CHANGES IN NEUROPSYCHOLOGICAL
FUNCTIONING IN AN AGING
POPULATION

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CHAPTER I

Overview

The process of aging has been highly correlated with a level of performance decrement across a number of psychological and behavioral indicators. A decline in the overall structural and neurological integrity of the central nervous system has also been documented. The primary focus of this study will be to investigate the various changes which take place in neuropsychological function in healthy individuals who are 50 years of age and older. Differences and similarities in levels of performance will be determined for two groups of older subjects across a number of subtests from the Halstead-Reitan Neuropsychological Test Battery, the Wechsler Adult Intelligence Scale, and the Wechsler Memory Scale.

Quite often psychologists who are unaware of factors specific to an aging population assume that normative data obtained from young adults can be directly applied to older adults. This procedure can result in the inappropriate classification of well-functioning older adults as dysfunctional due to an age-related performance decrement. It is equally inappropriate to assume that all behavior changes substantially and that all functions decline as a result of aging. Little information currently exists with regard to normative levels of performance on the various Halstead-Reitan Battery subtests for older groups of normal adults. Since this is the most widely used test battery for the assessment of neuropsychological dysfunction, the gathering of this data is necessary so that level of performance standards are available against which to compare the performances of allegedly dysfunctional adults.

This investigation will gather preliminary level of performance data for normally functioning, healthy older adults who are able to manage well in the community. The existing literature which is relevant to the areas being considered within the purview of this investigation will subsequently be reviewed.

Introduction

It is generally accepted that a gradual decline in a number of

psychological functions is associated with aging post-maturity (Botwinick, 1973). Age-related changes typically cited include sensory limitations, slowness in response speed, declines in abstraction ability and ability to comprehend conceptual problems, and memory impairment, particularly relating to recent events (Reitan, 1967). Decrements in performance on psychological test measures tapping a number of areas of functioning are well-documented (Rabbitt, 1977). It is obvious that the overall integrity of the brain and nervous system plays a critical role in this regard (Reitan, 1967).

There is much debate in the field of gerontological research with respect to the exact definition and nature of the aging process itself. This debate is concerned with whether "normal" aging processes can or should be distinguished from "pathological" aging processes (Elias, Elias, & Elias, 1977). This typical distinction is well-characterized by Busse (1969) who refers to biological aging as those genetic processes which are time-related but independent of stress, trauma, or disease. Pathological aging refers to those disabilities which are the result of trauma and chronic illness. This often debated difference in perspective and causal attributions is actually more theoretical than pragmatic. Eisdorfer and Wilkie (1973) noted that since older people seem to be more susceptible to sickness, the interactive effects of aging and illness will plague the investigator who attempts to define age-related changes in any pure sense.

Definitional issues notwithstanding, no definitive mechanism has yet been proposed to account for the manner in which changes in the central nervous system (CNS) mediate changes in psychological test performance. The exact behavioral manifestations of well-documented age-related changes in the brain such as loss of neurons, structural and functional changes in surviving neurons, plaque formation, loss of dendrites, and glial cell changes, have yet to be determined (Bondareff, 1977). Secondly, the mechanisms by which degenerative changes in organ systems, such as the cardiovascular system, effect CNS functioning are largely unknown (Shock, 1962). Finally, certain abilities continue to mature while others deteriorate (Reitan, 1967).

The area of neuropsychology is concerned with the development of knowledge about brain-behavior relationships (Davison, 1974). It attempts to bridge the gap between psychological functioning and CNS functioning. Evidence for attributing age-related changes in psychological functioning to changes that occur in the brain has been gathered by a number of investigators (Marsh & Thompson, 1977; Wang, Obrist, & Busse, 1974; Welford & Birren, 1965). Thus, clinical neuropsychological tests which have been found to be valid indices of the integrity of the brain (Halstead, 1947; Reitan, 1955a, Vega & Parsons, 1967) should be particularly useful in attempting to assess a number of age-related behavioral changes.

The Halstead-Reitan Neuropsychological Test Battery (HRB) is the most widely used test battery for the assessment of behavioral deficits associated with brain dysfunction in adults (Klisz, 1978). It has proven to be a sensitive instrument for assessing the functional integrity of the brain in terms of differentiating the performance of brain-damaged versus non-brain-damaged people. It can also be utilized to identify behavioral deficits which are characteristic of subgroups of brain-damaged people (Parsons, Vega, & Burn, 1969; Reitan, 1964; Russell, Neuringer, & Goldstein, 1970). In a recent review of the literature pertinent to the validity of the test battery, Klove (1974) noted that it has proven to have a striking sensitivity to the organic integrity of the cerebral hemispheres.

Since it has been well-established that degenerative neuro-anatomical and neurophysiological changes occur in the brain as age increases, it would seem reasonable to predict that performance on neuropsychological tests that are sensitive to the integrity of the cerebral hemispheres would also show a decline. A number of studies utilizing the tests from the HRB have generated evidence to support this line of reasoning.

Halstead-Reitan Test Battery Performance and Aging

Reitan (1955c) investigated the relationship between the Halstead Impairment Index (the most valid indicator of brain-damage in the

battery) and chronological age. One hundred and ninety-four subjects with brain damage of various types and 133 hospitalized and non-hospitalized controls were categorized by five year intervals, ranging from 15 to 64 years of age. A weak relationship was found between the Impairment Index and age for the brain-damaged subjects. However, a strong relationship was found for the non-brain-damaged controls ($r = .54$). Additionally, the mean performance of each five year interval for normal 45 year old subjects and upward was well above the criterion level and into the range reflective of brain damage according to the test norms. The mean score was somewhat poorer for each succeeding age interval. It was concluded that while age was relatively insignificant in determining results when brain damage was clearly present, it was a distinctly pertinent variable in the normal control group, particularly in the age range from 45 to 65 years. A replication of this study by Reitan (1956) found comparable results.

Reitan (1957) administered the Halstead Category Test and the Wechsler-Bellevue Scale (W-B) to 138 normally functioning, highly educated (mean years of education 16.3 years) males, ranging from 27 to 65 years of age. The correlations between test results and age were the highest for the Category Test ($r = .45$) and the W-B Performance IQ ($r = .44$), while the Verbal IQ showed only a small correlation ($r = .14$). All the mean test performances showed a decline for the 55 year and older age range, but only the Category Test and the W-B performance tests showed a decrement in the 50 to 54 year interval. These results suggested that the earliest effects of aging appear on HRB measures and W-B performance tests, but not on Verbal IQ measures.

