to time.) EEG alpha slowing was shown to be related to increased variability, increased decision time, and slowness of voluntary movement in elderly *S*s. Surwillo points out two limitations of his investigations.

First, reactions to stimuli were obtained only in the presence of well-developed EEG activity. Second, only Ss with well-defined waves in the interval between stimulus and response were included in the analyses. This arbitrary selection of data imposes certain restrictions on interpretation.

Birren (1965) found no relationship between RT and EEG patterns in the elderly. Thompson and Botwinick (1968) designed a study to explore the manner in which an EEG activation pattern may relate both to RT and to the experimental condition of "set" or "expectancy" as related to the manipulations of preparatory interval durations and series. These functions were investigated with respect to age of Ss. The elderly Ss (62-87 years) had 12 or more years of education, were relatively healthy, and had a measurable alpha activity in the parieto-occipital tracing of the EEG. The young adults (19-35 years) met the same criteria. Old and young Ss did not differ in overall level of EEG change, but did react differently to variations in the preparatory interval. If EEG measures are accepted as rough indices of CNS arousal, the inference can be made that patterns of arousal are different for young and old, depending upon "set" as reflected in preparatory interval manipulation. An age difference in arousal pattern does not offer an explanation of age difference in RT as no relationship is shown between RT and EEG patterns. Thus in this study EEG changes did not explain the slowing in old age.

The methodology and the statistical analyses in both Birren's (1965) and Thompson and Botwinick's (1968) were quite complex; nevertheless, failure to find a relationship between RT and EEG measures in the elderly was surprising, if not somewhat disappointing. Thompson and Marsh (1973) questioned the sensitivity of the clinical resting EEG to minimal changes in cerebral functioning and concluded "there is still a strong inclination to expect significant EEG correlates of response speed (p. 124)."

In studies utilizing average evoked responses individual differences were markedly noted. The amplitude of earlier wave forms during the first 100 msec following the stimulus tended to increase with age for visual (Straumanis *et al*., 1965), auditory (Schenkenberg, 1970), and somatosensory (Luders, 1970) stimulation. The general agreement among these investigators is that changes in evoked responses with age are due primarily to CNS factors.

The studies of cerebral lesions and psychomotor performance indicate a general slowness involving initiation and execution of movement. Precise location of the cerebral sites related to this phenomenon is not conclusive. Vanderwolf (1971) has provided evidence for certain electrophysiological activity in the limbic-diencephalic system, particularly in the hippocampus which is associated with voluntary movement. Jung and Hassler (1960) believed that extrapyrâmidal structures function as motor mechanisms of attentive behavior in close cooperation with brain reticular formation which they consider chiefly as the center for motor coordination. A diffused area rather than a narrowly limited one is indicated. Hicks and Birren (1970) summarize the findings:

> A unitary system, slowness of RT, seems to have a multiplicity of central nervous system antecedents. The evidence suggests the existence of a system that is diffuse in location but specific to structure. Brain-damaged patients are quite likely to have destruction in one or more parts of this cortical-subcortical system because of its diffuseness. Older individuals, in whom there is often cellular loss which may or may not be uniform throughout the brain, would as likely be affected as the brain-damaged in terms of structure involved, although the extent of the destruction might not be as great (p. 396).

From the evidence accumulated via exclusion of the peripheral factors, by the findings of electrophysiological studies including alpha rhythm of EEG measures and evoked potentials, by the similarity of functioning in the brain-damaged and the older adult, and by the known biological characteristics of the aged brain, it may be said that psychomotor performance, specifically RT, reflects the general state or condition of the integrity of the CNS.

RT has been presented as a significant indicator of psychomotor efficiency; the personality dimension of extraversion as presented in Eysenck's theory is postulated to reflect the inhibition/arousal aspects of the CNS. In the next section Eysenck's theory is presented briefly and studies relating it to the older adult are reviewed.

2. Personality Dimension of Extraversion

In this section, part one presents Eysenck's concept of the personality dimension of extraversion-introversion with its physiological basis. Part two reviews the literature and research relative to extraversion and the older adult.

A. Eysenckian Concept of Extraversion

In formulating his theory, Eysenck (1967) postulated the personality dimension of extraversion-introversion to have a biological basis. Individual differences in the cortico-reticular loop which modulates cortical arousal and inhibition are thought to be applicable to individual differences in personality along the extraversion-introversion continuum. Individual differences are attributed to the quality of the excitation-inhibition balance, "i.e., the overall resultant of all excitatory and inhibitory potentials which are postulated to be active at any given moment (Eysenck, 1967, p. 80)." Excitation of the cortical-subcortical areas would characterize the introvert. It is within these areas that "processes of an unknown character facilitate learning, conditioning, memory, perception, discrimination, thinking and mental processes generally (p. 75)" occur. Resulting from the excitation of the cortical-subcortical area would be an increased efficiency of the cortex and a decreased behavioral excitation or increased behavioral inhibition. The extravert, on the other hand, would be cortically inhibited; cortical processes of an unknown character would reduce the cortical efficiency, manifesting itself in an increased behavioral excitability and a decreased behavioral inhibition.

Ideally, the measurement of the excitation-inhibition balance would be made in terms of separate measures of the excitatory and the inhibitory potentials. Eysenck noted that for the present these potentials are hypothetical constructs and not physiological variables, and therefore can be assessed only by some observable performance. He further suggested that it is impossible to separate the specific influences of excitation and inhibition so that a deficiency in performance may be described or explained in terms of increased cortical inhibition or, conversely, in terms of decreased cortical excitation.

Eysenck postulated a higher level of arousal in the introvert and a higher level of inhibition in the extravert. This postulate was derived from his general theory relating extraversion-introversion and the reticular formation arousal system. In his words:

> In terms of our excitation-inhibition theory most stress in accounting for extravert-introvert differences has been laid on inhibition . . . in linking up this theory with neurophysiology stress seems to have shifted to arousal, differences in arousal level and high arousal thresholds (p. 231).

Eysenck specified that the cortico-reticular loop is the responsible agent of arousal.

> Neural messages ("sensations") going along the classical ascending afferent pathways relay to the particular projection areas involved in the cortex; they also send collaterals into the reticular formation, which in turn instructs the reticular formation to continue to send "arousal" messages or else to switch to "inhibition" (p. 230).

Accordingly, the reticular loop is concerned with "information processing, with cortical arousal and inhibition, and in its application to personality differences with introversion and extraversion (p. 230)." Differences in behavior related to the personality dimension of introversion-extraversion are identified with threshold in various parts of the ascending reticular activating system.

In weighing the contributions of both concepts of arousal and inhibition, Eysenck does not consider that arousal alone is sufficient. The experimental work associated with involuntary rest pauses, with vigilance decrement and with adaptation requires a theory of inhibition; ". . . a simple account in terms of arousal is clearly not sufficient (p. 248)."

Gray (1964) has reviewed the work of the Soviets, namely, Teplov's and Nebylitsyn's, which attempted to extend Pavlov's theory of a physiological basis of personality to man. The dimension known as "strength of the excitatory processes," weak-strong, has been shown to have similar characteristics to Eysenck's continuum of introversion-extraversion, both of which are "dependent on the degree to which the cerebral cortex is bombarded by impulses from the non-specific reticular activating system (RAS) . . . (Gray, 1967, p. 152)." The concept of arousal, or levels of arousal, is therefore indicated. Experimentally the evidence identifying strength of nervous system with introversion-extraversion comes from the studies of sensory thresholds. In the Russian studies (Gray, 1964, 1967) those individuals with weak nervous systems had lower absolute thresholds in visual and auditory modalities than those individuals with strong nervous systems. Likewise, it was found that introverts have lower auditory (Smith, 1967) and pain (Haslam, 1966; Lynn & Eysenck, 1961) thresholds than extraverts.

Gray (1967) proceeded to give other studies which supported the introversion = weakness of the nervous system hypothesis; namely, studies of distractibility, stimulus intensity, flicker phenomenon, drug effects, and reactive inhibition. Presentation of the details is not necessary for development here. (See Gray, 1967, p. 157-163, for references to the studies.)

The Russians have a second concept, "equilibrium of dynamism," which is based on conditionability, the speed of formation of positive and negative conditioned reflexes. Gray (1961) presented the development of these concepts. Here it is sufficient to state that the introversion = equilibrium of dynamism hypothesis receives support from EEG studies and speed of conditioning. However, the Russians maintained "strength of nervous system" to be orthogonal to "equilibrium of dynamism." Gray had hinted (1967) and then strongly supported (1970) the concept that conditionability not be the basis for the postulated introversion-extraversion dimension. He recommended (1970) the replacement of greater conditionability of the introvert with a greater sensitivity to punishment and to frustrative nonreward. Gray made this conclusion after studying eyeblink conditioning in man and the physiological locus of the drug sodium amobarbital, an extraverting agent, in animals. From these studies he conceptually extended the arousal area to include the limbic system components, the orbital frontal cortex, septal area, and the hippocampus. This system added the negative feedback loop to which the ascending reticular activating system is coupled. Gray (1970) states it thus:

> Eysenck has consistently presented a picture of increased cortical arousal in the introvert leading to increased behavioral inhibition, though he has sometimes used the vocabulary of "arousal" or "excitation" (higher in the introvert) and sometimes that of "cortical inhibition" (higher in the extravert). If we now substitute for "cortical" arousal, the degree of activity in the feedback loop constituted by the ARAS, the orbital frontal cortex, the medial septal area and the hippocampus, we see that there is indeed a considerable amount of evidence that activity in this system leads precisely to the kind of behavioral and sensory (selective) inhibition so emphasized by Eysenck and his group (p. 261).

Thus, general agreement as to the physiological basis of extraversion-introversion seems established. The cortico-reticular structures involved have not been completely delineated and the arousal/inhibition quality of the cortical area awaits further differentiation.

In presenting his theory, Eysenck (1967, 1973) borrowed the concepts of "genotype" and "phenotype" from biology. Genotype refers to personality in its constitutional or physiological aspects, reflected in the results of experimental tests such as conditioning, pain tolerance, vigilance, drug effects, etc. Phenotype, on the other hand, refers to descriptive social behavior. This behavior is a function of constitutional differences in interaction with the environment. The observable introversion-extraversion behavior can best be measured in terms of questionnaires and personality inventories. While the relationship between the laboratory tests and the questionnaires is not absolute, the correlation is significant (both theoretically and empirically) to use one as the predictor/indicator of the other.

Eysenck's theory postulating observable personality dimensions to have a physiological basis has been presented briefly. The application of this theory with its concepts of cortico-reticular arousal/inhibition and behavioral introversion-extraversion to the older adult has certain particulars which are considered in the next part.

B. Extraversion and the Older Adult

That brain injury or pathology should produce changes in personality seems a reasonable hypothesis, for impairment of the nervous system must result in some changes in the organization of biological determinants of both cognitive and non-cognitive behavior. The fact that from maturity onward there appears to be a gradual process of diffuse brain damage leads to the prediction that with advancing age (beyond maturity) there will be, likewise, personality changes.

Blakemore (1967) noted that the basic assumption in relating individual differences to neural processes has been that

> inter-individual behavioral variation is dependent to some extent upon the state or nature of the nervous system which each individual possesses. . . . In case of injury or pathology of the brain . . . neurological efficiency will be reduced, and corresponding changes and impairments of behavior will be observed (p. 320).

In terms of Eysenck's theoretical formulation, brain injury or pathology

> would interfere with the reciprocal exchange of neural impulses between the cortex and the reticular activating system, thus increasing the effects of the suppressor mechanism. The results of brain damage would therefore be related to increased cortical inhibition, leading behaviourally to such effects as slow formation of conditioned responses, swift accumulation of reactive inhibition and extraversion (Blakemore, 1967, p. 325).

Birch, Belmont and Karp (1965) have suggested that the cortico-neural processes of brain-injured Ss are characterized by states of excessive inhibition. In an earlier study, Birch et al. (1964) found that when brain-damaged and neurologically intact patients were compared, the intact individuals tended to judge the auditory stimuli as equal to, or to overestimate, the intensity of the second tone. In contrast, the neurologically impaired patients underestimated the intensity of the second tone, a tendency which diminished as a function of the time interval between stimuli. The interpretation advanced for this temporal phenomenon was that the basic mechanisms of arousal and inhibition are the same for both intact and brain-damaged subjects, but that the latency period for recovery is increased following neurologic damage. The interpretation was suggested by the slope of the brain-damaged group's time curve. Thus a slower rate of return to baseline functioning and a delay in the recovery rate for re-establishing response balance may exist in the brain-damage. In the 1965 study the time interval between tones was systematically extended beyond the 5 sec to the 9 sec interval. It had been hypothesized from the previous data that the brain-damaged Ss would overestimate the time interval (as do the intact Ss) if the time interval were lengthened to allow for recovery. Twenty neurologically impaired and 20 intact patients participated in the study, 17 of whom had participated in the previous (1964) study. The Ss were required to make a "louder than" or "softer than" comparison judgment between two auditory stimuli, successively presented tones. To guard against response set, the time intervals (5-9 sec) and tone intensity (89-93 db) were randomized. The brain-injured group showed a consistent shift from the "softer than" judgment to the "louder than" judgment as the time interval increased. At the 9 sec interval the brain-damaged group had overestimated to the same degree as the intact group at the 3 sec interval. This finding was interpreted to support the hypothesis that the brain-damaged required a longer latency period to return to normal levels of responsiveness after stimulation. The prolonged state of inhibition of the brain-damaged patients may be caused by alteration of recovery rates in the reticulo-cortical system or spread of inhibition of a local excitation-inhibition system.

Experimental evidence supporting increased inhibition or neural satiation (see Kohler & Wallach, 1944, for development of satiation concept) in the brain-damaged may be gleaned from studies related to perceptual processes, e.g., spiral after effect (Holland, 1965), flicker fusion (Landis, 1954), and perception of apparent movement (Saucer & Deabler, 1956). These perceptual processes have been related to phenotypic expression of extraversion. In Paramesh's (1963) study, introverts were shown to have a longer persistence of after effects than extraverts ($p < .01$). Firth (1967) has shown the influence of personality on flicker fusion when noise is introduced as an experimental variable. Introverts who are hypothesized to be at their optimum level of arousal show no change in performance under noisy or quiet conditions. Extraverts show a significant improvement ($p < .05$) under noisy conditions.

When the older adult is considered, there is again ample support for the hypothesis that with increasing age there is an increase in inhibition. Braun and Gerselhart (1959) stated that the main and striking finding was the relative inability of elderly Ss (62-84 years) to acquire the conditioned eyeblink response. Difference in the number of conditioned responses between children (8-10 years) and the elderly was significant beyond the .002 level. The same level of confidence held for the difference between young adults (18-25 years) and the elderly. The children and young adults showed no significant differences in the number of conditioned responses given. Older Ss have been shown to be less vigilant on auditory tasks (Griew & Davies, 1962), to have shorter duration in after effect persistence (Griew & Lynn, 1960; Holland, 1965), and significantly underestimate stimulus duration (Fiefel, 1957).

Generally, in studies comparing young adults with older adults, the older adults perform in a manner consistent with having higher inhibitory potentials than younger adults. However, the older adult does not seem to display the postulated extraverted behavior which increased inhibition would suggest. In fact, certain behavior patterns of the elderly suggest social introversion. Studies of age differences in social responsibility (Schaie, 1959), rigidity or resistance to change (Chown, 1961), social attitudes (Eysenck, 1947), higher vocabulary levels than general intelligence would indicate (Foulds & Raven, 1948; Dockey, 1954; Wechsler, 1958), and color preferences (Eysenck, 1941) all support increasing introverted patterns of behavior with age.

This social introversion is further evidenced by measures such as questionnaires and inventories. Eysenck (1959) and Eysenck and Eysenck (1969, 1973) have shown that Extraversion scores (E-score) decrease with increasing age. In the normative sampling for the *Eysenck Personality Inventory* (*EPI*) the Pearson correlation between E-score and age was -.24 (Eysenck & Eysenck, 1968). Likewise, in the standardization of the *Personality Questionnaire* (*PQ*), the E-score for 2,312 males decreased from a mean of 14.46, *sd* 4.27 for the 16-19 year-olds to a mean of 10.44, *sd* 4.97 for the 60-69 year-olds (Eysenck & Eysenck, 1973).

Lynn (1964) has stated that, in a consideration of Eysenck's theory for aging, the two levels--excitation-inhibition balance and introversion-extraversion behavior patterns--of personality need to be distinguished. He felt that although the two levels "tend to be associated in subjects of the same age, it does not necessarily follow that they shift in the same direction during the ageing process (Lynn, 1964, p. 344)." Lynn suggested that as people get older the reduction in efficiency in some tasks can be "compensated for by the advantages of increased experience (p. 347)"--conditioned behavior patterns.

At this time it is not possible to determine whether the postulated increase in inhibitory potentials in the older adult is due to a decrease in cerebral arousal or due to structural changes which have decreased the number of possible neuronal firings. The concepts are not that well defined nor directly measurable; neither is the instrumentation sufficiently sophisticated to distinguish between arousal level (excitation-inhibition balance) and arousability (structural/functional integrity).

This part presented the application of Eysenck's theory of extraversion to the older adult. An apparent inconsistency arose in that the excitation-inhibition balance seemingly shifted toward greater inhibition with increasing age; whereas, social behavior patterns become more introverted with increased age. It was suggested that behavioral introversion compensates for the reduced efficiency accompanying old age. Reduction of cognitive efficiency has constituted much of the study of the older adult. A model of intelligence which exhibits age relatedness and has a postulated physiological-acculturation basis will be presented in the next section.

3. Fluid and Crystallized Intelligence

In this section the model of intelligence proposed by Cattell (1943, 1963), Horn and Cattell (1966), and Horn (1968, 1970) is presented. This model is closely linked to developmental considerations and distinguishes two major (second-order) dimensions of intelligence, fluid and crystallized.

These two dimensions of intelligence, fluid and crystallized, have emerged from the factor analytic studies of primary mental abilities as defined initially in Thurstone's (1938) research. Cattell (1963) has shown that there are more than one "general ability" second-order factors. Two of these second-order factors have been shown to be highly cooperative, i.e., they agree in loading positively most of the general ability primaries. One of these factors should be defined primarily by abilities which seem to be quite closely related to intense acculturation; whereas, the other should be defined primarily by abilities which are less closely linked to this. The former has been called crystallized intelligence (g_c), and the latter, fluid intelligence (g_f).

The dimensions of fluid intelligence are assumed to be related to neurophysiological antecedents reflecting differences due to hereditary influences. g_f is the major measurable outcome of the influence of biological factors on intellectual development. In addition, g_f represents that part of intelligence which "results from the interaction of basic physiological capacity with a set of subject- and cultural-invariant experiential antecedents (Baltes & Labouvie, 1973, p. 166)." g_f represents processes of reasoning in the immediate situation in tasks requiring abstracting, concept formation and attainment, and the perception and eduction of relations. The measurement is best made when "task materials are culture fair; that is, the fundaments are either novel for all persons being measured or else are extremely common, overlearned elements of a culture, and the aids (Cattell, 1963; Horn, 1965) needed to attain solutions are not those made available, by favored educational opportunity, to some persons and not to others among those measured (Horn, 1966)." The tasks which best define g_f (as obtained by Horn, 1965, in a comprehensive study of factor structure among primary mental abilities) are such as the following: (a) Letter grouping and series; (b) Figure classifications, Topology and Matrices; (c) Common word analogies; (d) Nonsense equations and paired associates memory. These tests are relatively weak indicants of acculturation and thus provide good measures of fluid intelligence. Fluid intelligence is assumed to exhibit a pattern that closely matches the growth and decline of maturational and/or biological processes--a steady decline from early maturity.