Fifty brain-damaged and 50 non-brain-damaged control subjects were matched in pairs with regard to sex, age, education, and race by Reitan (1962). For statistical analysis, subjects were grouped 34 years and less, 35 to 44 years, 45 to 54 years, 55 years and older, and were compared on the Halstead Impairment Index, Category Test, Localization score of the Tactual Performance Test (TPT), and Part B of the Trail Making Test (TMT). While the brain-damaged subjects consistently performed more poorly than their counterpart control sub-

jects, both groups tended to show progressively poorer performances with advancing age. Within the brain-damaged and control groups a 10 year deviation in age was required for significant performance differences to appear. It was generally concluded that similar changes in test performance occurred as a result of brain damage, and as a result of about 30 years of aging. Thus, this study provided evidence of a quantitative change in performance as an age-related effect that was similar to the impairment shown by younger brain-damaged subjects.

Reed and Reitan (1962) compared the performances on the TPT of 50 heterogeneously brain-damaged subjects matched in pairs with 50 non-brain-damaged subjects, across the variables of age, sex, education, and race. For purposes of analysis, the subjects were divided into an older group (mean age 53.2 years, range 45-65 years) and a younger group (mean age 32.3 years, range 21-44 years). They found that brain-damaged subjects consistently performed significantly less well than did their matched counterparts across both age groups. A significant difference in level of performance was also found for the young versus old groups of control subjects, but not for the young versus old groups of brain-damaged subjects.

Reitan and Shipley (1963) reported scores on the HRB for a young (92 subjects below age 40) and old (64 subjects who were 40 years of age or older) group of males. Although level of education was not reported, it may be assumed to be higher than average since at least 20% had an M.D. or Ph.D. All the comparisons of scores between the groups indicated that the young subjects significantly out-performed the old subjects.

Reed and Reitan (1963a) attempted to gather further evidence in order to attribute part of the age associated changes in psychological test performance to changes in brain functioning. The W-B and HRB were administered to 40 young, heterogeneously brain-damaged and 40 young control subjects using a matched pair design. Subsequently, t -ratios were used to rank the tests with regard to their sensitivity to the integrity of brain functioning. The same tests were administered to two older groups of normal subjects (mean age of group I = 44.7

years, education 16.7 years; mean age of group II = 55.3 years, education 13.9 years) and ranked with respect to their sensitivity to the age factor. A significant relationship was found ($\rho = .49$) between the two rank-ordered distributions of tests. These results further support the perspective that age associated changes in ability may be at least partially explained on the basis of changes in the organic condition of the brain.

Reed and Reitan (1963b) had three judges rank 29 tests frequently used in neuropsychological evaluations on the dimensions of immediate adaptive intelligence versus stored memory taking into account the complexity of the response required. Data on 20 of these tests were gathered for an old (mean age 52.9 years, mean education 12.4 years) and a young (mean age 28.1 years, mean education 11.8 years) group of normal subjects. The performance of young subjects was found to be significantly superior to that of old subjects on those tests judged to be most heavily dependent on immediate adaptive abilities. On tests judged to be more dependent on stored memory, the performance of older subjects was slightly superior, though not significantly so. There was substantial agreement between the obtained and predicted rank-ordered distribution of mean differences ($\rho = .77$, $p < .01$). The central hypothesis that tests which require immediate problem-solving behavior would be more influenced by age than those which require the recall of stored information was supported.

Fitzhugh, Fitzhugh, and Reitan (1964) conducted a study to test the effects of age differences within the context of longstanding cerebral dysfunction. Two hundred and eighty-three male and female patients suffering from numerous types of chronic brain damage were divided into young (mean age 24.2 years, mean education 6.5 years) and old (mean age 49.7 years, mean education 6.1 years) groups. Twenty-two measures from the W-B and the HRB were given to all subjects. The young group had significantly better mean scores than the old group for 15 of the 22 measures. Utilizing the rank-orderings of the tests employed by Reed and Reitan (1963b), they found that the young group was clearly superior to the old group on tests requiring immediate

problem-solving ability, while the inter-group differences were significantly less pronounced on tests more heavily dependent upon previously accumulated experience. Thus, this study lends support to the perspective that the aging process exerts a similar influence on neuropsychological measures for both normal and brain-damaged subjects.

Utilizing a subgroup of subjects used in their earlier study, Fitzhugh and Fitzhugh (1964) divided subjects into four different groups as a function of age and performance on the Category Test. Groups of young and old, good and poor abstraction ability subjects were formed. Selection on the basis of Category Test performance produced groups which differed with respect to educational level and age of onset of brain damage. The young, good abstraction group significantly exceeded the performance of the old good abstraction group on TPT Localization, TPT Time, Trails A and B, Rhythms, Speech Sounds Perception, Digit Symbol, and Picture Arrangement. The means of the old, poor abstraction group were generally comparable to those of the young, poor abstraction group on problem solving tasks, and tended to exceed them on measures judged to tap stored information. No overlap was found between the means of the good abstraction groups and the poor abstraction groups. Both old groups performed better on tasks requiring utilization of stored information than upon tasks requiring immediate problem-solving skills. Both young groups tended to show the opposite pattern. High abstraction ability scores did not reverse the pattern for the old group to make them look like the patterns for the young groups.

In an attempt to cross-validate some of the previous findings in the literature with regard to W-B and HRB findings, Vega and Parsons (1967) administered these tests to a group of 50 brain-damaged (mean age 41.7 years, education 10.2 years) and 50 hospitalized controls (mean age 40.8 years, mean education 11.1 years). In reviewing the correlations of test scores with age and education, they found that the coefficients were generally higher for the control group than for the brain-damaged group. In addition, the test scores were usually more highly correlated with age than with education. No test score

was significantly correlated with education for the brain-damaged group, and no correlation with age reached the .01 level of significance. They concluded that further normative test data needed to be gathered on healthy, nonhospitalized, self-supporting individuals in order to provide answers to questions regarding "normal" performance level for various groups.

Goldstein and Shelly (1975) attempted to test the hypothesis that if the effects of aging are similar to those of diffuse brain damage, then less difference in neuropsychological test performance level should be found between old, brain-damaged and old normal subjects than between young brain-damaged and young normal subjects. Sixty heterogeneously brain-damaged Veterans Administration Hospital patients were matched on the variables of age and education with 60 non-brain-damaged patients, and then divided into four old and young subgroups of 30 subjects each using a median split (young group mean age 36.1 years; old group mean age 51.3 years). All subjects were given the Wechsler Adult Intelligence Scale (WAIS) and the HRB. A reduction in the number of variables compared was accomplished through the use of factor scores, of which four were obtained: 1) nonverbal memory, 2) language ability, 3) motor ability, and 4) psychomotor problem-solving ability. Significant differences were found for the performances of young versus old subjects and brain-damaged versus non-brain-damaged subjects. However, the predicted interaction between age and diagnosis was not found. The factor of motor ability showed a large discrepancy between the young groups and little discrepancy between old groups. For the language ability factor, there was little difference between the young groups, and a large difference between the old groups. The differences between young groups and old groups were similar on the nonverbal memory and psychomotor problem-solving factors. The pattern of decline with aging was not a simple one and required consideration of specific kinds of abilities.

Schaie and Schaie (1977) proposed an alternative explanation for the pattern of test results found to be associated with the normal aging process. They noted that there was a great degree of similarity

between the performance pattern of patients with acute or chronic right hemisphere damage and older normal adults on the WAIS. In response to the criticism that this pattern of similarity is an artifact of task characteristics, such as time limitations, Storandt (1977) found that when the WAIS was administered without the usual time limits or bonuses, older groups still performed significantly more poorly than did younger groups on the Performance tests. These findings were consistent with those of Doppelt and Wallace (1955) which will be dealt with in greater detail at a later point.

Klisz (1978) found in a reanalysis of the data reported by Reed and Reitan (1963a) that the tests which best distinguished between the performance of middle-aged versus older normal adults were, in descending order, right hemisphere measures, general impairment indicators, and finally, left hemisphere measures. Thus, a collection of evidence suggests the possibility that there may be a greater decline of right than of left hemisphere functions in older adults.

Prigatano and Parsons (1976) attempted to assess the effects of age and education in a cross-validation of the Vega and Parsons (1967) study. A group of 35 subjects (mean age 34.6 years, mean education 11.2 years) with definite brain damage, and a group of 25 subjects (mean age 33.2 years, mean education 12.2 years) referred for neuropsychological testing but evidencing no signs of brain damage were given the HRB. For brain-damaged subjects, age was significantly correlated with performance on the Category Test, TPT (Time, Memory and Localization), and the Impairment Index. Age was not found to be significantly correlated with performance on Speech Sounds Perception, Rhythms, or Finger Tapping. Education was found to correlate significantly only with the Rhythms test. For the control subjects, age was found to be significantly correlated with performance on all tests, and education was not found to be correlated significantly with any of the measures. It was concluded that age exerted a definite influence on test performance. It was suggested that in order to maximize accuracy of test interpretation, the effects of various non-brain-damage factors such as age and education on test performance for

particular reference groups needed to be determined.

Only two studies can be found which have attempted to gather any type of normative data with regard to the performance level of older subjects on the HRB tests. Leuthold, Berge, Matthews, and Harley (1975) administered a number of HRB tests to 193 VA Hospital patients (age range 55-79 years), three-quarters of whom were diagnosed as being psychotic or having chronic brain syndrome secondary to alcoholism. They found that the older groups consistently performed more poorly than the younger groups. Fifty-two percent of the subjects in the youngest age groups and 90% of the subjects in the oldest age groups earned Impairment Indices of 0.80 or greater. According to Reitan's standards, these indices are associated with moderately severe and severe levels of impairment.

The only study known to collect data on relatively normal, older subjects was conducted by Pauker (1977). In this investigation using Canadians, 58 subjects between the ages of 46 and 57 years, and 33 subjects between the ages of 58 and 76 years were tested. It was found that HRB test performance declined across the two older age groups as a function of age, and within each group as a function of IQ. Many of the mean performance levels for the various tests were found to exceed Halstead's cut-off scores. These results, however were not correlated with an allied measure of memory functioning, such as the WMS.

In his review article on the neuropsychological performance correlates of aging, Reitan (1967) concluded that a substantial body of inferential evidence indicated that changes in functioning associated with aging are at least partially the result of impaired cerebral functioning, realizing that social and environmental factors may also play a role. In a most recent concurrent analysis Klisz (1978) concluded that at least some of the changes in neuropsychological functioning observed in normal older people can be attributed to changes in brain structure and functioning.

In conclusion, a formidable body of evidence suggests that there exist age-related effects on neuropsychological test performance as

a result of changes in CNS functioning. There is some disagreement as to whether the pattern of performance changes associated with aging is similar to any particular type of brain damage (e.g., diffuse or right hemisphere dysfunction). Finally, much more information needs to be gathered regarding the exact manner in which the documented, age-related performance decrements affect the scores obtained by older, normal individuals on various HRB tests. It is this type of data, of which there is a marked absence in the published literature, that is most needed by the practicing neuropsychologist.

Validity of the Trail Making Test in Older Populations

It has been pointed out that much of the normative data which has been gathered for young and middle aged adults cannot be directly applied to aging individuals. This procedure can lead to the inappropriate classification of normally functioning older adults as physically or emotionally dysfunctional (Swenson, 1961). On the other hand, it is inappropriate to assume that all behavior changes as a function of age. All norms which are derived from a mature adult population should not be automatically suspect (Oberleder, 1964).

While it has been shown that age has a significant effect on a number of the HRB tests in terms of decrements in performance, it is important to know whether the performance on any particular test is on the average so poor, that it renders the discriminative utility and validity of the measure suspect. Klisz (1978) notes that across most of the HRB test measures, age-related declines in performance were not as great as those associated with brain damage. Thus, most of the measures retain their discriminative ability when employed with an older population. However, in the case of the TMT, a number of studies have produced evidence which indicates that a large percentage of misclassifications occur in older samples if the standard cut-off scores are employed.

The first wide-spread usage of the TMT occurred when it was incorporated as a performance subtest in the Army Individual Test of General Ability in 1944, at which point it was given its current name. In

this context, the TMT was used primarily as a quick screening device in determining level of intellectual functioning. Armitage (1946) attempted to use the test as part of a battery designed for the purpose of evaluating brain dysfunction. He was able to show highly significant differences between the performances of heterogeneously brain-damaged and control subjects (composed of normals and neurotics). The controls made fewer errors and showed a greater ability to recognize and correct them.

Reitan (1955b) administered the TMT to a group of 27 rigorously diagnosed brain-damaged subjects (mean age 30.2 years, mean education 10.6 years) and a group of hospitalized controls matched for sex, age, race, and education. Both Trails A and B were scored as the number of seconds required for completion. Significant differences between groups were found on both parts as well as their sum. He determined a cut-off score based on the combined performances on Trails A and B, which was able to discriminate between groups with a misclassification rate of approximately 17% for each group. This cut-off score was not cross-validated. Therefore, it probably reflected some of the chance characteristics of that sample, and he cautioned that this score should be used with care as a basis for drawing clinical conclusions on other samples. Reitan concluded that the TMT was a fairly valid indicator of certain effects of brain damage.

Reitan (1958) administered the TMT to 200 patients with a number of different types of verified brain damage (mean age 34.9 years, mean education 10.6 years) and 84 hospitalized persons without anamnestic or clinical evidence of brain damage (mean age 33.4 years, mean education 11.2 years). Highly significant differences in the performances of the two groups for Trails A and B individually, as well as for their total score were found. The use of a similar cut-off score as that used by Reitan (1955b) for the combined converted scores resulted in a 16.7% misclassification rate for the controls, and a 14% misclassification rate for the brain-damaged subjects.