Crystallized intelligence is assumed to be a "precipitate out of experience . . . due to subject-related differences in experiential processes associated with the cause of acculturation (Baltes & Labouvie, 1973, p. 166)." It indicates the breadth of awareness and subtlety of relations previously perceived, concepts previously attained, etc. g_c will be measured most purely "under conditions in which subjects must use concepts and aids representing relatively abstruse elements of the collective intelligence of the culture (Horn & Cattell, 1966, p. 255)." The measure of g_c is taken through tests such as: (a) Vocabulary and general information; (b) Syllogistic reasoning and inferences; (c) Social situations and experiential evaluation; (d) Arithmetic reasoning; (e) Ideas as in ideational fluency. In these tasks the perception of relations, eduction of correlates, reasoning, etc., required for problem solving must usually be premised upon the absorption of what has been the "collective intelligence of culture." For example, in an analogy such as: Hippocrates - Galen: Aeschylus - Greece, Euripides, Pericles, Zeno (taken from Terman's Concept Mastery Test), perception of relations is required for the solution, but one must be knowledgeable about a rather esoteric aspect of Western culture to reach the solution. Persons who can solve rather complex problems of the kind which define g_f may often fail to solve a simple analogy problem if they lack a type of information. This illustration is given to support the differentiation of g_f and g_c and to show the culture base of g_c. g_c is assumed to be dependent upon education and acculturation, therefore, a longer period of increase is expected into late adulthood and subject to slight, if any, decline in old age.

A certain degree of correlation is assumed between these two types of intelligence since the ability to appropriate that which at one time must have been novel is a precondition for g_c. This correlation would be expected to diminish with increasing age.

The general theory is that fluid intelligence increases throughout childhood and into young adulthood, but then levels off and eventually declines; whereas, crystallized intelligence increases throughout most of the entire period of development, from childhood to late maturity. The reasons for these predictions are given in Horn (1965). A general summary is given below:

(1) The neural and other physiological structures upon which intellectual functioning is based mature by growth and increase in complexity until the late teens or early twenties.

This maturation is reflected directly in the increase in g_f, which is dependent upon the adequacy of the physiological structures which support learning. Maturation is also indirectly reflected in g_c.

(2) Injuries to the neural and other physiological structures which occur throughout life are cumulative and irreversible. During the course of a perceptible time span they may not be noticed. In childhood the injuries may be masked by larger effects of neural growth, learning and development. The injuries, however, have a long-term limiting influence on intelligence development. In adulthood when masking influences cease to be effective the results of neural damage become evident.

(3) In the population of older people large injuries to the neural structures are likely to be more frequent than in younger people. The effects of these larger injuries will be manifested in g_f; the mean g_f for older adults is likely to be lower than the mean g_f for younger adults.

(4) Some learning occurs incidentally and is manifested primarily in g_f. During childhood an intensive acculturation occurs through formal education. Consequently, g_c increases at a rapid rate during this period. However, maintaining a culture demands a continuous learning throughout adulthood. There are many inducements and incentives which encourage an adult to acquire more of the collective

intelligence. Thus g_c may indeed increase with age. (Cf. Cattell & Horn, 1967.)

Horn and Cattell (1967) have shown the postulated changes in a cross-sectional study. Using a sample of 297 older teenagers and adults, age range of 14 to 61 years, a series of tests of second-order factors of intelligence was given. The results of this study showed intelligence to both increase and decrease with age depending upon the definition adopted, crystallized or fluid. Linear effects associated with sex, education, perceptual-motor speediness, fluency and carefulness were partialed out. The results were clear: fluid intelligence declines with age in adulthood and this decline is not ascribable to decline in other functions; and older adults perform better than younger adults in tasks depending primarily on crystallized intelligence, and the differences are not ascribable to sex, education or the other functions mentioned above.

When the question of decrement in the intellectual functioning of the older adult is addressed, the issue of methodological differences also arises. Cross-sectional and longitudinal studies both have their limitations. In a series of articles and studies (Schaie, 1965, 1970, 1973); Schaie & Strother, 1968; Baltes & Schaie, 1974) an attempt was made to minimize the particulars of cross-sectional (failure to recognize the differential experiences of the life span) studies and longitudinal (failure to recognize environmental impact related to a given period of time) studies by advocating and adopting a sequential method of data collection and analysis. The latest of these studies (Baltes & Schaie, 1974) has shown decrement only in a visuomotor flexibility factor. Increase with age was observed only in the crystallized intelligence factor. On the other two factors, cognitive flexibility and visualization, no age changes were recorded.

Thus the importance of using at least a two-factor concept of intelligence rather than an omnibus intelligence is seen both theoretically and empirically. This definition of intelligence becomes imperative in studies of the older adult where differential age changes occur.

This section has presented the two-factor theory of intelligence as proposed by Cattell. Fluid intelligence is assumed to have neurophysiological antecedents, to be relatively free of educational and acculturational affects and to be age related. Crystallized intelligence is assumed to be dependent upon educational and acculturational opportunities and to exhibit little or no decline with increased age.

4. Intelligence and Extraversion

In factor analytic studies of intelligence, noncognitive,personality factors have generally been grouped under second-order factors such as extraversion, ego-strength, and anxiety levels (Cattell, 1963; Vernon, 1965). In factor analytic studies of personality, cognitive, intellectual factors have generally been considered independent or orthogonal to the personality dimensions (Cattell, 1957; Eysenck, 1952, 1969).

Cattell's (1963) study, using 278 junior high school students, showed extraversion to be significantly correlated with a third-order general ability factor, $r = .18$, $p < .05$. At the second-order level extraversion was shown to be correlated, $r = .29$ and $r = .17$, with fluid and crystallized intelligence, respectively. Extraversion, in this study, was a second-order factor derived from the primary factors of the High School Personality Questionnaire (Cattell & Bellof, 1959). The primary factors of this questionnaire have the same meaning as the factors constituting the 16 PF.

Eysenck's studies (1952, 1969) indicate relative independence of general intelligence to extraversion. However, there is some accumulation of evidence that extraversion is related to academic achievement. Lynn and Gordon (1960) have suggested that introverts differ from extraverts on four principal characteristics which may affect academic achievement; namely, (1) Learning speed, introverts appear to form conditioned responses more quickly; (2) Intelligence, introverted neurotics have higher vocabulary levels and tend to do better on intelligence tests; (3) Work decrement, introverts can maintain a longer attention period at a given task; and (4) Accuracy and speed, introverts tend to be slower and more accurate.

To evaluate these four characteristics, 60 university students, ages 18-23, were tested on Raven's Progressive Matrices and Mill Hill Vocabulary Test. The finding pertinent to the development here is that no significant correlation ($r = -.05$) was found between intelligence as measured by Raven's Progressive Matrices and extraversion; on the other hand, a product-moment correlation of -.27, $p < .05$, was obtained for the extraversion-vocabulary relationship.

These studies leave the question of relating extraversion to intelligence somewhat ill-defined. Age-relatedness or change and the conceptual difference between Eysenckian extraversion and Cattell's extraversion open an area for research endeavor.

5. Summary and Hypotheses

It has been shown that psychomotor efficiency, measured via a simple reaction task, serves as a significant reflector of the general neuro-cortical condition and central nervous system functioning. Peripheral nerve factors were excluded as the main effects' contributors to a slower reaction time and central factors were accentuated. The main point is that with advancing age slowness in response reflects a basic change in the speed with which the CNS processes information. Thus speed of response becomes a limiting factor for the older adult. General observations suggest that given enough time the older individual can do most of the things he did when he was younger. Whereas, in the younger person, speed of response is seen as a dependent variable; with older people speed of response explains other kinds of behavior--perception and memory become less efficient, retrieval from long-term memory store decreases as does the likelihood of novel associations. (See Birren, 1970, 1974.) Generally among older adults those who have a longer response latency would be predicted to do less well on intellectual tasks than those with a shorter latency.

Eysenck's theory of extraversion with its biological basis has been presented. Individual differences in personality along the introversion-extraversion continuum are hypothesized to be related to differences in the cortico-reticular loop which modulates cortical arousal and inhibition. Increased efficiency in the mental processes would occur with increased arousal or decreased inhibition. Support for the neurophysiological basis of personality has been given by the Russians' concept of weak - strong nervous system, experimentally indicated through sensory thresholds. The structures involved have not been completely delineated; evidence from

Gray's work (1964, 1970) would add limbic system components, orbital frontal cortex, septal area and hippocampus to the reticular ascending pathways postulated by Eysenck. The observable introverted-extraverted phenotype behavior patterns are hypothesized to be a function of constitutional differences in interaction with the environment.

In applying Eysenck's theory of extraversion to the older adult, the two dimensions, excitation-inhibition balance and expressed behavior patterns, may need to be considered separately. With age there is an apparent shift toward greater inhibition, a predicted direction if the physiological structures are assumed to have accumulated impairment over life's years. However, the expressed behavioral patterns seem to tend more toward introversion. The explanation offered is that introverted behavior patterns are the result of previous conditioning and therefore not susceptible to the rate of decrement found in the new conditioning which is dependent upon present reticulo-cortical arousal. In order to clarify the "nature" of extraversion among the older adults a perceptual phenomenon, Spiral After-effect, which is explainable in terms of cortical inhibition (Holland, 1965) will be utilized to establish the empirical relationship between an index of the excitation-inhibition balance and Extraversion scores of the _Eysenck Personality Inventory_ for older _S_s. Among older adults, those who exhibit less inhibition or more introversion would be predicted to do better on intellectual tasks than those who exhibit more inhibition and extraversion.

Cattell's two-factor model of general intelligence has been reviewed. The two factors, g_f and g_c, have emerged from factor analytic studies of primary mental abilities. g_c is closely related to education and acculturation and appears to be little affected by the aging process. g_f, on the other hand, is assumed to have neurophysiological antecedents and susceptible to the accumulated injuries of a long life span. Differential aging patterns have been shown for g_f and g_c (Horn & Cattell, 1967), consequently the necessity to include at least a two-factor model of intelligence when the older adult is under consideration.

Thus the literature clearly demonstrates age-related changes with regard to intellectual functioning. These changes are more observable in the non-educational, non-bound, more flexible fluid intelligence which requires non-learned, unpracticed novel responses. Paralleling this literature, neurophysiological, medical, and neuropsychological literature is replete with neurophysiological changes generally described as a decreased efficiency of functioning. However, a vagueness exists as to what determines these age changes beyond a general descriptive level. There is increasing vagueness in the question of individual differences in aging beyond social dimensions, in particular, personality disposition.

Hence, this thesis intends to study a personality dimension, Extraversion, with respect to intellectual functioning in old age; to test Extraversion's hypothetical neurophysiological basis in a sample of older adults and to evaluate the relative contribution of this personality factor with the more clearly understood contribution of general neurophysiological integrity in the maintenance of intellectual functioning in old age.

With these objectives in mind, the following hypotheses, in the null form, are presented.

Among older adults:

1. (a) There is no significant correlation between the Extraversion scores of the EPI and the duration of the after image as induced by the Spiral After-effect procedure. (b) Concurrently, there is no significant correlation between the Extraversion scores of the EPI and Reaction Time latency.

2. There is no significant difference among mean scores between Fast, Moderate, and Slow Reaction Time (Latency) groups on (a) Fluid Intelligence scores and (b) Crystallized Intelligence scores.

3. There is no significant difference among mean scores between Extraverted, Ambiverted, and Introverted groups formed from the Extraversion scores of the EPI on (a) Fluid Intelligence scores and (b) Crystallized Intelligence scores.

4. In a multiple regression equation with Fluid Intelligence scores as the criterion variable and Education, Occupation, Reaction Time, and Extraversion as the predictor variables there is no significant predictor among the predictor variables included in this equation.

5. In a multiple regression equation with Crystallized Intelligence scores as the criterion variable and Education, Occupation, Reaction Time, and Extraversion as the predictor variables, there is no significant predictor among the predictor variables included in this equation.

6. If a multiple regression is computed for the total group ($N=120$) and for two randomly chosen subgroups ($n=60$), there will be no significant difference between the multiple Rs for each of the subgroups compared to (a) each other, and (b) the total group, the criterion variables being Fluid and Crystallized Intelligence scores, respectively.

7. If the B weights and constant from each random subgroup are applied to the scores of the other random subgroup and multiple Rs computed, there will be no significant difference between the cross-validation multiple Rs compared to (a) each other, and to (b) the multiple R for the total group, the criterion variables being Fluid and Crystallized Intelligence scores, respectively.

The following chapter will outline the sample, the tools, research procedure, and statistical operations used to test the hypotheses.

CHAPTER II

RESEARCH DESIGN

This is a descriptive study designed to provide information regarding the influence of response speed and extraversion on the intellectual performance, fluid and crystallized, of the older adult. It was also designed to explore the nature of the extraversion personality dimension in the older adult. This chapter presents a description of the subjects, followed by a presentation of the tools utilized in the research, and the procedure for carrying out the testing. The last section of the chapter discusses the statistical operations used in the analysis of the data.

1. The Subjects

The subjects for this study were 120 males, aged 60 years and over. The elderly men were recruited for participation in this study from six Ottawa Housing Authority Senior Citizen Apartments: Clementine Towers, Hampton Court, Golden Manor, McLaren Apartments, Regina Towers, Rochester Court; from four church-related social groups: Holy Cross, St. Theresa, St. Joseph, St. George; and from senior citizen groups of two social clubs: RA Center Senior Bridge Club and Knights of Columbus Council No. 5717.

Recruitment took the following form and generally proceeded according to plan. Initial contact was made with the social activities coordinator, or some such representative person; in the cases of the church-related groups the parish priest was initially contacted. Through this contact person, arrangements were made to address the residents or members at a regularly scheduled meeting.

At the first meeting the researcher was identified as a graduate student of the University of Ottawa doing research for her doctoral thesis on the topic of some characteristics of the aging person. They were told that at this time only male volunteers were being sought. Information given included that approximately two hours' participation would be required, that during this time they would be asked to do several simple tasks and answer a questionnaire, and that they would be paid a nominal sum for their time and participation in the research. A pre-arranged date was set for the initial testing session. A poster was tacked to the bulletin board to serve as a reminder of the date.

Although the above paragraph gives the initial contact that certainly was necessary for introducing the researcher and the study, the few participants of the first testing session deserve credit for recruiting the majority of participants. The number of responders on the first visit was generally few, but by words of encouragement and reassurance from those who did participate the numbers grew considerably in subsequent visits. This was most true of the residents of the senior citizen apartments and the RA social club. "Being paid" after each session also served as a concrete, visible incentive. It was necessary to reassure some participants that this study was not for the government, income tax purposes, pension plan, etc. Upon inquiry, the participant was told simply that the study was part of the requirements for the degree. The nature of the study was not divulged.

The subjects were chosen from among the volunteers if they met the following criteria: (a) aged sixty years or over; (b) independent occupant, i.e., not receiving home or institutional nursing assistance in basic living procedures; (c) presently not taking mood-changing medication; (d) exhibiting no gross motor deficits; (e) capable of understanding the tasks required; (f) able to read English. The first 120 males who volunteered and met the criteria were accepted. All participants considered themselves retired.

Demographic data including age, education, and occupation prior to retirement were collected for each S. A summary with mean and standard deviation for age and education, and the number in each occupation is given in Table 1 for the total group (N=120). Age ranged from 60-90 years, with a mean age of 70.9, and a sd of 6.3 years. The

Table 1

Mean and Standard Deviation of Age and Education, and Number in Each Occupation (N=120)

	Age	Education	Occupation	
			Type	N
Mean	70.9	8.9	Unskilled laborer	27
S.D.	6.3	4.0	Skilled laborer	57
			Clerical worker	11
			Managerial position	20
			Professional	5

mean education was 8.9 years, with a sd of 4.0 years. Type of occupation was used to indicate the general social class to which the S belongs. Social class has been a rather confusing, and not agreed upon, variable to delineate. In this study, occupation prior to retirement was considered to be as meaningful as any other division. In Table 1 it can be observed that nearly two-thirds of the participants were from the unskilled and skilled laborer divisions.

2. The Tools of the Research

The subjects of this research were assessed on a measure of psychomotor integrity, a simple reaction time test. A personality inventory was used to index the personality dimension of introversion-extraversion. These two measures constituted the predictor (independent) variables of this study. Due to the theoretical underpinning of extraversion as a measure of cortical inhibition, Spiral After-effect was included to delineate the nature of extraversion in the older adult. In addition, two measures of cognitive functioning were taken, reflecting fluid and crystallized intelligence. These two measures constituted the criterion (dependent) variables of the study. These measures are presented in the order given.

A. Reaction Time Instrumentation

The Reaction Time Test was of the simple reaction time type with a warning signal. The instrumentation consisted of a self-standing, blackened 30" X 24" board which had a single yellow light, Bayonet Panel Lamp 14 V 230 Ma 1991 - miniature incandescent, placed one inch below center of the board, up 11 inches from the bottom. The board was placed on a card table. A standard telegraph key mounted on a small wooden block was placed on the table immediately in front of the board and directly below the light. The key was so wired that when the key was depressed, the light went on. The light-on was the warning signal. The light-off was executed through the abort system controlled by the experimenter. The timing of the abort was random so that the light was on not less than two seconds and not more than ten seconds. Model 5810 Timer, Lafayette Instruments, was used. This timer is accurate to the .01 second. The latency period was the time in milliseconds between the execution of light-off and the releasing of the telegraph key. The latency time was measured by Model 54517 Clock/Counter, Lafayette Instruments, and was printed by Model 56025 Printer, Lafayette Instruments. The clock/counter is accurate to the .1 millisecond. Reset occurred when the key was depressed again. The apparatus was set up so as to be self-pacing. A schematic diagram of the reaction time instrumentation is given in Figure 1. Figure 2 gives a pictorial representation of the apparatus. The latency time was the datum used.

B. Eysenck Personality Inventory

The Eysenck Personality Inventory (EPI), 1963, is a self-report questionnaire comprised of 57 items to which the subject must answer "yes" or "no." Two parallel forms of the test are available, Form A and Form B. The EPI purports to measure two distinct and orthogonal personality dimensions, i.e., Extraversion-Introversion and Neuroticism-Stability. A Lie Scale is also included to pick out attempts on the part of Ss to answer questions in a socially desirable manner. The EPI (Form A) appears in Appendix 1.

The normative, validity and reliability data presented in the Manual (Eysenck & Eysenck, 1968) are based primarily on undergraduate students. The appropriateness of utilizing this test with a sample restricted to older males may be questioned. However, in subsequent research on age-relatedness, Eysenck and Eysenck (1969, 1973) have prepared norms, in the form of means and standard deviations, and have shown linear trends in extraversion, with E-scores decreasing with increased age, significant to the .0001 probability level.

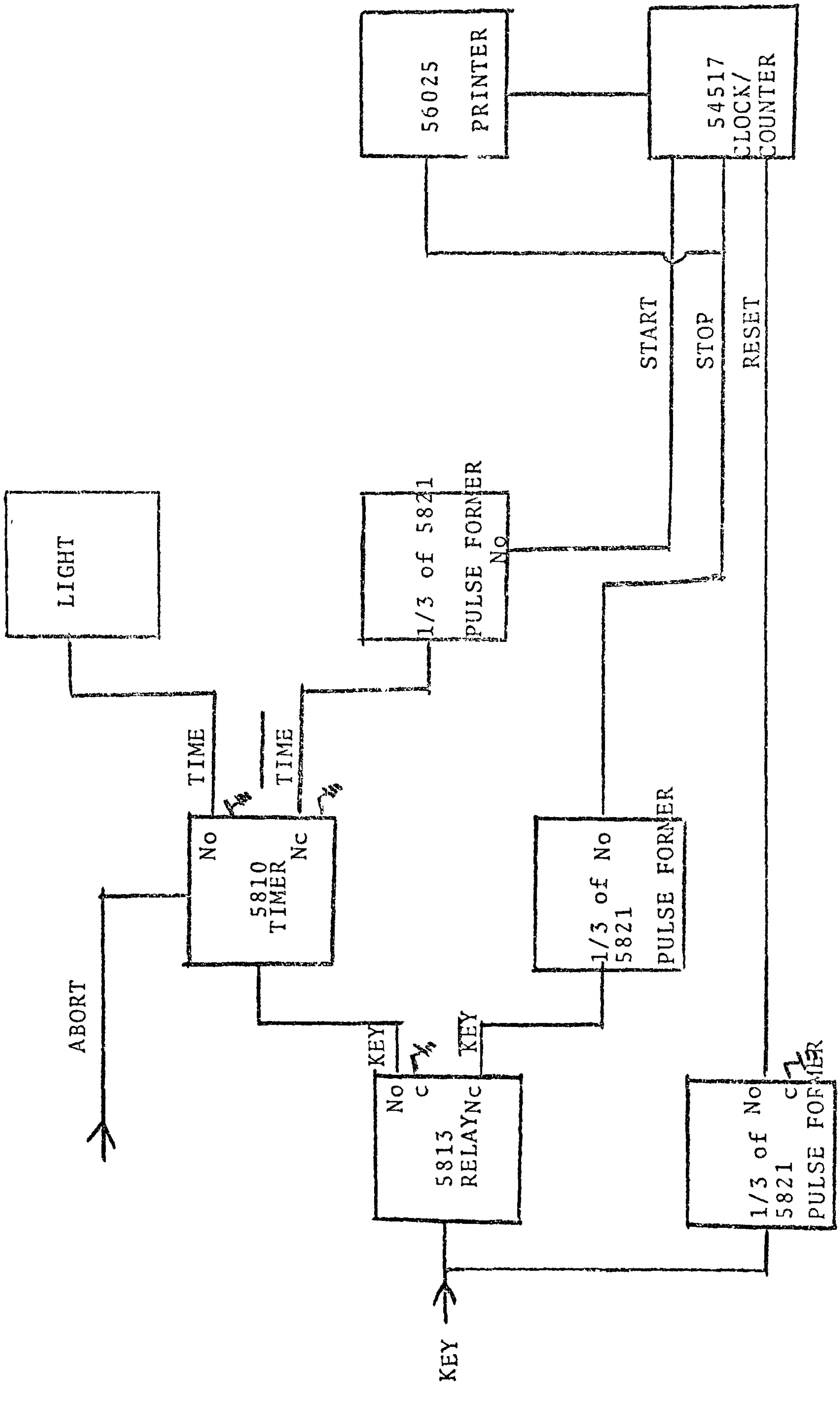

Figure 1.- Schematic Diagram of Reaction Time Instrumentation.