Brown, Casey, Fisch, and Neuringer (1958) attempted to assess the TMT's utility as a short, simple screening device for the detection of brain damage in a clinical setting. The patients were divided

into organic brain-damaged, psychotic, neuro-psychiatric, and normal groups, based on the final medical diagnosis assigned by the individual physician in charge of each case. The time scores for Trails A significantly differentiated between high and low IQ groups. Trails B differentiated between high and low IQ groups, and high and low age groups. Neither Trails A nor B considered individually or their combined converted score were able to distinguish between psychotic and brain-damaged groups.

L'Abate, Boelling, Hutton, and Mathews (1962) gave the TMT to a group of 30 verified brain-damaged subjects and a group of 30 hospitalized chronic undifferentiated schizophrenics matched along the variables of sex, education, and length of hospitalization. While the brain-damaged patients tended to be slower than the schizophrenics, no statistically significant difference between the two groups was obtained.

In a similar study, Smith and Boyce (1962) gave the TMT and the Minnesota Multiphasic Personality Inventory (MMPI) to 52 chronic undifferentiated schizophrenic patients (mean age 38.8 years, mean length of hospitalization 4.8 years) most of whom were taking some kind of medication. Using Reitan's (1958) frequency distributions for normals and brain-damaged subjects, no significant difference between the performance of brain-damaged and schizophrenic subjects was found. The schizophrenics did perform significantly worse than normal controls on Trails A and B. Utilizing Reitan's (1958) suggested cut-offs, over 80% of the schizophrenics would be considered as probably having organic impairment. In addition, performance on the TMT was found to be positively correlated with scores on most of the MMPI scales, especially the psychotic scales. Smith and Boyce (1962) concluded that psychiatric symptomatology probably retarded TMT performance.

Parsons, Maslow, Morris, and Denny (1964) conducted a series of three studies with the TMT in which the variables of behavioral agitation, anxiety, examiner differences, facility with letters of the alphabet, order of test administration, and ego involvement were

examined. Anxiety was the only variable found to be significantly related to TMT performance. However, significant correlations with education, age, and general intelligence were found. Parsons, et al. (1964) concluded that until these variables are considered in determining cut-offs, the TMT would not be a particularly effective general screening device for brain damage.

Orgel and McDonald (1967) compared three groups of hospitalized white males, homogeneous as to age, sex, and education on TMT performance. Twenty-one subjects per group identified as either brain-damaged, mixed neuropsychiatric, or hospitalized control were given the TMT. The subjects were similar to Reitan's (1958) subjects except that on the average they tended to be 10 years older. No significant differences in performance were found for any of the comparisons between groups. Orgel and McDonald (1967) concluded that for the appropriate application of the TMT to a clinical setting, more information would be required concerning test performance as a function of age.

Davies (1968) conducted two studies which examined the effects of age on TMT performance. In the first study, the TMT was given to 540 normal subjects with 50 men and 40 women assigned to each decade between 20 and 80 years. Using Reitan's cutting points for performance on Trails B, and Trails A and B combined, approximately 56% were misclassified in the 50 to 60 year decade, 75% in the 60 to 70 year decade, and 90% in the 70 to 80 year decade. In the second study, the test was given to young (mean age 31.5 years) and middle aged brain-damaged groups (mean age 45.9 years), which were then matched with control groups for age, sex, social class, and educational level. Different cutting points were suggested for both groups in order to minimize the percentage of misclassifications. Davies (1968) concluded that cut-off criteria for young samples can give seriously misleading results if applied to older age groups.

Lindsey and Coppinger (1969) tested the hypothesis that age-related decline in TMT performance can be accounted for by age-related decline in one of five simple capacities: 1) number saying capability,

2) visual search capability, 3) finding next letter capability, 4) simultaneous number capability, and 5) simultaneous number-letter capability. One hundred and one subjects between the ages of 40 and 80 (mean age 60.2 years) were selected from hospital wards, nursing homes, and domiciliaries. A significant correlation was found between all capabilities and Trails A and B except for number saying capability. Age did not correlate significantly with Trails B after the effects of the capabilities tests had been partialled out. Age did not contribute to TMT performance independent of its contribution to the capability tests, and the declining ability to deal with complexity, per se, was not a factor in age-related decline in TMT performance.

Goul and Brown (1970) attempted to assess the effects of age and intelligence on TMT performance. Ninety-three brain-damaged and 103 control patients were divided into five age groups between 20 and 72 years old. All subjects were given the TMT and the WAIS. At each age level and for each part of the TMT the brain-damaged subjects performed significantly worse than the control subjects, with the single exception of Trails A for the oldest subjects. In addition, significant correlations were found between IQ and the various parts of the TMT. It was concluded that the use of the TMT with subjects over the age of 60 is questionable. More than half the brain-damaged subjects over 60 were misclassified by the best cut-off score. With increasing age TMT performance decreases for both brain-damaged and control subjects, and the validity of the TMT also decreases. The TMT is a clinically useful screening device for organicity only if age and probably IQ are taken into account in the form of age-corrected cut-off scores. It may even be necessary to develop local norms for each setting in which the TMT is employed in order to insure the use of the most accurate cut-offs.

Botwinick and Storandt (1974) in a study of the effects of age and memory on a number of abilities gave the TMT to 120 men and women equally distributed throughout decade age groups from 20 to 80 years. The age groups differed in their performance on both Trails A and B, with age accounting for 10% of the test score variance on each part.

While significant sex differences were not found, education differences were significant. Persons with more than 12 years of education performed better than those with fewer than 12 years.

The above cited studies demonstrate conclusively that performance on the TMT is highly correlated with age for normal and control subjects. In brain-damaged subjects, when correlations with age were found, they were of a lesser magnitude. It was also fairly well established that the TMT does not discriminate well between the performance of psychotic and brain-damaged subjects. It seems that the degree of psychiatric symptomatology is negatively correlated with performance. In addition, test performance seems to be a function of a number of variables, many of them non-organic in nature such as education and intelligence. In spite of the general reactivity of the TMT to a number of variables, these studies support the perspective that the TMT can have clinical utility and validity if norms and cut-off scores are employed which adjust for the effects of age, and possibly education. Finally, almost all the studies fail to publish raw score means and standard deviations by age, when age has been found to be significantly correlated with performance. Thus, there is a current need to generate and report data in this area with regard to the performance levels of normal, healthy, non-institutionalized older individuals.

Halstead-Reitan Test Battery Performance and Education

A number of studies have found that level of education was correlated with neuropsychological test performance. Since the purpose of these tests is to assess integrity of brain functioning, it would be important to know the degree and pattern of variability in test performance which might be introduced into and accounted for by the variable of education in a particular reference group. A few studies have attempted to determine the nature and extent of influence that level of education has on particular HRB tests.

In their earlier cited study, Vega and Parsons (1967) found that for their hospitalized medical-surgical subjects, performance on the Category Test, TPT Memory and Localization, Rhythms, Speech Sounds Perception, Finger Tapping, and Revised Impairment Index was significantly

correlated with level of education. When education was partialled out of the relationships found between age and performance, significant correlations remained for performance on the Category Test, TPT Memory and Localization, and Revised Impairment Index. For the brain-damaged group, no test score was found to be significantly correlated with education.

Prigatano and Parsons (1976) in their cross-validation study found no significant relationship existed between education and performance for any of the tests given to their psychiatric control subjects. In many instances the correlation coefficients approached zero. The same results were found for their brain-damaged group, with the single exception of performance on the Rhythms Test.

Thus, markedly different results were obtained for psychiatric patients as compared to medical-surgical patients with regard to the effects of education on their test performance. It is clear from a comparison of the results of Vega and Parsons (1967) with those of Prigatano and Parsons (1976) that differences in the performance of various control or reference groups need to be determined and considered when making clinical inferences as to the presence or absence of brain dysfunction.

In the only study in which level of education was treated as an independent variable, Finlayson, Johnson, and Reitan (1977) assigned 51 subjects with unequivocal evidence of brain damage and 51 controls (composed of normally functioning, hospitalized medical, and psychiatric subjects) to pairs of groups on the basis of the number of years of formal education each had completed. The university groups were composed of people who had completed at least three years of college credit. People who had completed grade 12 but who had not gone to college were assigned to the high school groups. People with less than 10 years of education were assigned to the grade school groups. All subjects were male and less than 50 years of age. The groups did not differ significantly with regard to mean age, and at each education level the control and brain-damaged groups did not differ in mean years of education. The W-B and HRB were administered to all

subjects. The effects of level of education on performance for the HRB was minimal with respect to control subjects. Level of education was found to have no significant effect on performance for any of the group comparisons on TPT (Time, Memory, or Localization) and Finger Tapping. The university group performed significantly better than both other groups on the Category Test and Trails A. The university group exceeded the grade school group only on Rhythms and Trails B. The grade school group performed significantly poorer as compared to both the high school and the university group on the Speech Sounds Perception Test. Thus, level of education had a minimal effect on HRB test measures.

The above studies indicate that when education is found to have an effect on neuropsychological test performance for a particular reference group, its effect is usually neither large nor pervasive across most subtest measures. In one of the two studies which dealt with the effects of education in terms of correlational analysis, six of the eight tests were found to have a significant relationship with education for a medical-surgical reference group. In the other study, none of the same eight tests were found to be significantly correlated with education for a psychiatric reference group. In a well controlled experimental study which utilized a mixture of control subjects as a reference group, the few tests which were found to be reactive to the effects of level of education required that there be a four to eight year difference in mean educational level for the effects to be significant. Thus, while it has been established that for particular reference groups there may be a positive relationship between level of education and certain HRB tests, a large difference between groups in mean years of formal education is required for education to exert a significant influence on performance.

Allied Measures of Neuropsychological Functioning and the Effects of Aging

The Wechsler Adult Intelligence Scale and Aging

Many studies have examined the changes occurring in intellectual abilities as a function of age-related effects. Yet a number of dis-

agreements still exist as to the proper interpretation of the data gathered (Botwinick, 1967). Reviews of the literature clearly indicate that a decline in many intellectual abilities is an integral part of aging (Botwinick, 1977; Jones, 1959). The more recent literature indicates that these declines may start later in life than previously thought, be smaller in magnitude, and include fewer functions. Disagreements about data interpretation center around inconsistencies in the areas of 1) what is meant by aging, 2) types of tests used, 3) definitions of intelligence, 4) sampling techniques, and 5) shortcomings of various research methods (Botwinick, 1977). It would not be consistent with the intent and emphasis of this investigation to detail the history of these disagreements. Instead, the circumscribed area regarding the relationship of age to changes in performance on the WAIS as an allied measure of neuropsychological functioning will be examined.

The WAIS is the most widely used and well-researched instrument of its kind for the measurement of adult intelligence (Matarazzo, 1972). It has also been extensively normed on older populations (Doppelt and Wallace, 1955). Studies which have attempted to discern the relationship between WAIS performance and age mainly fall into the two categories of cross-sectional and longitudinal. Cross-sectional studies compare the performance levels of different individuals in different age groups at a single point in time. Longitudinal studies measure changes in performance level across time for the same individuals. Neither method is without its own shortcomings. The cross-sectional method tends to magnify age decline. This is partially due to the fact that education has been shown to be highly correlated with intelligence ($r = .70$ for the WAIS), and generally, the older the subject, the fewer years of formal education he or she is likely to have (Matarazzo, 1972). Additionally, the overall quality of education has increased over the last century rendering comparisons of number of years of formal education unequal. Longitudinal studies tend to minimize age decline partially as a function of selective subject dropout (Schaie, Labouvie, & Barrett, 1973). The more highly functional, educated

subjects tend to remain available for retesting purposes (Riegel, Riegel, & Meyer, 1967), resulting in highly biased samples. While the biases of these two methods tend to work in opposite directions, close inspection of the interpretations of the data generated tend to be similar; differences tend to be quantitative and not qualitative (Botwinick, 1977).

The results of cross-sectional studies to date have been consistent. The finding that elderly normal subjects score higher on Verbal than on Performance tests has been called a "classic aging pattern". This constitutes one of the best replicated results in the area, as Eisdorfer, Busse, and Cohen, (1959) note that it holds true for men and women, white and black subjects, individuals of different socioeconomic status, and for people in mental hospitals as well as those residing in the community. Verbal abilities hold up well as they seem to be a function of experience and stored information. Performance abilities decline with age as they seem to tap psychomotor speed and perceptual-integrative functions. These findings will be explained in greater detail in the following sections.

It is important to remember that while a classic aging pattern undeniably exists, individual differences in performance are still great as reflected by the fact that correlations between age and intelligence test scores range between .40 and .50 (Matarazzo, 1972). This indicates that only about 20% of an individual's test score variance can be accounted for by age. Thus, other factors also play a role in test performance.

In his excellent review article Botwinick (1977) notes that longitudinal studies, as compared to cross-sectional studies, show less decline in performance ability, and this decline occurs later in life. However, where maintenance or improvement in function is seen cross-sectionally, it is also seen longitudinally (such as with verbal functions). In addition, data gathered by Eisdorfer and Wilkie (1973), and Jarvik, Kallman, and Falek (1962) indicate that in very late life, the differential patterns evidenced by verbal versus performance functions may give way to overall decline in functioning. By and large

though, the same general patterns of performance are present longitudinally and cross-sectionally.