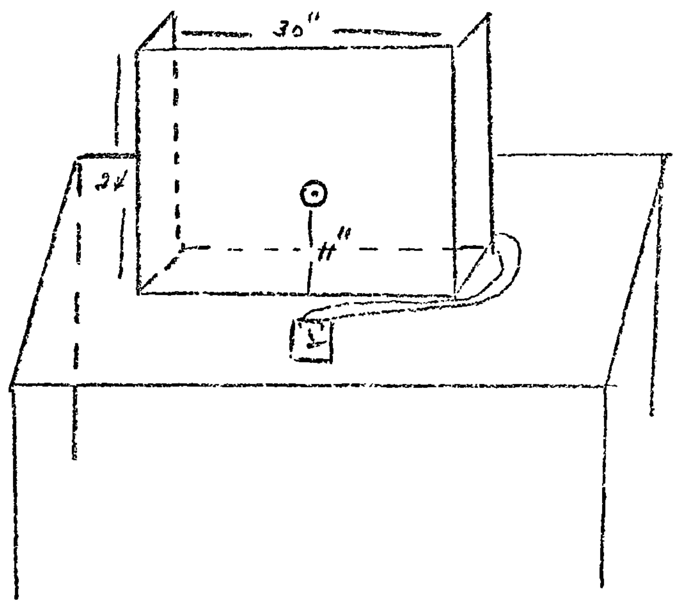

Figure 2.- Pictorial Representation of Reaction Time Apparatus.

Eysenck's personality theory has postulated a brain-behavior relationship relating low and high cerebral excitation, fast and slowly developing cerebral inhibition to psychological extraversion and introversion, respectively. As this study was concerned with these neurophysiological substrates to behavior in old age, Eysenck's EPI was the logical measure of this factor.

Research has shown that Eysenck's test scores of Extraversion correlates with physiological measures of human function, appropriate and directional differences between Extraverts and Introverts being demonstrated, e.g., in classical eyeblink conditioning Introverts condition faster than Extraverts (Eysenck, 1965); Extraverts have shorter duration of after-effect phenomenon than Introverts (Paramesh, 1963); Extraverts improve performance under noisy conditions, whereas Introverts, who are hypothesized to be at optimal arousal, exhibit no change in such conditions (Firth, 1967); and Introverts have lower sensory thresholds than Extraverts (Smith, 1967; Lynn & Eysenck, 1961).

The Extraversion score is of primary interest in this study. However the Neuroticism dimension as measured by the EPI is considered in the initial correlation matrix and regression.

C. Spiral After-effect

The Spiral After-effect (SAE) is explainable theoretically in terms of cortical inhibition and thus postulated to be related to the Eysenckian concept of extraversion (Claridge & Harrington, 1963). The inclusion of the SAE in this study is to furnish a theoretically acceptable neurophysiological measure of extraversion as contrasted with a self-report (EPI). This is of special interest in light of Lynn's (1964) distinctions between neurophysiological conditions of excitation-inhibition and the behavioral patterns of extraversion-introversion in the older adult.

The instrumentation for producing the desired after-effect is herein described. A 9-inch, 4-turn, arithmetic, black on white, spiral was attached to the shaft of a small motor, Hi-Drive Model #8-100, 3-6 volt, Wilson's of Cleveland. The small motor was mounted on a self-standing structure with a 10" X 9" frontal surface of dull-tan, non-contrasting pressboard. The structure was placed on a card table. A small silver knob at the center of the spiral served as a focal point. The speed of the rotation was 100 rpm; the direction of the rotation was inward. After a 45-second period of eye fixation upon the rotating spiral, a 24" X 30" white screen was placed before the subject. The duration of the after-effect, the illusion of movement in the opposite direction to that previously experienced, was timed by a stop watch. Duration time, as reported by the experiencing subject, was considered the raw data.

The specifics of the instrumentation and presentation were based on the research reported by Holland (1965).

D. IPAT Test of "g": Culture Fair

The IPAT Test of "g": Culture Fair, Scale 2, Form A, was used as the measure of fluid intelligence. Scale 2 is designed for eight- through fourteen-year-olds and for unselected (non-college) adults. "It extends over use in an adult clinic and for elderly persons (Cattell & Cattell, 1973, p. 12)." Scale 2 consists of 46 items arranged in four subtests, Series, Classifications, Matrices, and Conditions. Two parallel forms, Form A and Form B, of Scale 2 are available. Answer sheets, CF 2-AS-6A, were used. The IPAT Test of "g": Culture Fair, Scale 2, Form A, appears in Appendix 2.

Even though the Handbook (Cattell & Cattell, 1960, 1973) suggests using Scale 2 for elderly persons, no normative, reliability or validity data are given for older age populations. However, the test was considered appropriate for research use as factor analytic studies (French, 1951; Cattell, 1963; Horn & Cattell, 1967) have shown these items to load on the g_f factor.

The subtests of the IPAT Culture Fair test appear to be derived from two primary factors (see Horn & Cattell, 1967), namely, Induction, which proposes an eduction of a correlate from relations shown, as in the Series test, and Figural Relations,[1] which proposes an eduction of a relation when this is shown among common figures, as in Classifications, Topology (Conditions), and Matrices. In a summary of some results from studies in which g_f and g_c factors have been identified, Induction shows a .41 loading on g_f, and a .06 on g_c; Figural Relations, a .57 on g_f and .01 on g_c (Horn, 1968).

In Cattell's 1963 study, the IPAT Culture Fair subtests had the following loading on the second-order factors, g_f and g_c, respectively: Series, .35 and .43; Classifications, .63 and -.02; Matrices, .50 and .10; and Topology, .51 and .09.

The total raw score was considered the appropriate datum.

E. Wechsler Adult Intelligence Scale - Selected Subtests

Four subtests of the Wechsler Adult Intelligence Scale (WAIS)--Information, Comprehension, Arithmetic, and

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1 These labels are those employed by French et al. (1963) and Guilford (1959), and are in common use.

Similarities--were used as measures of crystallized intelligence. The Vocabulary subtest was omitted in the interest of avoiding fatigue effects. It is also known that the Vocabulary score is least susceptible to age-related changes (Wechsler, 1958; Doppelt & Wallace, 1955).

The four _WAIS_ subtests can be seen to be tests of the primary factors:Verbal Comprehension, Experiential Evaluation, General Reasoning, and Semantic Relations.[2] Horn and Cattell (1966) show that these primary factors load more highly on the g_c second-order factor. The respective loadings for g_f and g_c obtained in their study were: .08 and .68 for Verbal Comprehension, .08 and .43 for Experiential Evaluation, .31 and .34 for General Reasoning, and .37 and .43 for Semantic Relations.

In Cohen's (1957) factorial study of the _WAIS_ for different age groups, the loadings of the Verbal subtests for the over-60 group are as high on the Memory factor as on the Verbal Comprehension factor. Information, Comprehension, and Similarities load .29, .39, and .42, respectively, on the Verbal Comprehension factor. On the Memory factor, they load .41, .38, and .10, respectively. The Arithmetic subtest shows a .52 loading on the Memory factor and .04 on the Verbal Comprehension. Cohen explains that memory is a factor at all ages for successful response in the Verbal tests, but until

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2 _Ibid_.

old age is reached, the variance in memory ability involved in these tests is inconsequential. With old age and differential rates of deterioration, scores on these verbal tests come to depend as much on the memory ability as on the verbal comprehension ability.

The Digit Span subtest of the WAIS was administered as a separate measure and not included in the Crystallized score. Factorial studies of Horn (1965) suggest the Digits Forward and Digits Backward may load differentially on the general ability factors. Thurstone (1941) and Cohen (1957) found Digit Span to load significantly only on the Memory factor.

The total of the scaled scores of the four subtests was considered the appropriate datum for the Crystallized score. The scaled score of the Digit Span and the number of Digits Forward and Digits Backward were used in the respective analyses.

3. The Procedure of the Research

The data collecting and testing sessions were generally held in the recreation room of the residences, the church halls or a side room as in the RA Center. Attempts were made to remove immediate distractions--this was done by drawing room dividers or seating the S so he would be facing a wall corner, away from the general movement. This procedure did not remove the general living noises but did make for directing attention to the task at hand. Overhead lighting of the room was used--in all cases, fluorescent. No other lighting effects were attempted.

Each of the Ss was asked specific demographic and health information. This information served to screen Ss. The criteria given in Section 1 were used. The only criterion which was slightly waived was (f) able to read English. With seven Ss who understood and spoke English, but could not read, the items of the EPI were read by the examiner and the S responded orally.

The EPI was self-administered, with the exceptions noted above. Few difficulties were presented; one or the other word/expression had to be explained/defined with 12 Ss. The Ss were encouraged to answer all the statements. In the instance where considerable hesitancy was expressed, the S was told to "just pick one."

For the determination of the reaction time the S was seated before the apparatus placed on a card table, at a distance which he considered comfortably within reach of the key. The S was free to choose which hand or finger he desired to depress the key. The S was shown the sequence of depressing the key, light-on, light-off, and key release. He was made aware that the latency between the light-off and key release was the measurement taken. The S was encouraged to give speeded responses. The instruction was "to release the key as soon as the light goes off." All Ss were given five practice trials. With nine Ss more than five practices were needed before the examiner felt the S was fully aware of the procedure and rhythm. Twenty trials comprised the testing session. The average of the latency times of the 20 trials constituted the mean reaction time of each S and is the figure used in the statistical treatment.

During the reaction time task the examiner sat behind the apparatus so as not to give any movement clues to the S. In a second session the five WAIS subtests--Information, Comprehension, Arithmetic, Similarities, and Digit Span--were administered and the Test of "g": Culture Fair was given. Half the Ss were given the WAIS subtests first and half were given the Culture Fair test as their first task. This procedure was followed to control order effects and to balance fatigue factors (Underwood, 1957). The tasks were given at different times during the day--morning, mid-afternoon, and early evening--so as to diminish any effects the time of day may have on performance (Colquhaun & Corcoran, 1964).

Administration of the tests followed the standardized procedure of instruction and timing as given in the respective Manuals (Wechsler, 1955; Cattell & Cattell, 1973). With the Culture Fair test the practice items were gone over several times to ensure the Ss' understanding of the task involved. Administration of this test was of a modified group style; no more than four Ss were tested at any one time. In several cases the S had to be assisted in finding and keeping the proper column on the answer sheet.

The final measure taken was the Spiral After-effect. The apparatus was placed on a card table and the S was seated approximately three feet from it. The S was told to focus upon the central silver knob. The spiral rotated at 100 rpm for 45 seconds. After this time lapse the examiner placed a white screen in front of the rotating spiral. The S was encouraged to continue a forward focus and report when the perception of a spin reversal occurred, and when the perception ceased. This reported time period, measured by a stop watch, was recorded for each trial. There was a two-minute rest period between trials. The Ss were given three practice trials. The average of the time periods of the next five trials constituted the data used in the statistical treatment.

Four Ss reported no after-effect perception even after repeated trials and eight Ss were otherwise unavailable for this testing session.

4. Statistical Operations

A. Analyses for Hypotheses Testing

This section presents the statistical measures used to test the hypotheses stated previously in Chapter I.

Initially, an intercorrelation matrix of Pearson product-moment coefficients of the demographic and predictor variables was formed. This initial correlation served as an aid in determining the convergent and discriminant validation of the specific variables under study (cf. Campbell, 1960) and a test of the initial hypothesis of this experiment.

To test null hypotheses 2 and 3, a 3 X 3 two-factor analysis of variance was made to study the main effects and the interaction effects of Reaction Time and Extraversion on the dependent variables of Fluid and Crystallized intelligence. The quasi-experimental design and the continuous variables of this research require a somewhat arbitrary formation of groups (Cohen, 1968). The procedure for group determination is given in Chapter III.

For testing null hypotheses 4 and 5 of significant predictors among predictor variables, a preliminary correlational matrix was formed between the predictor variables and the criterion variables. A stepwise multiple regression indicated that four predictor variables, Education, Occupation, Reaction Time, and Extraversion, constituted the significant contributors to the variance. A multiple regression equation with Education, Occupation, Reaction Time, and Extraversion as the predictor variables was computed. From this equation the relative contribution of each predictor variable was obtained. An *F* test was made for the significance of the contribution of each predictor variable. The multiple regression serves to maximize the correlation of each predictor to predict the criterion variable (Ferguson, 1971).

To test null hypothesis 6, a multiple *R* was computed on the total sample (N=120) and on two randomly chosen subgroups (n=60). The multiple *R*s of the total group and each subgroup were converted to z-scores.

In order to test for significance of the differences between the two random subgroups, the standard error of the differences between two zs was computed using the following formula:

$$ze = \sqrt{\frac{1}{n_1 - 3} + \frac{1}{n_2 - 3}}$$

where n_1 = number in one subgroup

n_2 = number in second subgroup.

The difference between the zs of the two random subgroups z_1 and z_2 divided by the standard error of differences, z_e, results in:

$$z = \frac{z_1 - z_2}{z_e}$$

which can be evaluated for significance by a table of the standard normal curve (Edwards, 1967).

Because the assumption of independence is violated in the comparison of the total group and the subgroups contained in the total group, a specific standard error was computed using the following formula (Dayhaw, 1969; McInnis, 1972):

$$R_s = \frac{1 - R_t^2}{\sqrt{N_s - 1}} \sqrt{\frac{N_t - N_s}{N_t - 1}}$$

where R_t = multiple R for the total group

N_t = number in the total group

N_s = number in the subgroup

This formula gives the standard error of the difference between a multiple correlation coefficient of a subgroup and the multiple correlation coefficient of a total group containing the subgroup (McInnis, 1972).

In order to test null hypothesis 7, it was necessary to cross-validate the multiple <u>R</u>s obtained on each of the two subgroups. In order to do this, the _B_ weights plus a constant from the multiple regression of one random subgroup were applied to the scores of the other random subgroup and vice versa, using the formula, $\hat{Y} = K + B_1X_1 + B_2X_2 + \ldots + B_nX_n$ (Kelly _et al_., 1969). _B_ weights were used rather than beta weights because they were being applied to raw scores and not to standardized scores which the application of the beta weights demands. The predicted scores, $\hat{Y}$, for each subgroup were then correlated with raw scores to provide a new multiple _R_.

To test for the significance of the differences between the cross-validated multiple _R_s, each was converted to a z-score and the standard error of the differences between two zs was computed (Kelly _et al_., 1969). In addition, the significance of the differences between each cross-validated multiple _R_ and the total multiple _R_ was calculated using the standard error, R_s, as defined above.

B. Additional Analyses

The potential intrusion of the confounding variables of Education and Occupation was tested through analysis of covariance. Kerlinger and Pedbazur (1973) state that for covariates, the predictor variables should be (1) significantly correlated, and (2) correlated in the same direction. Cohen

(1968) suggests that with multiple *R*s the subtraction method of covariate analysis be used. Since covariates are predictor variables which contaminate the main effects of other predictors they may be removed. Thus, the question is asked, how much variance in Y (and its significance) is accounted for after the covariate(s) has been removed? The subtraction method proceeds in the following manner: Find $R^2_{Y.1,2,3,4}$, the proportion of Y variance accounted for by all predictor variables; then find $R^2_{Y.1,2}$, the proportion of Y variance attributable to the covariates of Education and Occupation. The difference is the increment due to the influence of Reaction Time and Extraversion; this difference is testable by the *F* test using the formula:

$$F = \frac{\left(R^2_{Y.A,B} - R^2_{Y.A}\right)/b}{\left(1 - R^2_{Y.A,B}\right)/\left(N-a-b-1\right)}$$

with *df* = b and (N-a-b-1)

where $R^2_{Y.A,B}$ is the incremented R^2 based on *a*-*b* predictor variables

$R^2_{Y.A}$ is the smaller R^2 based on *a* predictor variables

a and *b* are the number of original (a) and added (b) predictor variables, hence the number of *df* each "takes up." (Cohen, 1968)

The multivariate analysis of covariance is used on the criterion variables of Fluid scores and Crystallized scores.

Horn (1965) has suggested Digits Forward and Digits Backward may load differentially on g_f and g_c. The Digit Span subtest of the WAIS was therefore not included in the Crystallized score. A Pearson product-moment correlation matrix was made among Fluid scores, Crystallized scores, Digit Span score, Digits Forward and Digits Backward for significant relationships, and then these relationships were tested for significant differences. Another matrix was made between the predictor variables and Digits.

Finally, a brief treatment was given to the subtests. A correlation matrix was made among the predictor variables and (1) the subtests which constituted the Fluid score, and (2) the subtests which constituted the Crystallized score. The relative loadings of each subtest to the respective total score is presented in further intercorrelation matrices.

All multiple Rs were computed using "S P S S," Statistical Package for the Social Sciences, computer program.

For all statistical analyses, a p level of .05 was used as significant.

The method of subject selection, the tools of the research, the research procedure, and the statistical operations employed to test the hypotheses have been presented. In the following chapter, the results of the research are presented and discussed.

CHAPTER III

PRESENTATION AND DISCUSSION OF RESULTS

This chapter presents the results of the data collection, the results of the statistical treatment of the data, and discussion of the results in the light of the objectives of the research, the theoretical background, and the hypotheses outlined in chapter one. The material is organized under three sections:

1. Presentation of the Data
   A. Selection Data for three groups based on Extraversion scores
   B. Selection Data for three groups based on Reaction Time
2. Presentation of Results
   A. Analyses for Hypotheses Testing
   B. Additional Analyses
   C. Summary of Results
3. Discussion of Results

1. Presentation of the Data

The demographic data obtained for each subject included age, education, and occupation prior to retirement. Table 1, p. 48, showed the means and standard deviations of the data. The data for each subject is presented in Appendix 3. Appendix 3 also presents the values or scores obtained on the predictor measures, Reaction Time, <u>EPI</u> scores, and Spiral After-effect. The criterion measures of Fluid Intelligence scores and Crystallized Intelligence scores are given in Appendix 4. The scores of the subtests constituting the Fluid and Crystallized scores are also recorded in Appendix 4.

The formation of groups from continuous data necessitates applying somewhat arbitrary cut-off points. The following sections describe the formation of the groups for Extraversion and Reaction Time.

A. Selection Data for Groups of Introverted, Ambiverted and Extraverted Subjects

An initial sample of 120 Ss was classified on the basis of Extraversion scores (E-scores) on the Eysenck Personality Inventory (EPI), Form A; the Manual (1968) suggests using the 30 percentile and 71 percentile as cutting points. For this grouping, more stringent cutting points were used, namely, the 26 percentile and 76 percentile. This grouping was determined by the score distribution so there would be no overlap. Accordingly, the groups formed were: (1) Introverted group with E-scores of 9 or less (n=28); (2) Ambiverted group with E-scores of 10 to 14 (n=65); and (3) Extraverted group with E-scores of 15 and over (n=27). From among the Ambiverted group a random selection of n=35 was made to "equalize" the "n" of each group. The "n" of 35 was chosen in order to reach a total "n" of 90 which, in a 3 X 3 analysis of variance design, gives a theoretical n=10 for each cell.