The Kansas City Study of Middle Age and Aging conducted by Doppelt and Wallace (1955) is of central interest to this investigation. Their study involved the standardization and extension of the WAIS norms from age 60 to 80 years and older based on the performance of 475 individuals. In addition, in order to test the contention that the performance of older individuals is unduly affected by time limits, both regular and irregular (no time limits) scores were gathered for all timed tests except Digit Symbol (due to the nature of its construction). Only slight differences were found between the regular and irregular mean scores for all timed subtests except Block Design. Additional time seemed to make very little difference in terms of performance or rank order of the individual in his or her age-sex group.

Differences between mean scores of men and women on the Verbal, Performance, and Full Scale Scores of the WAIS were not statistically significant. Although there was a general tendency for men to score higher than women, the difference in any age group was not large enough to warrant separate treatment of the data for each sex. The shapes of the curves for the Performance tests were generally different from those for the Verbal tests. The performance tests reflected a sharper decrement in performance with increasing age. Typically, peak achievement on the Performance tests was attained in the twenties, and decline occurred after age 30. For the Verbal tests, maximum achievement occurred in the thirties and was maintained past the age of 40 years. A sharp drop did not occur in the Full Scale Score until the age of 70. Even after this age, Verbal test scores remained relatively stable. For most of the Verbal tests, the mean scores of the oldest group did not fall a standard deviation below the mean of the reference group (age 20 to 34 years). The overlapping of the age groups was great and there was much more variation within any age group than between age groups.

Among the Verbal measures, Information, Vocabulary, Comprehension.

and Arithmetic reflected the smallest declines up to age 70. In addition, the Information subtest was found to correlate highest or second highest across all older groups with Full Scale Score as compared to all other Verbal tests. Among the Performance measures, Digit Symbol showed the most marked decline. It was found to have the second highest correlation with Full Scale Score across all age groups as compared to the other Performance tests.

Thus, it appears that on a measure such as the WAIS, which has been well-normed on an aging population, the relationship between age and performance can vary depending upon the ability in question. On a measure such as Information, performance across age groups is maintained with minimal decline until the age of 70. On the other hand, performance on Digit Symbol has been found to drop rapidly across age groups.

The Wechsler Memory Scale and Aging

As was noted at the beginning of this chapter that the variables of age and susceptibility to disease are inextricably tied together, so it is also the case for the variables of memory and learning.

The processes of learning and memory are so inter-related and so interdependent that it is often difficult to determine whether or not they are distinct...if a man does not learn, he has nothing to remember. Conversely, if he cannot remember, there is no sign of his having learned. (Botwinick, 1967, p. 107)

Therefore, although the terms have a sort of conceptual independence they are not operationally independent. A number of studies have tried to design techniques of analysis which would approximate this conceptual independence, and the conflicting results found have fueled numerous debates. The individual processes themselves are complicated and are composed of a number of component factors.

This complexity is evidenced by the fact that in a recent herculean investigation conducted by Botwinick and Storandt (1974), 120 males and females (range 21 to 80 years old) were given approximately 30 different memory/learning tasks organized into seven groups of pro-

cedures. They found that short-term memory functions were age-related, whereas long-term recall was not related to age. Elderly subjects did as well with the long-term memory tasks as did the younger adult subjects. Recall was found to be best for all age groups if the event took place when the subjects were between 15 and 25 years of age. Neither meaningfulness of information nor its verbal versus nonverbal aspects played a greater role in one age group as compared to another. With advanced age, delayed recall tended to be poorer relative to initial recall as compared to younger subjects. While the ability to recall was found to decline with age, the ability to recognize did so to a very much smaller degree.

There is little disagreement that various memory functions decline in later years (Jones & Kaplan, 1956; Wechsler, 1961). However, there are a number of differing opinions as to the mechanism by which this process occurs and the relevance of each of the various factors involved. Some degree of uncertainty in this regard will probably always remain because direct knowledge about this process cannot be obtained. An inherent limitation exists in so far as neither memory nor learning can be directly observed. Reliance upon alleged behavioral manifestations is required from which inferences as to mechanisms of action are derived (Melton, 1963).

A sizable body of evidence exists in support of the contention that in the case of memory function as measured by paired associates type learning, the decline noted in aging populations may be due less to memory retrieval and memory storage functions than to initial registration of the information in the nervous system. Hulicka and Weiss (1965) found that given a paired associates task, older subjects learned less on equal exposure, thus requiring more trials to reach criterion levels of performance. However, once having learned the material, their retention was as good as that of the younger subjects. Davis and Obrist (1966) found that over a 48 hour interval, elderly subjects performed more poorly than younger subjects in terms of learning and relearning. However, when age differences in initial learning and immediate recall were covaried out, no significant difference in speed of relearning was found.

Moenster (1972) found that when the effects of learning were co-varied out from the effects of memory, the highly significant age effect in memory was reduced to non-statistically significant proportions. From their expansive study of memory function, Botwinick and Storandt (1974) concluded that older people have their primary difficulty in learning/memory at the point of acquiring new information. Once input has occurred, memory ability did not prove to be very susceptible to impairment processes. In addition, a great number of individual differences occurred in memory performance. Many variables, procedural and otherwise, seemed to determine performance scores.

No tests which measure memory function exist which have been comparably subjected to vast number of cross-validating studies across all types of subject characteristics, as is the case with the WAIS. However, the WMS was developed in 1945 in response to the lack of clinically useful, practical, standardized memory tests. It was composed of seven tests entitled Personal and Current Information, Orientation, Mental Control, Logical Memory, Memory Span, Visual Reproduction, and Associate Learning, as the result of some 10 years of experimentation. Provisional norms based on the examination of approximately 200 normal men and women between the ages of 25 and 50 years were published by Wechsler (1945). He noted that the graph of means of the WMS tests paralleled very closely that of the Performance section of the W-B. A method was arrived at for computing Memory Quotients based on equating these scores with the weighted scores of the W-B Full Scale IQ. Thus, Wechsler had developed a memory scale with relatively satisfactory standardization in which allowance was made for memory variations with age (correction scores for age were provided) and which allowed for direct comparison with the individual's IQ.

A number of investigations have since attempted to discern the psychometric properties of the WMS and discover the dimensions along which it can make useful discriminations. In a study utilizing 622 patients, Davis and Swenson (1970) subjected the WMS test scores obtained to a factor analysis in order to determine if more than one substantive dimension was present. Data was collected for 50 patients

each, at five-year age intervals between the ages of 15 and 87 years, with the exception of age 75 and over, for which 21 patients were used. Two clear-cut factors were found, one loading on memory, and the other on freedom from distraction.