The means and standard deviations for the Total Population, the Total Sample, the Introverted, Ambiverted, and Extraverted groups are given in Table 2. Table 2 also gives the means and standard deviations of the Neuroticism scores for these groups.

Hartley's $F_{maximum}$ test was made to test for homogeneity of variance, an assumption of factorial designs.[1] The obtained F ratio was 2.27 (F_{max}.95 (3,35) < 2.40) and therefore the null hypothesis of homogeneity of variance was not rejected.

B. Selection Data for Groups of Fast, Moderate and Slow Subjects on the Reaction Time Test

Independent cutting points were determined on the basis of Reaction Time means. Initially, the 30 percentile and 71 percentile of the total population (N=120) were used on the raw scores. However, due to the skewness of the distribution (1.504), the raw scores were transformed into normalized standard scores (see Winer, 1962, p. 219). The cutting points of the grouping were $\pm$.50. The groups formed were: (1) Fast group (n=26), (2) Moderate group (n=38), and (3) Slow group (n=26). Appendix 5 shows the raw scores and transformed score data. Table 3 gives the means and standard deviations of the Total Population group, Total Sample group, the Fast, Moderate, and Slow groups.

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1 Hartley's $F_{maximum}$ test was made using INSTAPAK programs (Cooper, 1974).

Table 2

EPI (Form A) Score Distribution on Extraversion (E) and Neuroticism (N) for the Total Population, Total Sample, and Introverted, Ambiverted, and Extraverted Groups

Group	N	(E)		(N)	
		Mean	SD	Mean	SD
Total Population	120	11.9	3.5	9.4	4.3
Total Sample	90	11.9	3.9	9.3	3.9
Introverted	28	7.4	1.5	9.4	3.9
Ambiverted	35	11.8	1.2	8.9	3.3
Extraverted	27	16.7	1.9	9.8	4.7

Table 3

Reaction Time Latency and Normalized Standard Score Distribution for the Total Population, Total Sample, and Fast, Moderate, and Slow Groups

Group	N	Latency (msec)		Normalized Standard Score	
		Mean	SD	Mean	SD
Total Population	120	329.8	119.2	0	1
Total Sample	90	322.6	115.5	.23	.90
Fast	26	217.2	34.7	-1.17	.47
Moderate	37	301.0	31.4	-.01	.31
Slow	27	455.4	114.7	1.10	.43

Hartley's $F_{maximum}$ test was made on these groupings. The *F* ratio obtained was 2.15 ($F_{max}.95\ (3,37) < 2.40$); therefore the null hypothesis of homogeneity of variance for these groups was not rejected.

2. Presentation of Results

A. Analyses for Hypotheses Testing

The results will be presented in the sequence and terms of the null hypotheses given in Chapter I.

For the testing of null hypothesis 1, a Pearson product-moment correlation matrix was formed among the predictor variables. The correlation coefficient between Extraversion scores and duration of Spiral After-effect was -0.47, significant beyond the .001 probability level; therefore (a) of null hypothesis 1 is rejected. The correlation coefficient between Extraversion scores and Reaction Time means was -0.04, not significant, and (b) of null hypothesis 1 is not rejected. The intercorrelation matrix is given in Table 4.

Using the groups formed by the Extraversion scores of the *EPI*, Table 5 gives the mean and standard deviation of the duration of the Spiral After-effect for each group. Table 6 presents a one-way analysis of variance for significance determination among the groups. The *F* ratio, 18.64, indicates significance beyond the .01 level ($F\ .99\ (2,105) < 4.82$).

Table 4

Intercorrelations among the Demographic and Predictor Variables (N=120)[a]

Age	Educ	Occ	RT	E	N	SAE
1.00	-.08	.09	.39***	-.03	-.10	.02
	1.00	.49***	-.20**	.07	-.21**	.09
		1.00	-.15*	.02	-.13	.04
			1.00	-.04	-.03	.05
				1.00	.05	-.47***
					1.00	.04
						1.00

[a]For Spiral correlates N=108
*p < .05
**p < .01
***p < .001

Table 5

Means and Standard Deviations of Duration (sec) of Spiral After-effect for Introverted, Ambiverted, Extraverted, and Total Population Groups

	Introverted (N=25)	Ambiverted (N=58)	Extraverted (N=25)	Total (N=108)
Mean	14.2	10.9	9.4	11.3
SD	3.5	2.6	2.3	3.8

Table 6

Analysis of Variance Summary Table:
Spiral After-effect

Source	df	SS	MS	F
Between Groups	2	3044	1522	18.64*
Within Groups	105	8572	81.64	
Total	107			

*$p < .01$

TABLE 6a

A Posteriori Comparison (Scheffé Method) of Means of Duration of Spiral After Effect for Introverted, Ambiverted and Extraverted Groups.

	GROUP PAIRINGS		
	INTRO-AMBI	INTRO-EXTRA	AMBI-EXTRA
Means Difference	3.3	4.8*	1.5
Critical Value	(4.7)	(4.6)	(4.7)

* $P < .05$

Table 7

Analysis of Variance Summary Table:
Fluid Intelligence Scores - Total Raw Score (N=90)

Source	df	SS	MS	F
Reaction Time (A)	2	409.11	204.55	7.45*
Extraversion (B)	2	396.17	198.09	7.28*
Interaction (A X B)	4	126.18	31.55	1.15
Residual	81	2224.94	27.47	

*p < .01

Table 8

Analysis of Variance Summary Table:
Crystallized Intelligence Scores - Total Scaled Score
(N=90)

Source	df	SS	MS	F
Reaction Time (A)	2	2477.60	1238.80	14.39*
Extraversion (B)	2	193.69	96.84	1.13
Interaction (A X B)	4	230.52	57.63	.67
Residual	81	6972.02	86.07	

*$p < .01$

TABLE 8a

Means and Standard Deviations of Fluid and Crystallized Intelligence Scores for Introverted, Ambiverted and Extraverted Groups.

Groups	FLUID SCORES MEAN	FLUID SCORES SD	CRYSTALLIZED SCORES MEAN	CRYSTALLIZED SCORES SD
Introverted (N=28)	18.6	6.3	38.8	11.8
Ambiverted (N=35)	15.6	5.9	35.4	8.4
Extraverted (N=27)	13.7	4.1	37.7	11.5

TABLE 8b

Means and Standard Deviations of Fluid and Crystallized Intelligence Scores for Fast, Moderate and Slow Reaction Time Latency Groups.

	FLUID SCORES		CRYSTALLIZED SCORES	
GROUPS	MEAN	SD	MEAN	SD
Fast (N=26)	18.1	5.8	42.3	9.9
Moderate (N=37)	16.8	5.5	39.2	9.0
Slow (N=27)	13.1	5.1	29.4	8.7

TABLE 8c

A Posteriori Comparison (Scheffé Method) of Means of Fluid Intelligence Scores of Introverted, Ambiverted and Extraverted Groups.

	GROUP PAIRINGS		
	INTRO-AMBI	INTRA-EXTRA	AMBI-EXTRA
Means Difference	3.0	5.0[x]	2.0
Critical Value	(2.9)	(3.2)	(2.9)

x $P < .05$

TABLE 8d

A Posteriori Comparison (Scheffé Method) of Means of Fluid and Crystallized Intelligence Scores by Fast, Moderate and Slow Reaction Time Groups.

	GROUP PAIRINGS		
FLUID SCORES	Fast-Moderate	Fast-Slow	Moderate-Slow
Mean Difference	1.4	5.0*	3.6*
Critical Value	2.9	3.2	2.9
CRYSTALLIZED SCORES			
Mean Difference	3.1	12.9*	9.8*
Critical Value	5.2	5.6	5.2

$P < .05$

Table 6(a) presents the results of comparison of the mean differences among the groups. The *post hoc* procedure of Scheffé was used. As the table indicates the significant difference at the .05 level of confidence in the mean duration time which accounts for the significance in the variance is between the Introverted and Extraverted groups. This finding suggests that there may be some differential level of cortical inhibition in these two groups. This statement is based on the theoretical postulates of the spiral after-effect phenomenon. (see Holland, 1965)

A two-factor analysis of variance was used to test null hypotheses 2 and 3 for main effects and interaction effects of Reaction Time and Extraversion on Fluid Intelligence Scores and Crystallized Intelligence Scores. Table 7 shows that on Fluid Scores, Reaction Time and Extraversion as main effects are significant sources of variance, ($F_{.99}$ (2,81) $<$ 4.88); interaction effects are not significant. Table 8 gives the analysis of variance summary for Crystallized Scores. Therefore, null hypothesis 2 of Reaction Time being a significant main effect is rejected. Null hypothesis 3 of Extraversion being a significant main effect is rejected for Fluid Scores and not rejected for Crystallized Scores.

Table 8(a) and Table 8(b) present the means and standard deviations of the Fluid and Crystallized Scores for the groups formed on the personality dimension, Introverted, Ambiverted and Extraverted and the groups formed by reaction time latency, Fast, Moderate and Slow.

Table 8(c) locates the significant mean difference of the Fluid Scores in the Introverted-Ambiverted and Introverted-Extraverted comparisons. The Scheffé <u>post hoc</u> procedure was used in the comparison.

Table 8(d) indicates that for Fluid Scores and Crystallized Scores the significantmean differences for reaction time groups is between Fast-Slow and Moderate-Slow comparisons.

The post hoc procedures suggest that cortical excitation or arousal level is a significant effector on the Fluid Scores at the extreme end of the personality continuum. Likewise, it shows that with reaction time and the processing speed indexed there may be a critical point in the slowing which reflects the decline in performance on a broad range of intellectual tasks. These findings appear to be consistent with past research which indicates that these types of measures of intellectual functioning are resistant to generalized neuropsychological functional disturbances. cf with the "hold-no hold" concept applied to WAIS subtests.

A Pearson product-moment correlation matrix between predictor variables and criterion variables was made.

Table 9 presnts this matrix. The matrix suggests which predictors would make a significant contribution to a multiple regression equation. A stepwise regression indicated that four predictors-- Education, Occupation, Reaction Time, and Extraversion -- constitute a significant regression equation for predicting Fluid Scores and Crystallized Scores.

Table 9

Pearson Product-moment Correlations between Criterion Variables and Predictor Variables (N=120)[a]

	Age	Educ	Occ	RT	E	N	SAE
Fluid	-.18*	.27**	.30**	.37**	-.35**	-.04	.03
Crys.	-.14	.58**	.55**	-.47**	-.03	-.01	.20*

[a]For Spiral correlates N=108

*$p < .05$

**$p < .001$

Tables 10 and 11 are the summary tables for the multivariate analysis of variance for Fluid scores and Crystallized scores, respectively. Null hypotheses 4 and 5 were tested via multiple regression methods which yielded a constant, B weights, beta weights, standard error of B, and F ratios through which the significance of each predictor as a source of variance in the regression was determined. Tables 12 and 13 give the results for Fluid scores and Crystallized scores, respectively. For the Fluid scores, Occupation, Reaction Time, and Extraversion were significant contributors to the variance (F .99 (4,115) $<$ 3.51). Education, Occupation, and Reaction Time are the significant contributors to the variance on Crystallized scores. Null hypotheses 4 and 5 of no significant predictors in the regression equation are rejected. Tables 14 and 15 give the summary of the predictors in terms of multiple correlation, and the relative contribution or percentage of increment due to the particular predictor.

In order to test null hypothesis 6 of no significant difference between the multiple Rs for two randomly selected subgroups, and between (a) each subgroup and (b) the Total Group, the multipe Rs were first converted into z-scores and the standard error of the difference between two z-scores computed. Tables 16 and 17 show that there was no significant difference between the two random subgroup multiple Rs for

Table 10

Multivariate Analysis of Variance Summary Table: Education, Occupation, Reaction Time, and Extraversion as Predictors and Fluid Intelligence Scores as Criterion

Source	df	SS	MS	F
Regression	4	1332.61	333.15	14.84*
Residual	115	2580.59	22.44	

*$p < .01$

Table 11

Multivariate Analysis of Variance Summary Table: Education, Occupation, Reaction Time, and Extraversion as Predictors and Crystallized Intelligence Scores as Criterion

Source	df	SS	MS	F
Regression	4	8132.90	2033.23	35.22*
Residual	115	6638.57	57.73	

*$p < .01$

Table 12

Constant, B Weights, Beta Weights, Standard Error of B, and F Ratios of Predictor Variables with Fluid Intelligence Scores as Criterion

Variable	B	Beta	Std Error B	F
Education	.19	.14	.12	2.43
Occupation	.97	.19	.46	4.55*
Reaction Time	-.02	-.33	.00	17.67*
Extraversion	-.61	-.37	.12	24.13*
Constant	24.24			

*$p < .01$

Table 13

Constant, B Weights, Beta Weights, Standard Error of B, and F Ratios of Predictor Variables with Crystallized Intelligence Scores as Criterion

Variable	B	Beta	Std Error B	F
Education	.96	.35	.20	23.30*
Occupation	3.31	.33	.73	20.52*
Reaction Time	-.03	-.35	.01	30.67*
Extraversion	-.23	-.07	.20	1.32
Constant	33.18			

*$p < .01$

Table 14

Summary Table of Multiple Correlation:
Relative Contribution of Each Predictor Variable to
Prediction of Fluid Scores

Variable	Multiple R	R^2	R^2 Change	Simple R
Education	.27	.07	.07	.27
Occupation	.33	.11	.04	.30
Reaction Time	.45	.20	.09	-.37
Extraversion	.58	.34	.14	-.35

Table 15

Summary Table of Multiple Correlation:
Relative Contribution of Each Predictor Variable to
Prediction of Crystallized Scores

Variable	Multiple R	R^2	R^2Change	Simple R
Education	.58	.33	.33	.58
Occupation	.65	.43	.09	.55
Reaction Time	.74	.55	.12	-.47
Extraversion	.74	.55	.01	-.03

Table 16

Multiple Rs, z-Scores, Standard Error of Difference and Levels of Statistical Significance for Subgroup Comparison on Criterion Variable: Fluid Intelligence Scores

Group	N	R	z	t	df	p
Random Group I	60	.64*	.76			
Random Group II	60	.54*	.60	.84	118	ns

*$p < .001$

Table 17

Multiple Rs, z-Scores, Standard Error of Difference and Levels of Statistical Significance for Subgroup Comparison on Criterion Variable: Crystallized Intelligence Scores

Group	N	R	z	t	df	p
Random Group I	60	.69*	.84			
Random Group II	60	.80*	1.10	1.36	118	ns

*$p < .001$

Fluid scores and Crystallized scores. To test (b) of the hypothesis, the standard error of the difference between a multiple correlation coefficient of a subgroup and the multiple correlation coefficient of a Total Group containing the subgroup was computed for each subgroup comparison. Table 16 indicates that there was no significant difference between either subgroup and the Total Group for Fluid scores. For Crystallized scores, there was no significant difference between subgroup I and the Total Group, but there was a significant difference, $p < .05$, between subgroup II and the Total Group. Table 19 summarizes the comparisons.

To test the final hypothesis, the constant and B weights from each of the random subgroups were applied to the scores of the other subgroup and new multiple Rs computed between the new predicted raw scores, $\hat{Y}$, and the actual raw scores, Y. Tables 20 and 21 show that when the multiple Rs were converted to z-scores, there was no significant difference between the z-scores for Fluid scores and Crystallized scores, respectively. Tables 22 and 23 show that the cross-validation multiple Rs when compared to the multiple R of the Total Group there was a significant difference ($p < .05$) between Total Group and cross-validation II$\longrightarrow$I for Fluid scores and between Total Group and cross-validation I$\longrightarrow$II for Crystallized scores.

Table 18

Multiple Rs, z-Scores, Diff/Rs, and Levels of Statistical Significance for Random Subgroup Comparison with Total Group on Criterion Variable: Fluid Intelligence Scores

Group	N	R	z	Diff/Rs	p
Total Group	120	.58*	.67		
Random Group I	60	.64*	.76	1.48	ns
Random Group II	60	.54*	.60	1.15	ns

*p < .001

Table 19

Multiple Rs, z-Scores, Diff/Rs, and Levels of Statistical Significance for Random Subgroup Comparison with Total Group on Criterion Variable: Crystallized Intelligence Scores

Group	N	R	z	Diff/Rs	p
Total Group	120	.74*	.96		
Random Group I	60	.69*	.84	1.86	ns
Random Group II	60	.80*	1.10	2.40	.05

*$p < .001$

Table 20

Multiple R^2s, z-Scores, Standard Error of Difference, and Levels of Statistical Significance for Comparison of Cross-validation Groups on Criterion Variable: Fluid Intelligence Scores

Group	N	R2	z	t	df	p
Cross-validation II→I	60	.22*	.22			
Cross-validation I→II	60	.39**	.42	1.02	118	ns

*$p < .05$
**$p < .01$

Table 21

Multiple R^2s, z-Scores, Standard Error of Difference, and Levels of Statistical Significance for Comparison of Cross-validation Groups on Criterion Variable: Crystallized Intelligence Scores

Group	N	R^2	z	t	df	p
Cross-validation II→I	60	.60*	.69			
Cross-validation I→II	60	.44*	.47	1.19	118	ns

*$p < .001$

Table 22

Multiple R^2s, z-Scores, Diff/Rs, and Levels of Statistical Significance for Comparison of Cross-validation Groups and Total Group on Criterion Variable: Fluid Intelligence Scores

Group	N	R^2	z	Diff/Rs	p
Total Group	120	.34**	.35		
Cross-validation II⟶I	60	.22*	.22	2.16	.05
Cross-validation I⟶II	60	.39**	.42	1.05	ns

*$p < .05$
**$p < .01$

Table 23

Multiple R^2s, z-Scores, Diff/Rs, and Levels of Statistical Significance for Comparison of Cross-validation Groups and Total Group on Criterion Variable: Crystallized Intelligence Scores

Group	N	R^2	z	Diff/Rs	p
Total Group	120	.55*	.62		
Cross-validation II → I	60	.60*	.69	1.25	ns
Cross-validation I → II	60	.44*	.47	2.48	.05

*$p < .001$

B. Additional Analyses

The interrelationships among Education, Occupation, and Reaction Time were significant ($p < .05$, see Table 4), but were not related in the same direction (Kerlinger & Pedbazur, 1973). A multivariate analysis of covariance was executed to remove the potential contamination caused by Education and Occupation and to improve the predictive strength of Reaction Time and Extraversion. By subtracting out the covariates' contribution it was found that Reaction Time and Extraversion do contribute significantly, $p < .01$, to the variance found among Fluid scores and to the variance found among Crystallized scores ($F_{.99}(2,115) < 4.82$). Tables 24 and 25 provide a summary of these operations for Fluid scores and Crystallized scores, respectively.

In order to investigate the possibility of differential loadings of Digits on g_f and g_c an intercorrelation matrix was made. It is presented in Table 26. It indicates significant relationships among all the variables. In testing the significance of the difference in the loadings on Fluid and Crystallized scores, it is found that for the Digit Span score there is a significant difference ($p < .05$) between the loadings on Fluid and Crystallized scores. However, for Digits Forward and Digits Backward the loadings are not significantly different. Tables 27-29 show these comparisons and tests of significance. The predictor

Table 24

Multivariate Analysis of Covariance Summary Table: Fluid Intelligence Scores

Source	R	R^2	df	F
Covariates	.33	.11	2	
All predictors	.58	.34	4	19.5*
Within			115	

*$p < .01$

Table 25

Multivariate Analysis of Covariance Summary Table:
Crystallized Intelligence Scores

Source	R	R^2	df	F
Covariates	.65	.43	2	
All predictors	.74	.55	4	20.4*
Within			115	

*p < .01

Table 26

Intercorrelations among Fluid Scores, Crystallized Scores, Digit Span, Digits Forward, and Digits Backward

Fluid	Crystallized	Digit Span	Digits Forward	Digits Backward
1.00	.51	.44	.45	.34
	1.00	.65	.60	.53
		1.00	.89	.85
			1.00	.53
				1.00

All significant at $p < .001$

Table 27

rs, z-Scores, Standard Error of Difference, and Levels of Statistical Significance for Fluid vs Crystallized Loading of Digit Span Scores

Loading	N	r	z	t	df	p
Fluid	120	.44	.47			
Crystallized	120	.65	.77	2.30	238	.05

Table 28

rs, z-Scores, Standard Error of Difference, and Levels of Statistical Significance for Fluid vs Crystallized Loading of Digits Forward

Loading	N	r	z	t	df	p
Fluid	120	.45	.48			
Crystallized	120	.60	.69	1.64	238	ns

Table 29

rs, z-Scores, Standard Error of Difference, and Levels of Statistical Significance for Fluid vs Crystallized Loading of Digits Backward

Loading	N	r	z	t	df	p
Fluid	120	.34	.35			
Crystallized	120	.53	.59	1.81	238	ns

variables which showed a significant relationship ($p < .001$) to Digit Span scores, Digits Forward and Digits Backward were Education, Occupation, and Reaction Time. Extraversion was not significantly related to these criterion variables. Table 30 presents the matrix.