Based on a very insightful analysis of the results in the area at that time, Kear-Colwell (1973) noted that the failure of the WMS to clearly differentiate organic from non-organic patients (Cohen, 1950; Howard, 1950) did not necessarily reflect on its validity as a measure of memory, since there was no necessary or logical reason to believe that all organic disorders of the CNS would cause memory dysfunction. In citing Yates (1966) he noted that a unitary concept of brain damage was not adequate to understand the relationships between cognitive function and organic disorders. The WMS was administered to 250 subjects who were divided into either a group of confirmed-organic (17 head injuries, 15 dementias, 7 presenile dementias, 6 Parkinsonian patients, 6 CNS tumors, 5 epileptics, and 10 other diagnostic categories) or not-confirmed-organic individuals. The sample as a whole was functioning at an average level with respect to both intelligence and memory. A number of separate factor analyses were carried out on the data.

Kear-Colwell (1973) found that memory as measured by the WMS was intimately related to intelligence ($r = .82$), but there was still some variance independent of intellectual ability. The factor analytic results indicated considerable stability across samples for the three memory factors which were obtained. Factor I seemed to tap ability to learn or recall new material, and had a moderately high negative loading of the tests of Logical Memory, Visual Reproduction, and Associate Learning.

There was a tendency for these functions to deteriorate with age. The structure of memory, as measured by the WMS, was practically identical in persons where there was a confirmed lesion of the CNS and in persons where no such lesion could be confirmed. The group comparisons made indicated that of the confirmed-organic patients, only the dementias showed overall memory dysfunction when compared with

the non-confirmed-organic group. A complex concept involving both localization and extent of damage to the brain is required to explain the relationship between brain damage and cognitive impairment.

In an attempt at cross-validation, Kear-Colwell (1977) administered the WMS and the WAIS to an independent sample of 112 patients at a different facility. The average age of the subjects was significantly lower than that of the original sample as was the diagnostic split between number of patients with and without confirmed-organic involvement. The three factors found were practically identical in structure to those found earlier (learning and recall of novel information; attention and concentration; and orientation in place and time). He concluded that the existence of these three factors could be replicated in an independent sample which differed significantly in composition from the earlier sample. The high level of factor stability found indicated that the factors could be utilized in clinical practice as the patient's memory functions could be measured on stable, reliable scales of known meaning and relationship to general intellectual functioning.

In a more recent study, Kear-Colwell and Heller (1978) attempted to replicate earlier factor structure findings on a group of normal adults drawn from the general population. In addition, the effects of age, sex, and social class were examined in order to provide normative information for clinical application. Stratified sampling procedures were used with regard to the above three mentioned variables. The average age of the sample was 36.9 years (s.d. = 13.6) with a range of 17 to 64 years. In this investigation a Factor A was found, which was clearly a replication of Factor I (learning and recall of new information), and Factor B was clearly a replication also (attention and concentration). Failure to find a comparable third single factor which loaded on Orientation and Information was accounted for by the very limited variance associated with these two variables in this sample where very few errors occurred. A series of three split-plot analyses of variance found a highly significant difference between social class groupings, and no differences between males and females on Factor A.

A highly significant interaction between age and factor scores was found which is of much interest to the current investigation. This interaction was explained by the fact that younger subjects performed at a very significantly higher level than older subjects on Factor A. In addition, a Wilcoxon Matched-Pairs-Signed-Rank test comparing the test performance of the study's older group with Wechsler's 40 to 49 year old group found a significant difference in favor of the present study's older group. Kear-Colwell and Heller's (1978) group performed significantly better on Logical Memory, Associate Learning, Digits Forward, and Total Raw Score indicating that it may well be the case that an upward age drift has occurred in performance on these measures during the 30 years since Wechsler published his norms. WAIS scores were unfortunately not provided in order to determine comparability on this dimension between the two samples.

A few studies have attempted to gather data regarding the level of performance of specific referential groups of older people in order to extend the clinical utility of the WMS into the upper age range. Hulicka (1966) tested a heterogenous group of 60 to 89 year old subjects composed of hospitalized veterans, residents in homes for the aged, and members of Golden Age Clubs. It should be noted that this group's composition is not representative of normally functioning older individuals in the community, and that no data was collected with respect to subjects who were between the ages of 50 and 60 years. A significant decline with age in raw scores was found to be primarily present for performances on Logical Memory, Visual Reproduction and Associate Learning tests.

Klonoff and Kennedy (1965) noted that little attention in terms of level of performance had been devoted to well-preserved, non-institutionalized aged. Descriptive data and standardized measures of capacity in the aged were felt to be sorely lacking. They tested 172 healthy Canadian veterans between the ages of 80 and 92 years who were able to manage well on their own in the community at the time they were selected for the study. Within this restricted age range, no significant differences among total raw scores, Memory Quotients, or tests for the various age groups were found. However, obvious trends

in the data were noted. Visual Reproduction was found to be less intact than Associate Learning, and greater losses in measures of immediate as compared to remote memory were noted. Rote memory was superior to logical memory, and auditory retention superior to visual retention. Finally, they published the mean raw scores found for the various tests and age groups.

Russell (1975) developed a new scoring method for the assessment of long-term (recent) memory using the Logical Memory and Visual Reproduction tests of the WMS. These tests were chosen based on the work of Kimura (1963) and Milner (1968, 1970), in which major aspects of verbal memory were found to be located in the left temporal lobe, while aspects of figural memory were mainly located in the right temporal lobe. Thus, the development of measures which tap this aspect of memory as well as short- versus long-term (recent) factors would have marked clinical utility. Since Logical Memory is a verbal test and Visual Reproduction is a figural test, they presumably tap lateralized functions. The normal scoring procedure measures short-term memory function, and Russell's new system measures long-term (recent) memory functions. Measures of half-hour recall and percentage-retained were developed for each of the two tests. All measures were found to be highly reliable and valid except for the percent-figural-retained due to a highly restricted range of scores obtained. Russell (1975) concluded that this new scoring method for various memory functions is reliable, validly separates those who are brain-damaged from normal, and right from left hemisphere dysfunctional cases. It should be noted that only 30 normal subjects were used across a number of age ranges, and no information was provided with regard to the effects of age on this new measure.

In an initial validation study of Russell's (1975) scoring method, Logue and Wyrick (1979) compared the performance of a group of 29 normal older volunteers with a group of 29 dementia patients matched on the basis of age, sex, and educational level (ages ranged from 55 to 85 years). They found that both normal aging and dementia groups experienced declining ability in short-term and long-term memory, but

maintained relatively good retrieval of information scores. Both normally aging and dementia subjects experienced greater loss in figural than semantic memory, which would imply more impairment of right hemisphere memory functioning. They also noted that memory loss occurs in the normal aging process and normative data on memory scores are needed in order to differentially diagnose normal aging from other types of impairment.

Osborne and Davis (1978) reanalyzed the data of Davis and Swenson (1970) and provided equations for the calculation of age-corrected standard scores with a mean of 10 and a standard deviation of three for the Associate Learning, Mental Control, Logical Memory, and Visual Reproduction tests of the WMS. These equations were developed in order to facilitate intertest comparisons.