The matrices given in Tables 31 and 32 indicate that the differential correlation of Extraversion extends to the subtests. Extraversion shows significant relationships with Series, Classifications,Matrices, and Conditions, but not significant relationship with the subtests of Crystallized scores--Information, Comprehension, Arithmetic, and Similarities.

Tables 33 and 34 give the relative loadings of each subtest with the total score. The purposes of these matrices is to corroborate the reliability of the subtests when the population is limited to older adults.

C. Summary of Results

Considering the hypotheses as formulated in chapter one (pp. 43-44), the following results were obtained:

1. A significant correlation between Extraversion scores of the EPI and the duration of the after-image induced by the Spiral After-effect procedure was found; therefore, (a) of null hypothesis 1 is rejected.

Table 30

Pearson Product-moment Correlations between Predictor Variables and Digit Span, Digits Forward, and Digits Backward

	Digit Span	Digits Forward	Digits Backward
Education	.44*	.39*	.37*
Occupation	.45*	.46*	.31*
Reaction Time	-.43*	-.40*	-.33*
Extraversion	-.04	-.11	-.02

$^{*}p < .001$

Table 31

Pearson Product-moment Correlations among Predictor Variables and Four Subtests of Fluid Intelligence Score

	Series	Classification	Matrices	Conditions
Education	.21**	.08	.30***	.18*
Occupation	.28***	.26**	.16*	.18*
Reaction Time	-.25**	-.33***	-.25**	-.28***
Extraversion	-.32***	-.24**	-.25**	-.21**

*$p < .05$
**$p < .01$
***$p < .001$

Table 32

Pearson Product-moment Correlations among Predictor Variables and Four Subtests of Crystallized Intelligence Score

	Information	Comprehension	Arithmetic	Similarities
Education	.59*	.43*	.47*	.51*
Occupation	.52*	.41*	.46*	.49*
Reaction Time	-.42*	-.37*	-.35*	-.44*
Extraversion	-.08	.00	.05	-.08

*$p < .001$

Table 33

Intercorrelations among Fluid Scores and Scores on Subtests: Series, Classifications, Matrices, and Conditions

Fluid	Series	Classifications	Matrices	Conditions
1.00	.83	.61	.74	.76
	1.00	.36	.46	.54
		1.00	.28	.30
			1.00	.42
				1.00

All significant $p < .001$

Table 34

Intercorrelations among Crystallized Scores and Scores on Subtests: Information, Comprehension, Arithmetic, and Similarities

Crys	Information	Comprehension	Arithmetic	Similarities
1.00	.89	.82	.78	.86
	1.00	.71	.66	.66
		1.00	.43	.59
			1.00	.59
				1.00

All significant $p < .001$

2. Concurrently, no significant relationship was found between Extraversion scores of the EPI and Reaction Time latency; therefore, (b) of null hypothesis 1 is not rejected.

3. Extraversion scores of the EPI significantly contribute to the variance in Fluid Intelligence scores; (a) of null hypothesis 2 is rejected.

4. Extraversion scores of the EPI do not significantly contribute to the variance in Crystallized Intelligence scores; therefore, (b) of null hypothesis 2 is not rejected.

5. Reaction Time significantly contributes to the variance in Fluid Intelligence scores and Crystallized Intelligence scores; (a) and (b) of null hypothesis 3 are rejected.

6. With Fluid Intelligence scores as the criterion variable, Occupation, Reaction Time, and Extraversion are significant predictors; null hypothesis 4 is rejected.

7. With Crystallized Intelligence scores as the criterion variable, Education, Occupation, and Reaction Time are significant predictors; null hypothesis 5 is rejected.

8. When multiple Rs are computed for two random subgroups and compared to each other, there were no significant differences for either Fluid Intelligence scores or Crystallized Intelligence scores; (a) of null hypothesis 6 is not rejected.

9. When the multiple *R*s of the two random subgroups are compared to the multiple *R* of the Total Group there was a significant difference between the Total Group and a random group for Crystallized Intelligence scores. There was no significant difference in the *R*s for Fluid Intelligence scores. Null hypothesis 6(b) is not rejected for Fluid Intelligence scores and rejected for Crystallized Intelligence scores.

10. When the multiple *R*s of the cross-validation procedure are compared to each other, there were no significant differences either for Fluid Intelligence scores or Crystallized Intelligence scores; (a) of null hypothesis 7 is not rejected.

11. When the multiple *R*s of the cross-validation procedure are compared to the multiple *R* of the Total Group, there were significant differences for both Fluid Intelligence scores and Crystallized Intelligence scores; (b) of null hypothesis 7 is rejected.

The results of the data collection and analyses have been given. In the next section these results will be discussed in light of the objectives of the research and the theoretical background.

3. Discussion of Results

This section discusses the results of the statistical analysis presented in the previous section in the light of the objectives of the research, the theoretical background and development in the review of the literature.

Essentially, the question posed by this research endeavor focused on the significance (here used in its general sense) of the personality dimension of Eysenckian extraversion on intellectual performance in old age. Thus, this discussion must relate itself, first, to the nature of the extraversion measured by the <u>EPI</u>, and secondly, to the theoretical and practical significance of this behavioral dimension in the determination of intellectual functioning among the aged. As a further issue, the independence of reaction time, reflecting general brain integrity, deserves comment in its capacity as a predictor of intellectual functioning among the older adult and, in terms of its relationship to extraversion and the Spiral After-effect phenomenon both theorized and explained in terms of psychophysiological processes.

The Extraversion score of the <u>EPI</u> when correlated with the duration of the Spiral After-effect was statistically significant ($r = -.47$, $p < .001$). That is, given the validity of prior research relating the Spiral After-effect phenomenon to the dimension of extraversion, the extraversion measured in this research conforms to the Eysenckian model (cf. Claridge & Herrington, 1963). This appears as an important finding indicating that the extraversion observed is explainable in terms of low excitation and fast evolvement of inhibitory impulses at the CNS level. At the least, one can assert that these results support a psychophysical continuity with similar neurodynamics explaining this personality dimension in youth and old age (Lynn, 1964). Further, what can be said of behavioral introversion, or the popular notion of a trend towards it in old age, should it seems, take into account the neurophysiology of this trait, as well as the social psychology of its frequency. In regards to the cross-sectional research of Eysenck, especially the normative data quoted in the Personality Questionnaire Manual (1973), demonstrating an increase in mean introversion with age in the general population, the question of shift or differential life-span of introverts and extraverts remains an interesting question. However, this study cannot comment with respect to developmental changes in this regard, as development in itself was not considered. Table 35 presents the data of the normative populations from the Manuals (1968, 1973) and the data of this research population for Extraversion scores.

Eysenckian extraversion with its physiological basis postulates arousal of the afferent pathways, the projection areas of the cortex and the reticular formation. To

Table 35

Descriptive Data of Normative Populations and Research Population for Extraversion Scores

Group	N	Range	Skewness	Mean	SD
Normative English (EPI Manual, 1968)	1931	0-24 (possible)	not given	12.1	4.4
Normative American (EPI Manual, 1968)	1003	0-24 (possible)	not given	13.1	4.1
Normative Males (P.Q. Manual, 1973)	2312	0-24 (possible)	not given	13.2	4.9
Normative Age 60-69 Males (P.Q. Manual, 1973)	65	0-24 (possible)	not given	10.4	5.0
Research Males Age 60-90 years	120	3-21 (obtained)	0.20	11.9	3.5

these structures Gray (1970) added activity of the feedback loop, the orbital frontal cortex, the medial septal area, and the hippocampus. Research on general slowness involving initiating and executing movement has not pinpointed the precise location of the cerebral sites, but evidence supports including the limbic-diencephalic system, the extrapyramidal structures and the brain reticular formation (Vanderwolf, 1971; Jung & Hassler, 1960).

It would seem, then, that some of the neurophysiological structures and brain areas involved in Eysenckian extraversion and reaction time may, indeed, be common to both. The relationship between these two factors assumes an importance in determining whether or not, at an empirical, measurable level, extraversion and reaction time are independent. The nonsignificant correlation ($r = -.03$) between Reaction Time and Extraversion demonstrates a lack of concordance. Equally important is the nonsignificant correlation ($r = .02$) between Reaction Time and Spiral After-effect. Thus, though some of the same structures and areas may be involved in both reaction time and extraversion, the particular attributes of these physiological structures being indexed are not the same.

A useful conceptualization of reaction time is in terms of a systems model (see Rabbitt, 1968, and Birren, 1974) in which there is an input in the form of sensory stimulation, a processing within the cortical-subcortical areas and an output of motor response. The literature indicated that at the input level and the output level primarily peripheral nerve factors are involved and that age has minimal effect. However, at the central processing stage, an increase in age seemingly requires an increase in process time. The older person gets the job done; it just takes him longer to do it. Reaction time, then, has to do with processing speed.

In risking the application of the systems analogy to extraversion it perhaps could be stated that the introvert is capable of handling more input information (has lower sensory thresholds), has a greater storage capacity (forms conditioned responses quicker, hence, greater learning) and is capable of calling into the workspace more information (is less distractible and has fewer involuntary rest pauses). The inhibitory level of the extravert reduces the continual input feed, limits the storage capacity and controls the workspace dimensions. Behaviorally, the extravert's activity can be seen as attempts to supply what the introvert already possesses for interacting with the environment. The personality dimension of extraversion, then, is seen not in terms of speed, but in terms of capacity or level.

Lynn (1962) and Eysenck and Eysenck (1973) had suggested that reaction time may be more related to the personality dimension of psychoticism where speed of processing seems to be involved.

In the inference of neurophysiological functioning via psychological measures there is some risk of overstaing a causal relationship or even a similar one. In utilizing Eysenckian personality dimensions and the postulated biological basis it should be noted that often the constructs of cortical excitation and inhibition are applied somewhat indiscriminantly as though they are in effect a continuum. Eysenck does some theoretical fence straddling when he explains some behavioral or perceptual phenomenon in terms of either excitation or inhibition. These two cortical states may be unrelated neurophysiologically contrary to the implication made in Eysenck's theorizing.

Having established Eysenckian extraversion and reaction time as indices which are, respectively, sensitive to the arousal and structural integrity in the cortical-subcortical areas, the relative usefulness of these two variables in the prediction or accounting for the variance in performance comes to the fore. Eysenck (1967) has stated that mental processes generally would be facilitated by the excitation or arousal of the cortical systems involved. Reaction time has been shown to be related to information processing (Surwillo, 1968).

A two-way analysis of variance indicates that among this sample of older men reaction time and extraversion are main effects contributors to the variance of Fluid scores, and reaction time is a main effect in the prediction of Crystallized scores. There were no interaction effects. The importance of finding main effects is that the predicting variable is equally effective across all levels of the prediction, and therefore global statements accounting for the variance are permissible (Kelly et al., 1969).

The finding of extraversion as a significant variable in the determination of Fluid scores and not a significant variable in predicting Crystallized scores is an indirect indicator that the two dimensions of general ability are indeed susceptible to differential influences. Anastasi (1968) has indicated that it is impossible, and perhaps not even desirable, to separate the influences of hereditary and cultural factors in intellectual functioning since interaction between the child and his environment begins immediately upon, and even prior to, birth. It seems, though, that in this study of older men, a biobehavioral factor of extraversion is operative on certain types of tasks, namely, those tasks which are associated with neurophysiological organization, which may or may not be hereditary factors, maturation or damage.

Horn (1970) uses the term anlage(s) which refers to basic, unlearned central organizing factors in all behavior (intelligence), and "relates not only to conditions imposed on the development of abilities but also conditions which operate in the immediate expression of ability (p. 429)." Miller (1956) has discussed this kind of function (anlage) as a limit on the human's capacity for processing information. For example, in solving a problem in abstract reasoning, such as found in a Matrices test, it is necessary to hold several relations in mind at one time; if this cannot be done, the problem is failed. Thus the inability to solve even rather simple intellectual tasks relates to the inability to hold several elements within the span of immediate awareness. Anlages, then, seem to be integral to intellectual ability, and yet do not appear to depend upon formal learning and socialization. Some of the anlage functions delineated are span awareness, temporal integration, concrete vs. abstract capacity, ability (or inability) to change set, maintain attention and resist distraction. These functions express similar behaviors to those attributed by experimental and behavioral studies to the personality dimension of extraversion.

Perhaps the neurophysiological organization reflected in the anlage functions and incidental, non-formal learning is not limited to structural changes; arousal level or cortical excitation may well be included. In fact, this research would suggest such a condition. Extraversion's differential significance in Fluid and Cyrstallized scores indicates that its influence is more effective on those tasks which are least dependent upon formal learning, education, and acculturational factors.

The practical application of this finding for the older adult is seen primarily in the maintenance by the introvert of basic adaptive intellectual processes: the ability to take in numerous elements of a given situation, the ability to utilize basic functions such as anlages and incidental learning and the ability to give continuous attention to a situation. These abilities assist in forming new associations or applying them to new situations, which makes for more adaptive response.

Reaction time as a reflector of processing speed related to structural integrity appears to have a rather universal significant effect on intellectual functioning of the older adult as it influences both Fluid and Crystallized scores. The influence on Fluid scores is generally explainable in terms of neurophysiological integrity. The speed of processing is interfered with by inadequate neuronal efficiency due to neuronal depopulation, non-myelinization or biochemical changes. Crystallized scores, on the other hand, have been shown to be less affected by neurophysiological changes such as may occur with aging (Horn & Cattell, 1967). Several points should be noted which may relate reaction time to crystallized intelligence: (1) Crystallized does not mean non-changing; it means more related to the collective intelligence of a given culture rather than to the inner-directed concept awareness and aid development found in non-formal, incidental learning; (2) g_c and g_f are related; g_c is dependent, at some stage, on the capacity to form the concepts and develop the aids which later are utilized in formal learning and acculturation processes. In this study, Fluid scores and Crystallized scores have a correlation coefficient of .51, $p < .001$; (3) Among older persons, the WAIS subtests, used as a measure of g_c, load as highly on the Memory factor as on the Verbal Comprehension factor, the only exception being Similarities (see Cohen, 1957, and p. 58

of this research). Memory retrieval may well be associated with speed of processing (Schonfield & Robertson, 1966). Thus speed of central processing reflected in the reaction time could account for some of the variance found for Crystallized scores in older people.

The multiple regression methods produced four significant predictor variables for the prediction of Fluid and Crystallized scores, namely, Education, Occupation, Reaction Time, and Extraversion. Neuroticism, as measured by the EPI, was correlated with Education but fell out as a significant predictor in the stepwise regression procedure. Lynn (1962) had suggested that the neurotic-introvert did better on intellectual tasks than other personality groups. In this study of the older male, the neuroticism factor failed to show any significant relationship to performance on Fluid and Crystallized scores.

The implications of the significant findings with respect to reaction time and extraversion have been discussed above. Education is a significant predictor for Crystallized scores, but not for Fluid scores. This supports the theoretical basis of g_f and g_c, showing the dependence of g_c on formal educational influence. Occupation, as a predictor, has significance for both Fluid and Crystallized scores. With men, particularly, this reflects both the number of years in formal education and the demands of the job in maintaining intellectual functioning. In this study the correlation between Education and Occupation was .49, $p < .001$. It may be said that the more intelligent and more educated man obtained a job which enriched and supported his intellecual powers even through old age. An analysis of covariance which subtracted the influence of Education and Occupation did not alter the significance of Reaction Time and Extraversion in accounting for the variance.

A second aspect of the multiple regression methods is the reliability of the predictors considered for the group as a whole. In order to test this, the total group was divided into two random subgroups and separate multiple regressions were run for each subgroup, for Fluid and Crystallized scores, respectively. Three tests were applied to subgroup comparisons: (1) did the multiple *R*s differ significantly from zero, (2) did the subgroups differ significantly from each other, and (3) did the subgroups differ significantly from the total group? All multiple *R*s were significantly different from zero. When the standard error of the difference between the two subgroups and between each subgroup and the total group was calculated there were no significant differences for Fluid scores. For Crystallized scores there was no significant difference between the two random subgroups, but there was a significant difference, $p < .05$, for the comparison of one subgroup with the total group. This difference may be due to the relative contribution of the Education factor. For the subgroup, the B weight of Education was .76 and for the total group, .96.

For cross-validation purposes, the total group was divided into two random subgroups and separate multiple regressions run for each group. The B weights and constant from each subgroup were then applied to the scores of the other group and new multiple *R*s computed. Using the three tests applied to the previous subgroup comparisons it was found that all multiple *R*s differed significantly from zero. However, it should be noted that the multiple *R*s of the subgroup were not of the same magnitude; for Fluid scores, .22 and .39, and for Crystallized scores, .60 and .44. In the comparison of each subgroup to the total group a significant difference was found between one subgroup and the total group for both Fluid scores and Crystallized scores. This finding cautions the application and generalization of the study.

Unreliability has been a somewhat ever-present problem among studies of older people. In this study several factors may have contributed to the unreliability: (1) only one form, Form A, of the *IPAT Culture Fair* test was given; the giving of both forms, A and B, is suggested for increased reliability (Manual, 1973); (2) the skewness of the reaction time latencies; and (3) physiological factors which have been shown to affect task performance, such as oxygen intake, cerebral blood flow and hypertension were not monitored (cf. Jarvik & Cohen, 1973).

The results of the analyses for the Digit Span test deserve comment. In this study of older men, when the standard error of difference was calculated between the correlations of Digit Span scores with Crystallized and Fluid scores, a significant difference, $p < .05$, was found. This supports the inclusion of the Digit Span subtest in the Verbal WAIS scores. Cohen's (1957) work shows Digit Span to load significantly on the Memory factor (.45) and not at all (.00) on the Verbal Comprehension factor. These loadings were for persons over 60 years of age. In the previous discussion, memory retrieval was associated with processing speed; the Digit Span finding indicates that perhaps short-term memory may also be.

Horn (1970) had suggested that Digits Backward may be an anlage function and, therefore, should load on g_f. In this present study, no significant differences were obtained on the correlations between Fluid and Crystallized scores and Digits Forward and Digits Backward. In both cases the correlations were higher for Crystallized scores, but not significantly so.

This section has discussed the results of the study, centering on the personality dimension of extraversion in the aged person. The nature of extraversion in terms of its theoretical underpinning and its practical significance in the intellectual functioning of the older person was considered. In addition, the relationship of reaction time and extraversion was explored, as well as the predictive value of reaction time in older people's performance on intellectual tasks. Reliability of the study was considered in terms of the cross-validation procedure.

A summary of the findings and a presentation of the general conclusions follow. Finally, suggestions for further research are given.

SUMMARY AND CONCLUSIONS

This section summarizes the major findings of the study and puts forth the conclusions arising out of these findings. Suggestions for further research are made.

1. The significant correlation between E-scores of the EPI and the duration of the Spiral After-effect phenomenon supports the Eysenckian model of extraversion. This finding in a sample of older men adds the hypothesized neurophysiological dimensions to the social expression of extraverted behavior. The behaviorally introverted older adult is assumed, then, to have a higher cortical excitation and arousal level than the behaviorally extraverted older person.

2. The nonsignificant correlations between reaction time and E-scores of the EPI and between reaction time and duration of the Spiral After-effect phenomenon indicate that the dimensions of neurophysiological organization or structural integrity being indexed by the measures are not the same. For research purposes they may be considered as independent variables.

3. Reaction time indexing psychomotor integrity and reflecting central processing efficiency was shown to be a significant predictor across a wide range of intellectual tasks. For older people, reaction time appears to be a significantly potent indicator.

4. Extraversion, indexing dimensions of social patterns and cortical arousal, was shown to be a discriminating predictor of intellectual tasks. The variance in crystallized intelligence tasks was not significantly accounted for by the extraversion variable; whereas, for fluid intelligence tasks extraversion was a significant predictor. In light of the theoretical antecedents of g_f and g_c, it seems that extraversion is tapping fundamental abilities which are closely linked with neurophysiological organization.

5. Education as a predictor on the intellectual task was significant in the prediction of Crystallized scores, but not for Fluid scores. This finding supports the theoretical basis of the intelligence model used.

6. Occupation as a predictor on intellectual tasks was significant for both Crystallized and Fluid scores. Occupation is a rough index, with ill-defined dimensions. In this research, though, it may well indicate that the exercise of an active intellectual life is the best assurance of maintaining one.

7. Cross-validation procedures indicated that there is a significant difference between the multiple Rs of a random subgroup and the total group for both Fluid scores and Crystallized scores. The results of this research must be applied with due caution.

In general, the major conclusion from this study is that, in a sample of older men, Eysenckian extraversion is a significant predictor variable in intellectual tasks such as those which define fluid intelligence. The literature does not strongly support the influence of extraversion, Eysenckian or other, on intellectual tasks in younger people. But the finding in this study suggests that extraversion may be a significant predictor in the performance of some tasks for the aged person even though its influence is not manifested in the performance of those tasks by younger persons. The cortical excitation/arousal level underlining the dimension makes for theoretical interest and broad application.

The corroboration of Birren's proposal that response speed assumes the role of an independent variable in the older population is also a significant finding. In effect, response speed is a limiting factor which is significantly manifested across a wide range of intellectual tasks. The variance found in older people can be appreciated when all possible combinations of the two psychophysiological dimensions, fast-slow continuum of central efficiency and high-low continuum of cortical arousal, are imagined.

Further research is indicated to determine the extent of extraversion's influence. It is evident from this study that tasks significantly related to educational influences are not affected; this however, leaves one end of the intellectual continuum relatively unexplored. The question of sex differences in extraversion, particularly in older men and women, and its relative influence in older women's intellectual functioning could be investigated. The question of personality shift toward greater introversion with increasing age is still present; its meaning in terms of adaptation may be very fruitful. The cross-sequential method advocated by Schaie may be useful in such a study.

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APPENDIX 1

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

Yes	No
▮	::

Yes	No
::	▮

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

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E N L

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

PLEASE CHECK TO SEE THAT YOU HAVE ANSWERED ALL THE QUESTIONS.

APPENDIX 2

IPAT TEST OF "g": CULTURE FAIR, SCALE 2 (FORM A)

Test of "g": CULTURE FAIR

Scale 2, Form A

Prepared by R. B. Cattell and A. K. S. Cattell

Name ______________________________ Sex ________
First Last (Write M or F)

Name of School (or Address) ______________________________

Today's Date ____________________ Grade (or Class) ____________

Date of Birth ____________________ Age ____________________
Month Day Year Years Months

Test	Score	Remarks
1		
2		
3		
4		
		Total Score

M. ________

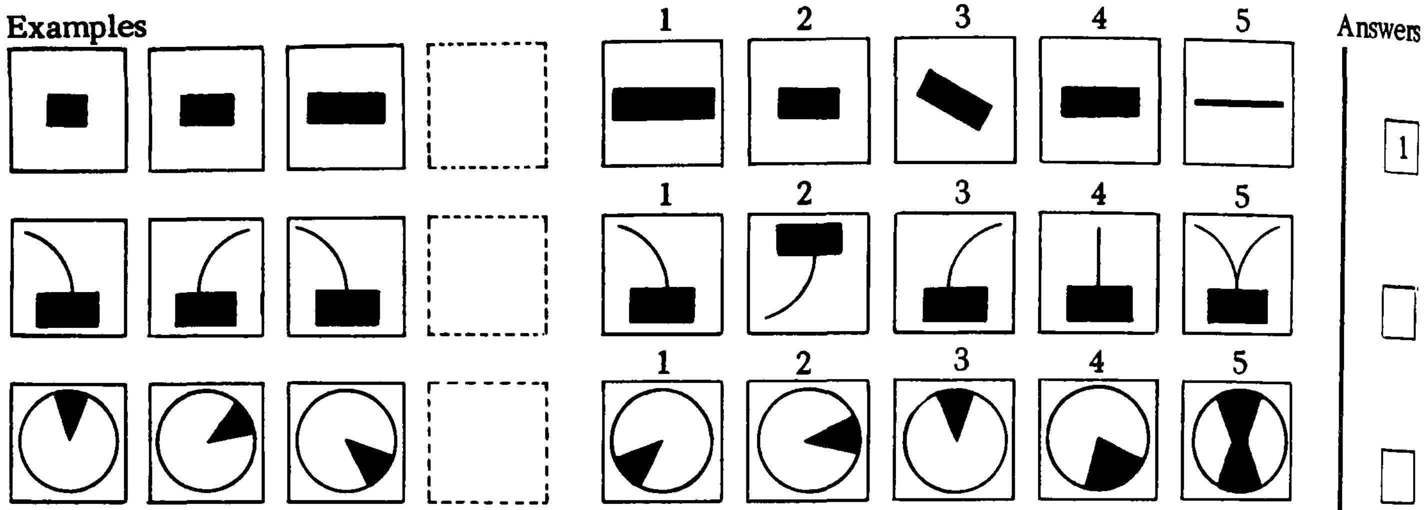
Q. ________

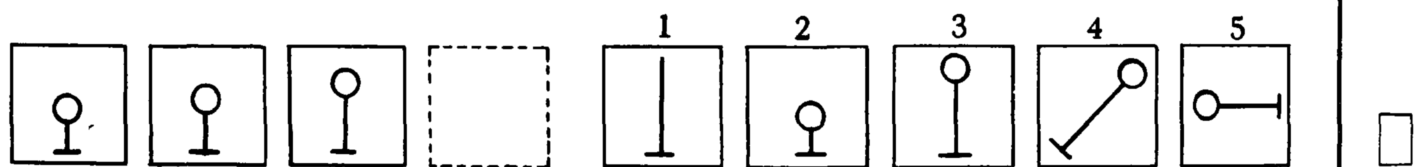
Do not turn the page until told to do so

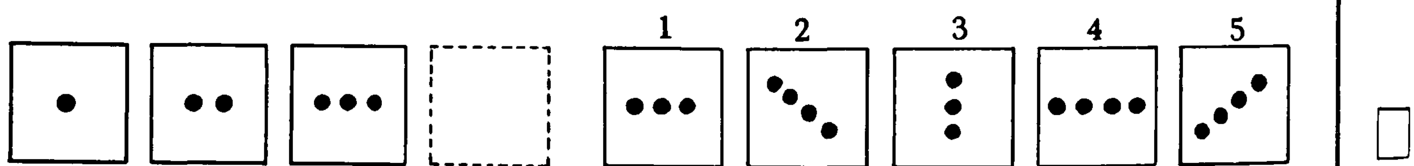
CF2-Atb-6AA

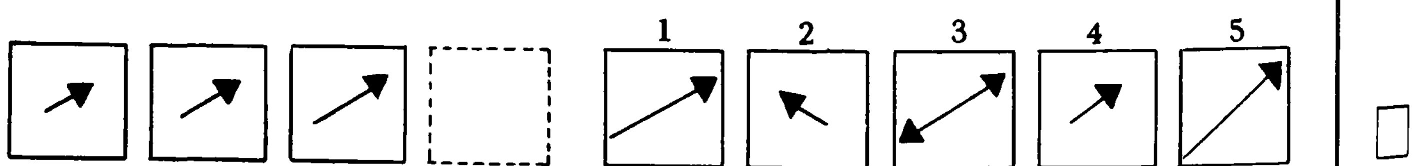
TEST 1

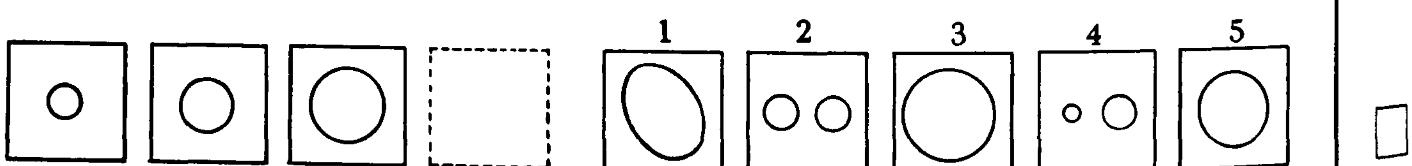
Examples

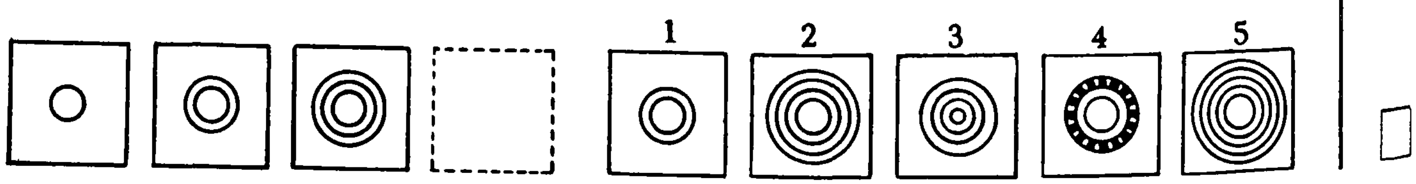


1. 

2. 

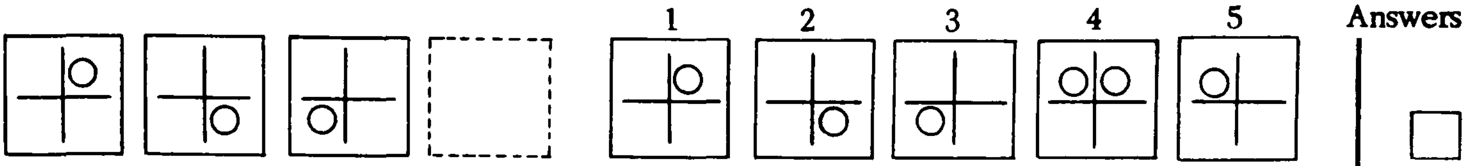
3. 

4. 

5. 

Go on to the next page.

Answers

6.


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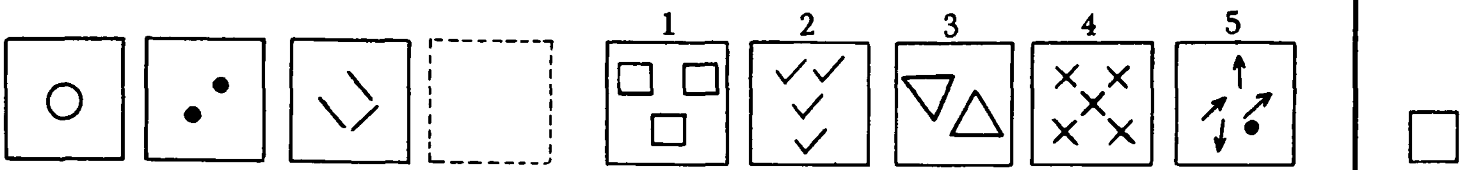

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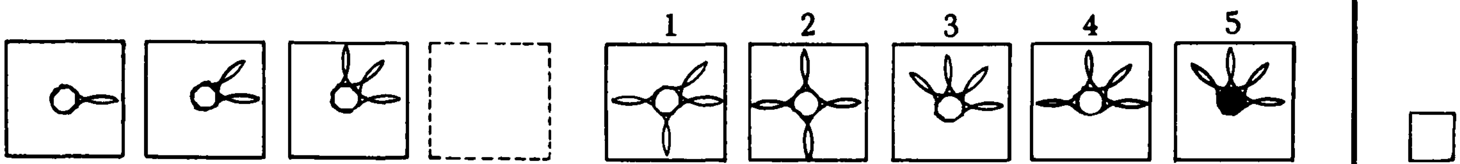

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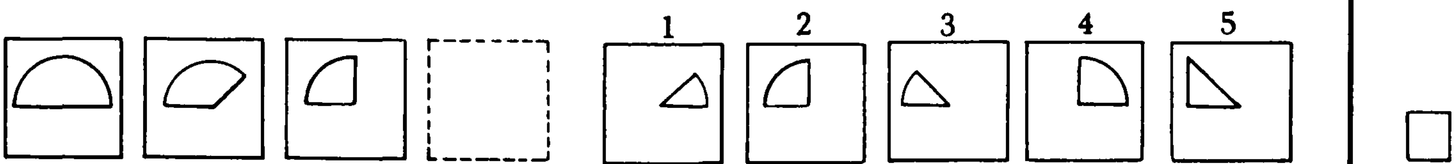

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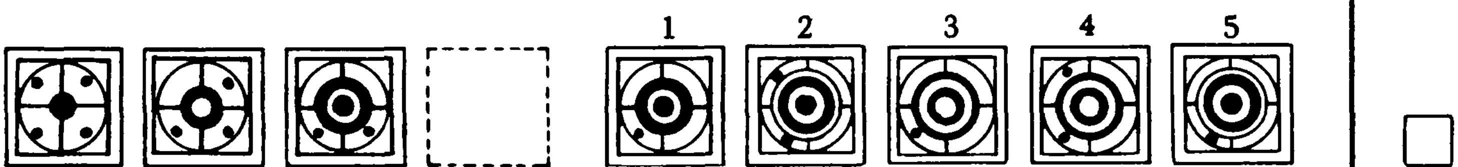

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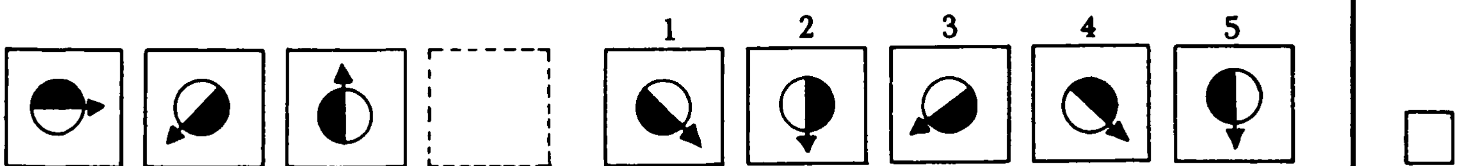

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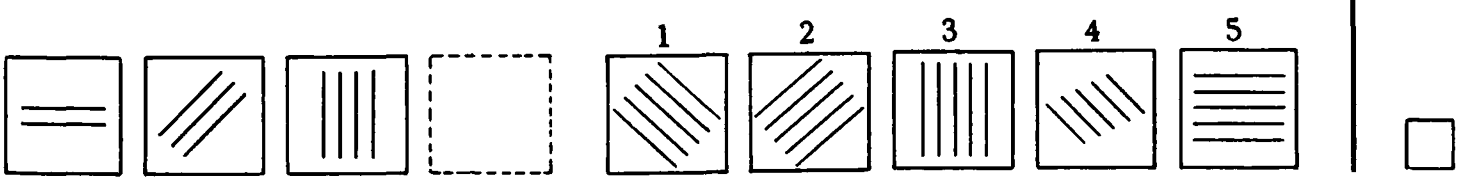
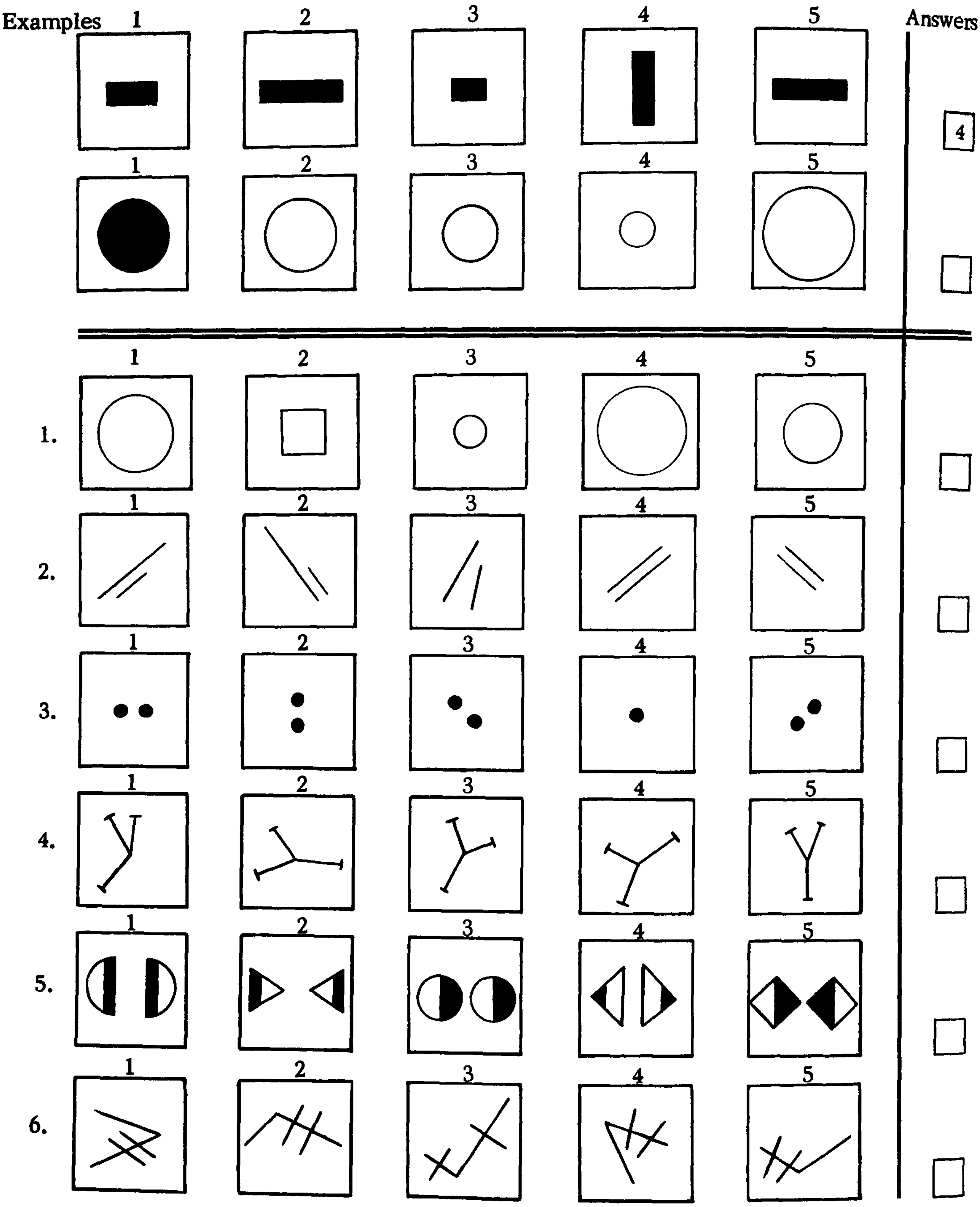


End of Test 1

STOP! Do not turn the page until told to do so

TEST 2



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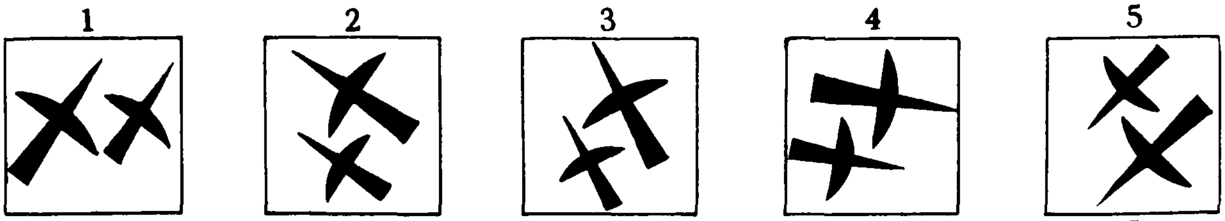
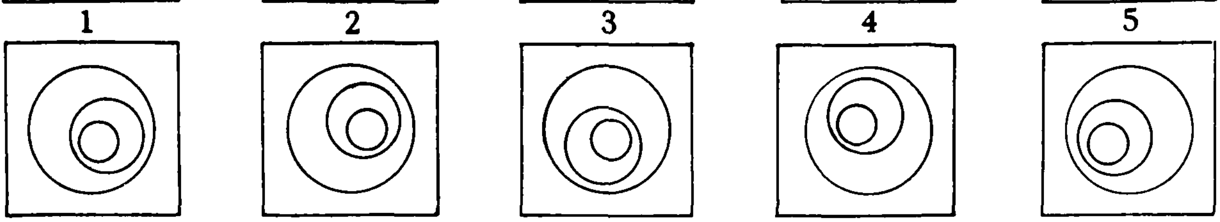
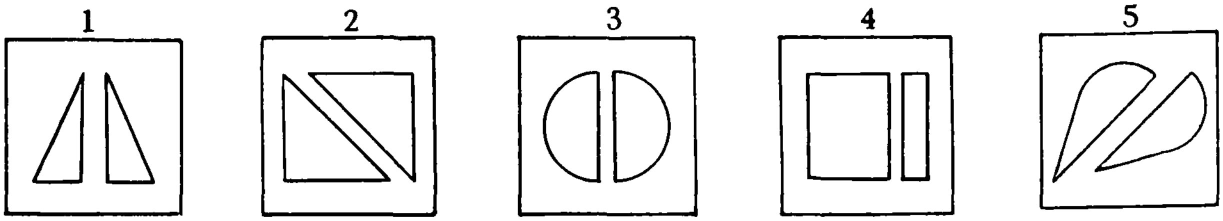
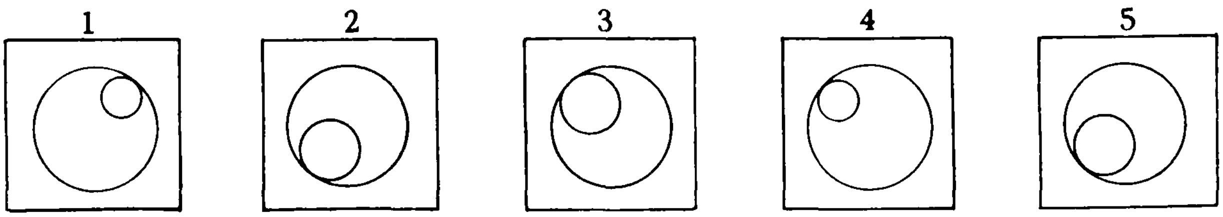
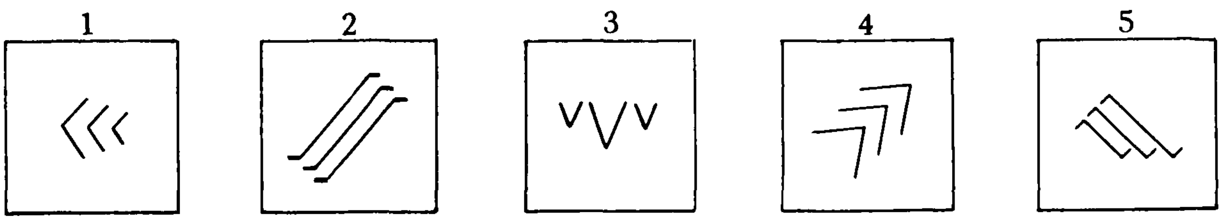
Answers

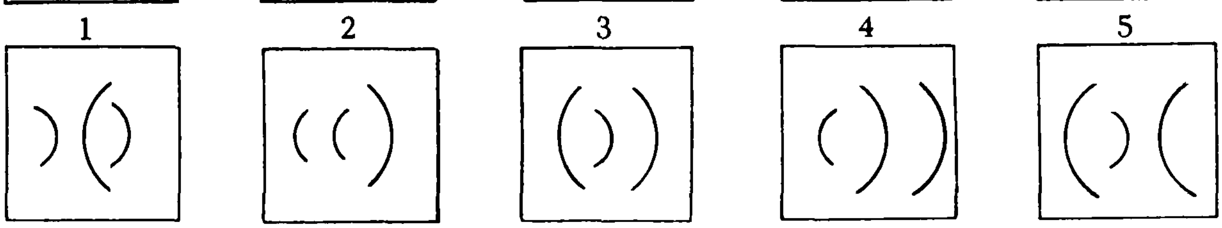
7. 

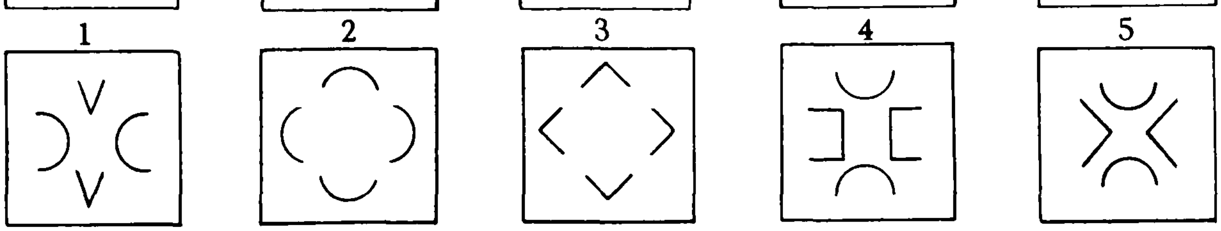
8. 

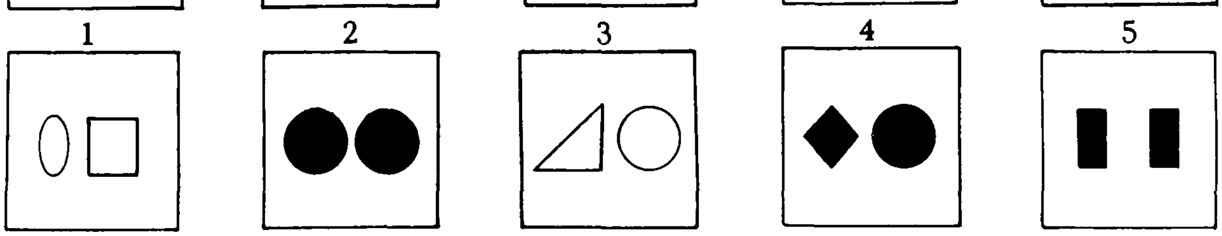
9. 

10. 

11. 

12. 

13. 

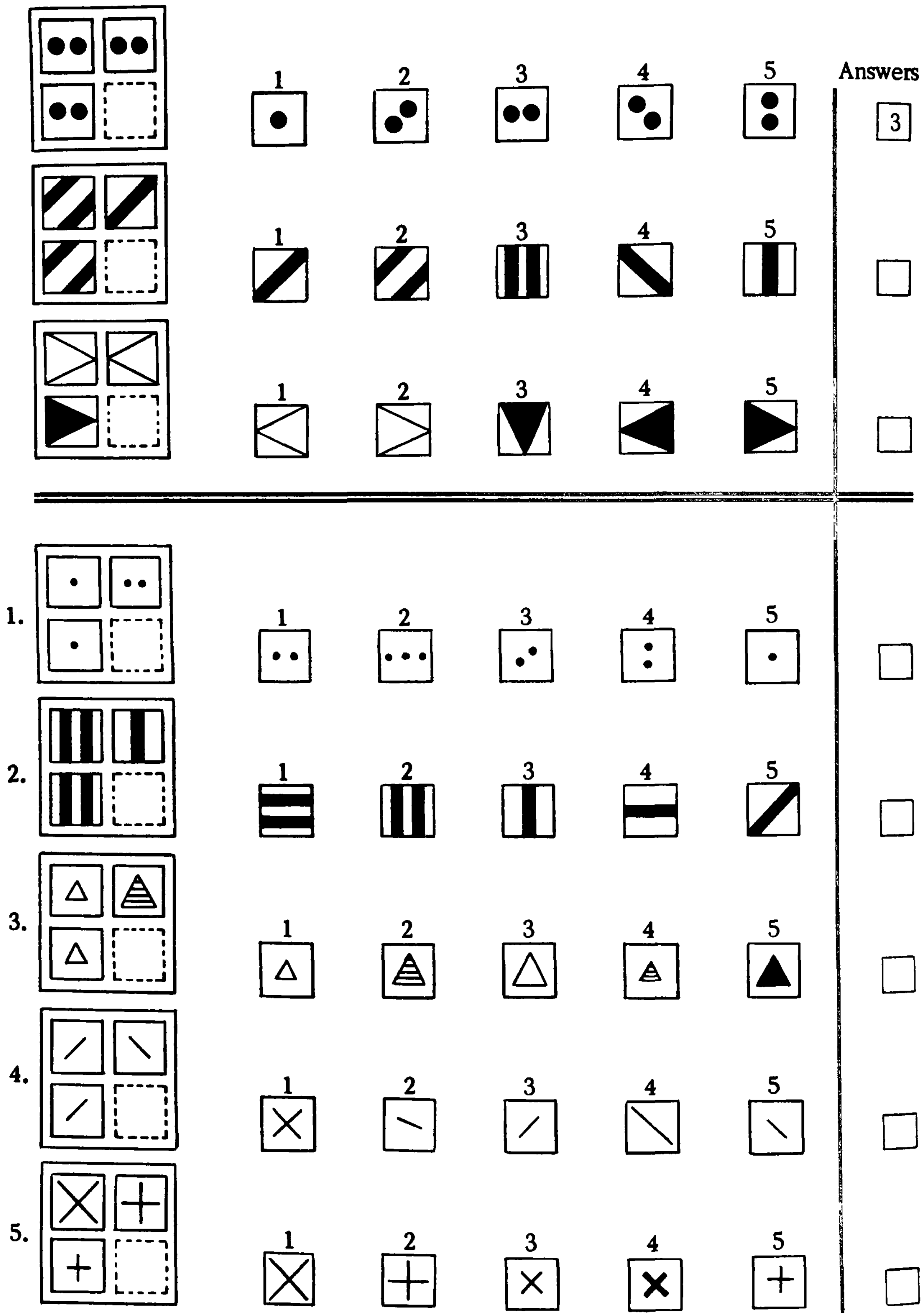
14. 

End of Test 2

STOP! Do not turn the page until told to do so.

TEST #3

Examples



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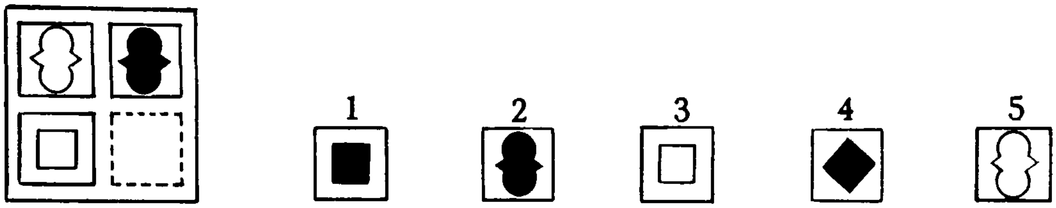
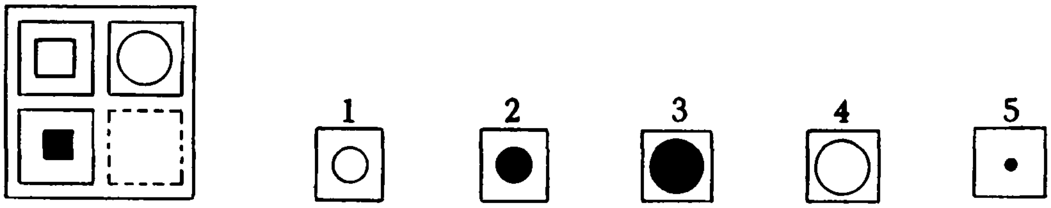
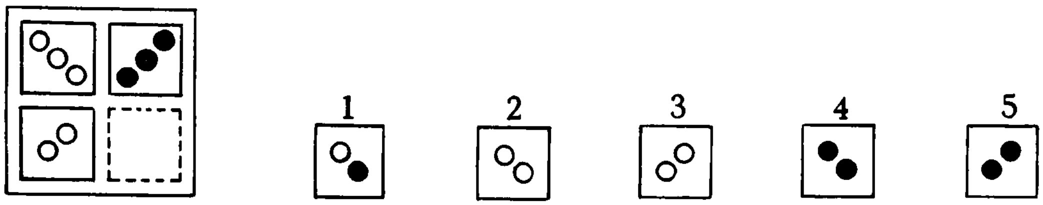
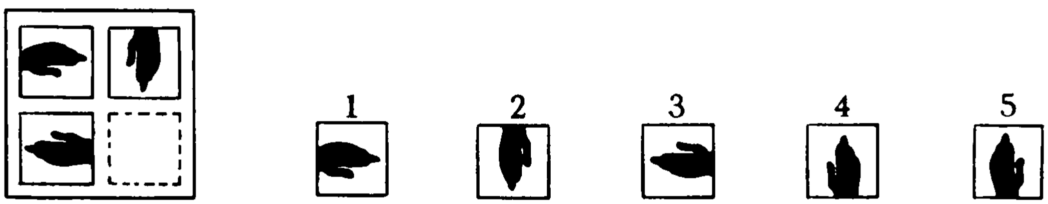
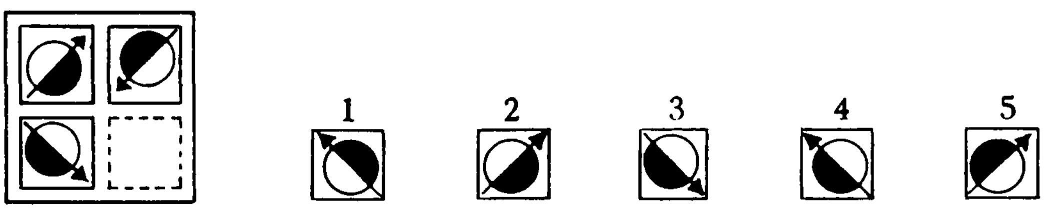
Answers

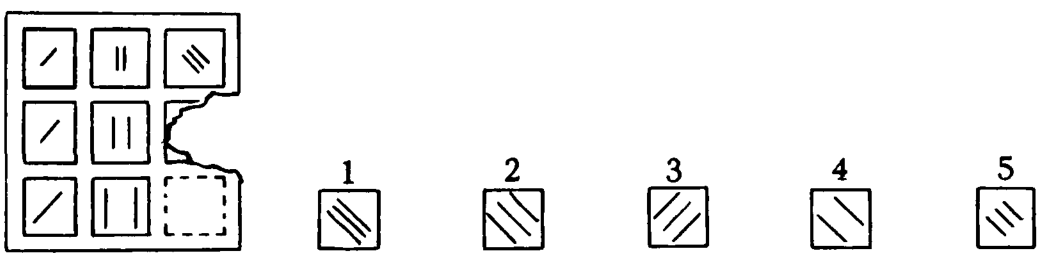
6. 

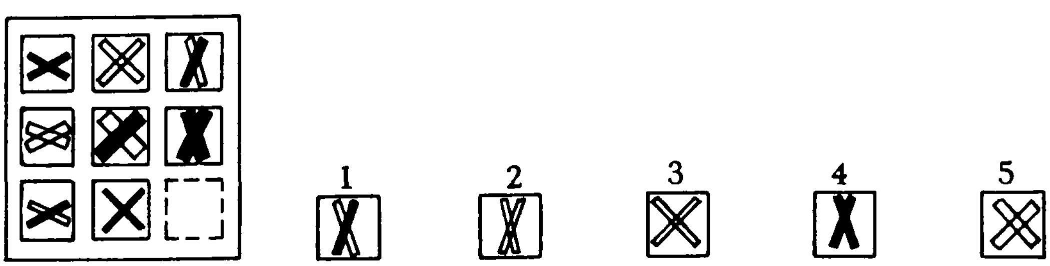
7. 

8. 

9. 

10. 

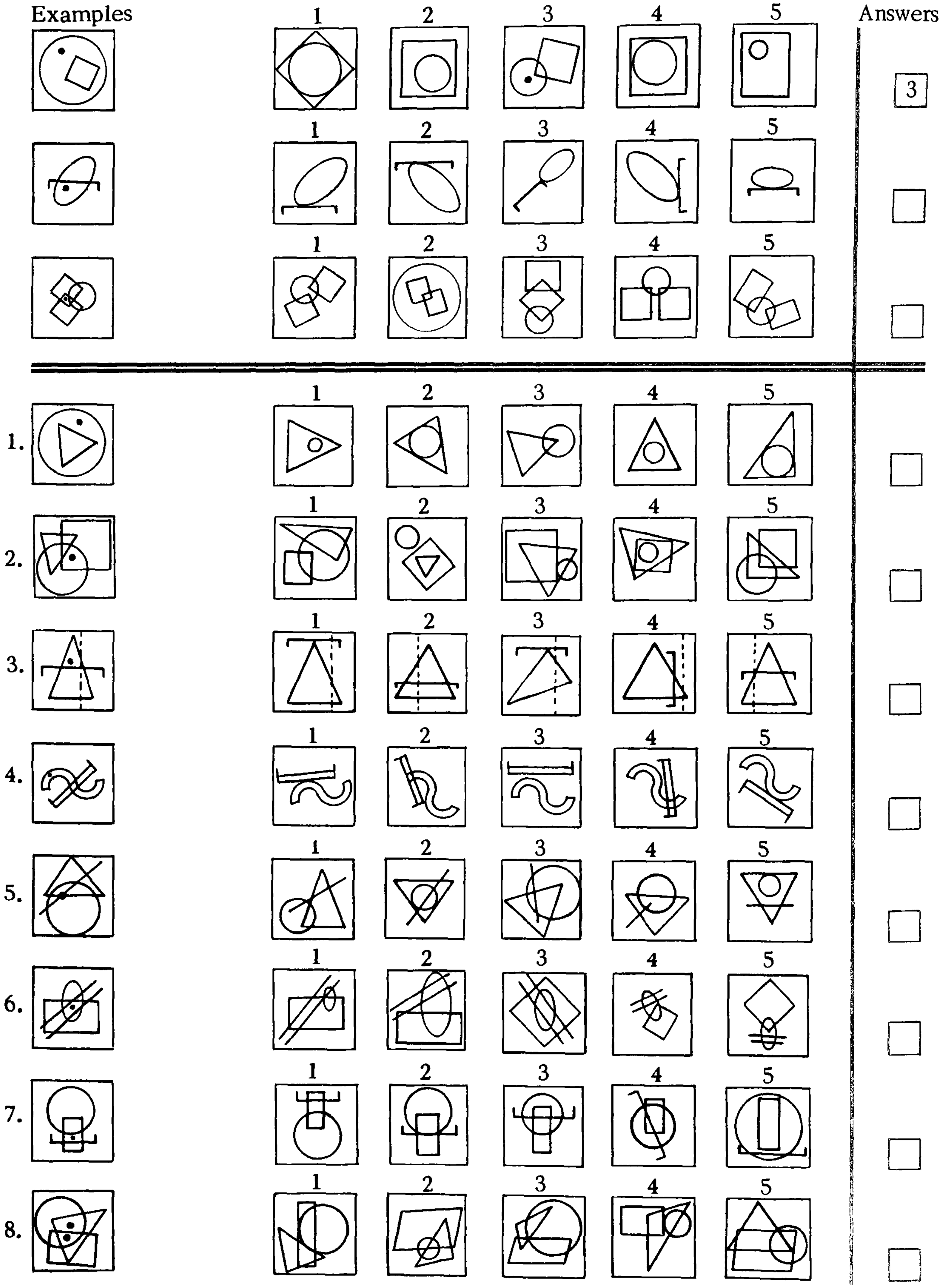
11. 

12. 

End of Test 3

STOP! Do not turn the page until told to do so.

TEST 4



End of Test 4

APPENDIX 3

DEMOGRAPHIC DATA: AGE, EDUCATION AND OCCUPATION; AND PREDICTOR VARIABLES: REACTION TIME, *EPI* SCORES AND SPIRAL AFTER-EFFECT

APPENDIX 3

DEMOGRAPHIC DATA: AGE, EDUCATION AND OCCUPATION; AND PREDICTOR VARIABLES: REACTION TIME, EPI SCORES AND SPIRAL AFTER-EFFECT

Subj	Age	Educ	Occ[a]	RT (msec)	EPI Scores[b] E	N	L	SAE[c] (sec)
1	65	16	2	288	3	13	2	19.6
2	78	14	1	317	5	5	7	-
3	72	12	3	259	5	7	3	11.4
4	73	9	2	233	5	9	7	16.2
5	71	10	4	280	6	7	2	17.4
6	81	12	4	642	6	3	7	8.6
7	60	10	4	139	6	9	6	18.4
8	69	5	2	248	7	10	7	13.8
9	83	12	4	276	7	8	4	12.4
10	71	8	1	263	7	11	5	10.6
11	63	9	2	198	7	5	3	11.4
12	82	2	2	430	8	14	7	17.2
13	70	3	1	520	8	13	7	18.0
14	66	13	5	381	8	8	5	20.4
15	70	8	2	355	8	16	4	1.4
16	69	10	1	352	8	6	8	15.2
17	73	9	1	343	8	16	5	14.8
18	78	3	2	342	8	3	6	-
19	65	8	3	339	8	16	6	10.2
20	64	9	1	489	9	13	2	18.6
21	67	7	1	277	9	12	3	16.4
22	73	13	4	246	9	12	6	14.8
23	72	3	2	303	9	6	7	12.6
24	70	7	2	399	9	10	6	10.8
25	69	0	1	462	9	7	6	-

a 1 - unskilled
2 - skilled
3 - clerical
4 - managerial
5 - professional

b E - Extraversion
N - Neuroticism
L - Lie

c Spiral After-effect

DEMOGRAPHIC DATA AND PREDICTOR VARIABLES
(Cont'd.)

Subj	Age	Educ	Occ	RT (msec)	EPI Scores E	N	L	SAE (sec)
26	71	10	2	307	9	4	9	13.2
27	75	10	2	216	9	8	4	14.6
28	67	10	2	280	10	6	3	15.4
29	76	7	4	277	10	10	4	13.6
30	65	12	4	225	10	4	0	12.4
31	66	12	4	191	10	7	6	-
32	63	0	1	216	10	20	4	11.8
33	66	9	2	286	10	11	3	16.2
34	67	0	2	270	10	10	6	10.8
35	69	8	1	311	10	7	7	11.4
36	63	9	1	204	10	5	5	12.7
37	74	13	2	474	10	14	6	-
38	72	8	2	228	10	15	5	8.6
39	78	6	1	730	10	11	3	9.4
40	73	4	2	399	10	5	6	10.2
41	72	8	2	597	11	7	5	14.6
42	70	7	2	562	11	16	5	16.2
43	86	7	4	497	11	4	8	10.0
44	81	6	1	455	11	12	8	9.6
45	71	12	2	440	11	10	0	11.6
46	78	4	1	339	11	13	1	13.2
47	74	16	4	331	11	4	8	5.4
48	79	12	2	336	11	13	7	9.2
49	67	14	4	354	11	9	4	6.4
50	70	8	2	488	11	11	6	8.6
51	83	12	3	331	11	5	4	11.4
52	72	3	2	320	11	15	2	9.6
53	68	8	3	303	11	16	5	10.8
54	77	18	5	264	11	7	5	-
55	67	8	2	253	11	6	4	11.2
56	62	13	4	214	11	8	5	4.8
57	65	10	1	205	11	12	6	-
58	66	8	4	520	12	8	6	9.0
59	86	4	2	452	12	10	7	12.6
60	67	2	2	438	12	17	1	14.8

APPENDIX 3

DEMOGRAPHIC DATA AND PREDICTOR VARIABLES
(Cont'd.)

Subj	Age	Educ	Occ	RT (msec)	EPI Scores E	N	L	SAE (sec)
61	60	6	2	397	12	13	8	12.6
62	67	10	1	291	12	11	8	-
63	71	10	2	347	12	8	7	13.6
64	74	10	4	279	12	4	5	15.4
65	70	5	2	270	12	7	5	9.6
66	71	6	2	269	12	4	7	10.0
67	73	10	3	257	12	9	8	11.4
68	64	10	2	223	12	11	6	12.6
69	67	10	2	179	12	10	4	8.4
70	74	8	1	173	13	6	5	6.2
71	72	12	3	214	13	16	5	8.4
72	73	12	3	249	13	9	5	9.6
73	65	4	2	250	13	15	5	8.4
74	72	10	2	314	13	18	2	11.4
75	74	10	1	379	13	10	7	12.6
76	68	8	2	340	13	14	6	9.8
77	65	10	2	308	13	5	4	10.4
78	66	10	2	451	14	6	7	11.2
79	66	8	2	411	14	17	4	12.0
80	86	3	1	402	14	7	1	16.4
81	90	8	2	870	14	12	6	10.2
82	62	11	2	355	14	7	4	8.6
83	82	0	1	437	14	7	7	7.4
84	69	12	2	411	14	1	8	12.2
85	79	18	5	240	14	4	3	-
86	69	7	2	307	14	5	6	10.6
87	77	12	1	271	14	2	6	13.6
88	75	15	2	258	14	13	7	13.4
89	66	12	2	235	14	11	2	8.6
90	69	12	4	226	14	1	7	-
91	77	9	2	231	15	4	5	11.2
92	73	15	5	257	15	10	5	8.6
93	71	8	3	242	15	12	6	10.4
94	74	6	2	385	15	13	2	6.2
95	74	12	2	481	15	7	5	9.4

APPENDIX 3

DEMOGRAPHIC DATA AND PREDICTOR VARIABLES
(Cont'd.)

Subj	Age	Educ	Occ	RT (msec)	EPI Scores E	N	L	SAE (sec)
96	69	4	2	597	15	4	5	12.8
97	81	13	3	568	15	6	7	9.4
98	68	4	2	299	15	15	3	11.6
99	81	16	4	352	15	7	8	-
100	80	12	4	231	15	12	1	10.8
101	67	8	2	266	16	9	6	8.4
102	83	0	2	359	16	14	8	16.2
103	65	15	2	344	16	10	2	9.6
104	62	10	2	323	16	3	8	10.0
105	71	8	1	263	16	10	0	4.8
106	64	3	2	223	16	15	5	8.6
107	73	7	2	401	17	7	8	11.2
108	60	12	2	241	17	8	2	9.0
109	64	13	4	217	18	15	6	-
110	64	12	1	404	18	1	8	6.4
111	63	12	1	216	18	11	2	7.2
112	72	15	3	238	19	20	4	8.8
113	77	0	2	231	19	15	4	10.4
114	65	11	4	310	19	6	1	12.2
115	72	14	2	273	19	8	7	6.2
116	69	5	1	272	21	6	4	8.4
117	67	14	4	239	21	18	5	9.0
118	63	10	1	226	11	10	2	7.6
119	65	6	1	338	9	11	7	12.3
120	69	13	3	310	12	7	2	8.8

APPENDIX 4

SCORES OF CRITERION VARIABLES

1 - Fluid score
2 - Series
3 - Classification
4 - Matrices
5 - Conditions
6 - Crystal score
7 - Information
8 - Comprehension
9 - Arithmetic
10 - Similarities
11 - Digit Span score
12 - Digits Forward
13 - Digits Backward

APPENDIX 4

SCORES OF CRITERION VARIABLES

Subj	1	2	3	4	5	6	7	8	9	10	11	12	13
1	26	9	4	8	5	50	14	14	9	13	12	7	6
2	25	7	7	8	3	48	12	18	7	11	10	7	4
3	20	7	7	5	1	44	12	13	12	7	12	9	4
4	26	8	5	6	7	41	8	9	14	10	14	8	6
5	17	3	5	6	3	48	12	10	12	14	11	7	5
6	19	8	4	2	5	36	11	10	9	6	9	7	3
7	21	6	7	4	4	58	16	19	12	11	11	7	5
8	18	6	3	3	6	25	7	8	7	3	9	6	4
9	27	9	5	8	5	61	16	17	13	15	11	8	4
10	21	6	5	7	3	37	10	10	7	10	12	7	6
11	20	5	6	5	4	44	11	10	11	12	11	8	4
12	15	4	7	4	0	23	5	7	7	4	6	5	3
13	16	3	4	5	4	21	6	7	5	3	6	5	3
14	31	9	6	9	7	47	13	11	12	11	12	8	5
15	15	6	3	3	3	41	12	13	7	9	9	6	4
16	9	4	3	2	0	29	11	9	7	2	9	6	4
17	11	1	5	2	3	17	6	5	6	0	7	6	3
18	13	2	4	4	3	32	7	11	8	6	10	7	4
19	19	6	8	4	1	48	11	17	12	8	12	9	4
20	14	5	3	5	1	34	7	9	9	9	6	5	3
21	16	5	5	3	3	36	9	9	7	11	11	7	5
22	22	5	6	6	5	55	13	15	15	12	15	9	6
23	17	8	4	2	3	38	9	12	10	7	11	8	4
24	9	3	6	0	0	25	7	6	7	5	7	6	3
25	4	2	1	1	0	19	6	7	6	0	4	4	3
26	29	8	5	9	7	49	13	10	13	13	14	8	6
27	18	6	4	5	3	36	12	10	7	7	10	8	3
28	25	6	5	8	6	41	10	10	11	10	14	7	7
29	20	6	7	5	2	47	13	10	12	12	11	9	3
30	29	7	7	9	6	53	14	14	10	15	11	8	4
31	29	9	7	7	6	47	11	11	12	13	10	7	4
32	25	9	7	5	4	25	5	6	6	8	7	7	2
33	17	7	4	4	2	43	11	16	7	9	6	6	2
34	15	4	4	4	3	26	9	8	5	4	4	4	3
35	19	5	7	4	3	26	9	4	7	6	6	5	3

SCORES OF CRITERION VARIABLES
(Cont'd.)

Subj	1	2	3	4	5	6	7	8	9	10	11	12	13
36	15	3	6	2	4	24	4	6	6	8	7	6	3
37	14	5	3	5	1	29	6	6	8	9	6	5	3
38	15	1	5	5	4	21	5	2	6	8	7	5	4
39	19	8	4	2	5	16	6	4	4	2	4	4	3
40	9	3	5	1	0	23	6	5	7	5	6	4	4
41	10	2	3	4	1	26	9	6	8	3	6	6	2
42	9	0	3	4	2	31	8	7	9	7	6	5	3
43	16	6	5	2	3	27	7	7	9	4	12	6	7
44	12	3	4	4	1	30	10	6	9	5	7	5	4
45	15	4	4	5	2	42	12	15	9	6	9	6	4
46	9	0	3	3	3	27	9	9	7	2	4	4	3
47	12	4	3	4	1	36	12	7	8	9	10	7	4
48	11	2	3	2	4	40	11	8	9	12	10	7	4
49	13	5	5	3	0	35	9	9	8	9	9	6	4
50	13	2	5	5	1	28	6	9	8	5	12	8	5
51	9	3	3	3	0	46	12	12	12	10	11	7	5
52	17	5	5	4	3	28	9	5	6	6	10	8	3
53	14	2	4	7	1	34	10	7	11	6	14	8	6
54	19	7	3	4	5	43	12	10	11	10	9	7	3
55	14	3	7	3	1	38	11	11	7	9	14	8	6
56	24	5	7	8	4	42	11	9	10	12	19	9	8
57	4	0	2	2	0	27	10	10	5	2	6	4	4
58	13	3	5	4	1	34	8	13	8	5	7	6	3
59	4	1	3	0	0	23	6	5	6	6	9	6	4
60	8	1	3	4	0	10	2	4	4	0	6	6	2
61	19	7	6	3	3	22	7	6	7	2	6	5	3
62	19	7	3	4	5	52	14	11	15	12	9	6	4
63	11	4	4	0	3	30	7	7	11	5	6	5	3
64	14	5	5	2	2	37	12	15	7	4	7	6	3
65	16	3	6	4	3	30	8	9	7	6	7	6	2
66	20	6	4	5	5	28	9	7	7	5	4	5	2
67	19	6	6	4	3	42	9	13	10	10	9	5	5
68	18	1	8	5	4	36	10	10	8	8	6	6	2
69	14	4	5	5	0	33	11	9	8	5	7	5	4
70	23	5	5	8	5	38	10	13	7	8	10	7	4

APPENDIX 4

SCORES OF CRITERION VARIABLES
(Cont'd.)

Subj	1	2	3	4	5	6	7	8	9	10	11	12	13
71	20	6	7	5	2	42	10	14	8	10	12	9	4
72	26	7	6	7	6	36	9	9	9	9	16	9	7
73	18	4	7	3	4	35	10	9	8	8	9	6	4
74	10	2	5	2	1	32	9	9	11	3	10	6	5
75	13	3	5	5	0	33	9	9	11	4	6	5	3
76	12	4	4	1	3	32	8	6	13	5	6	4	4
77	26	7	7	6	6	26	9	9	7	1	4	4	3
78	11	4	3	2	2	26	7	7	5	7	6	5	3
79	11	1	7	1	2	22	6	8	8	0	7	6	3
80	8	0	3	2	3	39	10	8	9	2	4	4	3
81	10	2	4	3	1	18	6	6	4	2	2	3	3
82	12	3	4	2	3	34	9	8	13	4	7	5	4
83	11	4	4	2	1	15	5	3	4	2	4	4	3
84	12	3	3	4	2	31	9	9	8	5	15	9	6
85	25	7	7	5	6	59	17	15	12	15	15	8	7
86	19	6	6	5	2	42	10	15	7	10	11	8	4
87	14	4	5	4	1	19	7	7	3	2	4	4	3
88	18	4	6	4	4	38	10	10	12	6	14	8	6
89	13	4	4	4	1	43	11	10	10	12	11	8	4
90	16	6	4	4	2	61	14	18	16	13	15	8	7
91	12	2	5	1	4	33	10	10	9	4	9	7	3
92	15	3	6	3	3	53	12	16	11	14	9	7	3
93	22	7	6	4	5	44	10	10	13	11	14	8	6
94	11	1	5	2	3	18	7	5	6	0	6	5	3
95	14	5	3	5	1	31	7	8	7	9	6	4	4
96	13	4	2	5	2	31	8	9	8	6	7	6	3
97	14	1	4	5	3	44	11	16	6	11	9	7	3
98	21	6	8	4	3	25	7	4	7	7	9	7	3
99	9	2	4	2	1	31	10	9	8	4	7	7	2
100	17	6	5	5	1	58	14	15	13	16	14	7	7
101	18	6	3	3	6	45	13	14	9	9	6	5	3
102	9	2	3	4	0	14	5	7	2	0	1	3	2
103	15	4	3	5	3	41	11	14	8	8	7	5	4
104	10	2	3	3	2	34	9	10	9	6	9	6	4
105	15	3	5	4	3	39	11	10	11	7	7	5	4

APPENDIX 4

SCORES OF CRITERION VARIABLES
(Cont'd.)

Subj	1	2	3	4	5	6	7	8	9	10	11	12	13
106	12	4	4	2	2	30	5	11	7	7	9	6	4
107	10	3	3	3	1	33	7	13	7	6	9	6	4
108	11	4	2	5	0	41	9	13	8	11	10	7	4
109	15	3	5	4	3	59	12	18	13	16	11	7	5
110	6	0	3	3	0	18	5	7	3	3	7	6	3
111	17	4	2	9	2	47	11	14	13	9	9	6	4
112	15	4	4	4	3	45	13	11	14	7	14	8	6
113	11	4	3	2	2	30	9	12	5	4	7	5	4
114	9	2	3	2	2	48	12	9	15	12	10	7	4
115	18	5	4	4	5	36	10	6	13	7	10	6	5
116	9	3	2	2	2	39	8	10	11	10	15	9	6
117	21	8	7	4	2	51	14	13	15	9	14	8	6
118	18	6	5	4	3	41	9	13	8	11	11	7	5
119	24	6	8	6	4	45	13	11	14	7	7	5	4
120	12	4	4	2	2	48	12	9	15	12	12	7	6

APPENDIX 5

RAW SCORE TRANSFORMATION TO NORMALIZED z-SCORES: REACTION TIME (N=90)

APPENDIX 5

RAW SCORE TRANSFORMATION TO NORMALIZED z-SCORES:
REACTION TIME (N=90)

Subj	Latency (msec)	z-Score	Normalized z-Score
1	288	-.29	-.12
2	317	-.04	.13
3	259	-.55	-.41
4	233	-.77	-.81
5	280	-.36	-.12
6	642	2.76	1.95
7	139	-2.10	-2.51
8	248	-.64	-.81
9	276	-.40	-.12
10	263	-.51	-.41
11	198	-1.07	-1.76
12	430	.92	1.03
13	520	1.70	1.52
14	381	.50	.82
15	355	.28	.64
16	352	.25	.64
17	343	.17	.38
18	342	.16	.38
19	339	.14	.38
20	489	1.44	1.33
21	277	-.39	-.12
22	246	-.66	-.81
23	303	-.17	.13
24	399	.66	.82
25	462	1.20	1.15
26	307	-.13	.13
27	216	-.92	-1.33
119	338	.13	.38
28	280	-.36	-.12
29	277	-.39	-.12

APPENDIX 5

RAW SCORE TRANSFORMATION TO NORMALIZED z-SCORES: REACTION TIME (N=90) (Cont'd.)

Subj	Latency (msec)	z-Score	Normalized z-Score
31	191	-1.13	-1.76
33	286	-.31	-.12
35	311	-.10	.13
43	497	1.50	1.33
44	455	1.14	1.15
45	440	1.01	1.03
46	339	.14	.38
48	336	.11	.38
49	354	.27	.64
51	331	.07	.38
55	253	-.60	-.41
56	214	-.94	-1.33
57	205	-1.01	-1.33
118	226	-.83	-.81
58	520	1.70	1.52
59	452	1.11	1.15
61	397	.64	.82
63	347	.21	.38
64	279	-.37	-.12
65	270	-.45	-.41
66	269	-.46	-.41
68	223	-.86	-1.33
69	179	-1.24	-1.76
70	173	-1.29	-2.12
72	249	-.63	-.81
74	314	-.07	.13
75	379	.48	.82
76	340	.15	.38
81	870	4.73	2.15
82	355	.28	.64
85	240	-.71	-.81
86	307	-.13	.13
89	235	-.75	-.81
91	231	-.79	-.81
92	257	-.56	-.41

RAW SCORE TRANSFORMATION TO NORMALIZED z-SCORES:
REACTION TIME (N-90) (Cont'd.)

Subj	Latency (msec)	z-Score	Normalized z-Score
93	242	-.69	-.81
94	385	.53	.82
95	481	1.37	1.33
96	597	2.37	1.79
97	568	2.12	1.67
98	299	-.20	-.12
99	352	.25	.64
100	231	-.79	-.81
101	266	-.49	-.41
102	359	.31	.64
103	344	.18	.38
104	323	-.03	.13
105	263	-.51	-.41
106	223	-.86	-1.33
107	401	.67	.94
108	241	-.70	-.81
109	217	.91	-1.33
110	404	.70	.94
111	216	-.92	-1.33
112	238	-.73	-.81
113	231	-.79	-.81
114	310	-.10	.13
115	273	-.42	-.41
116	272	-.43	-.41
117	239	-.72	-.81

ABSTRACT

Studies of older persons have shown that certain individual differences increase with age; for example, there is greater variance in task performance of the elderly than in task performance of the young. It has been suggested that some factors may have a pervasive influence on performance, but this influence becomes manifest only when the base of the factor is disturbed by extraneous forces or internal deterioration or change. Some latent influences may appear only when the mask effects and domination of other influences cease. This concept seems particularly applicable to the study of the older adult whose neurophysiological status is generally threatened both by the cessation of growth functions and the accumulative effects of a long life span.

In this study two variables, namely, response speed, an index reflecting structural integrity and central processing, and extraversion, a personality dimension in the Eysenckian model, expressing the cortical-subcortical excitation/arousal level, were investigated as significant variables in the older adult's performance on intellectual tasks. The involvement of neurophysiological structures and organization of both variables required consideration of their independence. Likewise, it was necessary to clarify the nature of extraversion in its application to old people.

ABSTRACT

This study was made via a quasi-experimental design. One hundred twenty men, 60 years of age or older, were the subjects. The following measurements were taken: (1) mean reaction time, simple type with a warning signal; (2) extraversion, E-score of the Eysenck Personality Inventory; (3) cortical inhibition, duration of Spiral After-effect phenomenon; (4) fluid intelligence, total score of IPAT Culture Fair test; and (5) crystallized intelligence, total score of selected WAIS subtests.

Analysis of the results indicated that reaction time and extraversion do not co-vary; that extraversion may be considered in terms of the hypothesized neurodynamics as well as its social dimension; that reaction time is a significant predictor of fluid and crystallized intelligence and that extraversion is a significant predictor of fluid, but not of crystallized, intelligence.

These findings were discussed in terms of their theoretical formulations and their practical significance in the behavior of older people. Reaction time and Eysenckian extraversion appear to be significant predictors of the elderly's functioning. Further research is required to determine the limitations of the predictors relative to the types of functioning considered. This is especially needed for extraversion which showed discriminant influence on basic general ability tasks.