In the most recent review article published to date, Prigatano (1978) noted that despite a number of limitations, the WMS has proven to be a sensitive measure of short-term verbal memory. As such, it can be helpful in identifying impairment of the left temporal lobe and its medial hippocampal connections. Prigatano also noted that the test was badly in need of restandardization and having its norms extended to include the functioning of older normal adults.

The preceeding review of the area indicates that the WMS is a valid test instrument when used to measure short-term memory and concentration, and particular long-term (recent) memory functions. It has also proved to have a well-established, robust factor structure. Older adult raw score and scaled score test norms for given reference groups have been made available for intertest and cross-study comparison purposes. Performance on the WMS of older adults verifies common clinical impression and allied research findings that memory functions related to learning and immediate recall of new information decline significantly with age. Finally, new normative data need to be gathered with regard to performance of normal older adults on a few of the WMS tests in view of the possibility that an upward drift has occurred since the publication of norms more than 30 years ago.

Cardiovascular Variables and Cognitive
Functioning in an Aging Population

It would seem that normal cognitive functioning is dependent primarily upon the integrity of the CNS, which itself is dependent upon the function of allied organ systems for support and maintenance. The cardiovascular system is probably the most critical supportive system in this regard. In so far as adequate circulation is provided to the cellular matter of the CNS by this system, optimal cognitive functioning is possible. Disorders of function which interfere with proper circulatory requirements need to be considered if one is trying to assess aspects of normal brain function.

A further consideration is introduced when normal functioning is considered across age groups. The necessity of this consideration is highlighted with regard to the data that has been collected on adult blood pressures, a gross measure of cardiovascular functioning. Mean systolic and diastolic pressures tend to rise as age increases (see Table 1).

Descriptive statistics on blood pressure values are important as an indicator of cardiovascular functioning in so far as they relate to hypertension. Hypertension is commonly defined as abnormally high arterial blood pressure. While the issue of degree of elevation is important with regard to cognitive functioning, in its extreme forms it can interfere with optimal functioning via the mechanism of massive neuronal loss as the result of the rupture of supplying blood vessels. The following are definitions as used by the U.S. National Center for Health Statistics in their 1964 study of hypertension and hypertensive heart disease in adults.

Hypertension - 160 mm. Hg. or over systolic, or 95 mm. Hg. or over diastolic.

Borderline Hypertension - Below 160 mm. Hg. systolic and below 95 mm. Hg. diastolic, but not simultaneously below both 140 and 90 mm. Hg.

Normotension - Below both 140 mm. Hg. systolic and 90 mm. Hg. diastolic

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TABLE 1

MEAN BLOOD PRESSURE IN ADULTS, BY AGE AND SEX:
UNITED STATES, 1960-1962

Age	Systolic ^a			Diastolic ^a		
	Both Sexes	Men	Women	Both Sexes	Men	Women
18-24	116.4	121.7	111.8	70.4	71.6	69.4
25-34	119.9	124.7	115.6	74.6	76.4	72.9
35-44	125.6	128.6	122.8	79.3	80.7	78.0
45-54	133.8	133.8	133.8	82.6	83.2	82.0
55-64	143.6	140.3	146.6	84.0	83.1	84.9
65-74	154.8	148.0	160.2	82.5	81.0	83.7
75-79	155.5	154.3	156.6	79.4	79.4	79.3
18-79	130.9	132.1	129.9	78.7	79.4	78.1

Note. From "Blood pressure of adults, by age and sex: United States, 1960-1962" by U.S. Public Health Service, Vital and Health Statistics, 1964, (Series 11, No. 4), 6.

^aMean blood pressure in mm. Hg.

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Based on these definitions and supportive findings, this study projected that in the U.S. 17.0 million (15.3 per 100 persons aged 18-79 years) people were estimated to have definite hypertension, and another 16.2 million (14.6 per 100 persons aged 18-79 years) people were estimated to have borderline hypertension. It was found that with increasing age, the prevalence of definite hypertension rose. At 18 to 24 years, less than two percent of all persons had definite hypertension, while nearly 40% of all persons aged 75 to 79 years had this disease. Men were more likely to have definite hypertension than women in age groups under 50 years. At older ages this relationship reversed itself. Relevant blood pressure statistics are presented in Table 2.

Thus, it can be seen that a large percentage of the older adults are estimated to be hypertensive. A few studies have tried to assess at what levels of elevation this condition might interfere with normal cognitive functioning. In a longitudinal study, Wilkie and Eisdorfer (1971) found that as compared to their normotensive counterparts, those subjects whose diastolic blood pressure was greater than 105 mm. Hg. (age 60-69) evidence significant intellectual loss over a 10 year period as measured by WAIS Full Scale and Performance change scores. An interesting finding was that those subjects initially examined at age 60 to 69, who had diastolic pressures between 96 and 105 mm. Hg. had higher performance scores upon retest than their normotensive counterparts. This finding is consistent with the perspective of Obrist (1964) who argued that a mild elevation of blood pressure may be adaptive in maintaining brain circulation to overcome increased cerebral-vascular resistance in aging persons.

In a study by Goldman, Kleinman, Snow, Bidus, and Korol (1974) which unfortunately did not use a control group, 14 male veterans (mean age 47.6 years, mean education 9.3 years) who had a mean diastolic pressure of 118.1 mm. Hg. and a mean systolic pressure of 173.0 mm. Hg. were given the Halstead Category Test and the WAIS. They found that a significant association was present between elevation of diastolic pressure (within the hypertensive range) and the number of

TABLE 2

PERCENT OF ADULTS WITH BLOOD PRESSURE OF AT LEAST
160 SYSTOLIC OR 95 DIASTOLIC, BY SEX AND AGE:
UNITED STATES, 1960-1962

Sex and Age	Systolic at least 160 mm. Hg. ^a	Diastolic at least 95 mm. Hg. ^a	Systolic at least 160 mm. Hg. or diastolic 95 mm.Hg. ^a
<u>Men</u>			
18-24	0.2	1.6	1.6
25-34	1.0	4.5	4.8
35-44	5.2	12.6	13.4
45-54	8.9	15.7	18.9
55-64	17.1	13.6	23.3
65-74	29.0	14.5	30.3
75-79	40.7	13.8	41.6
Total 18-79	9.3	10.5	15.0
<u>Women</u>			
18-24	0.1	1.1	1.1
25-34	1.1	3.0	3.1
35-44	3.8	7.5	8.4
45-54	12.8	13.4	18.2
55-64	26.1	18.3	31.8
65-74	46.9	18.9	49.9
75-79	44.0	13.0	45.9
Total 18-79	13.0	9.6	16.7
Both Sexes 18-79	11.3	10.0	15.9

Note: From "Blood pressure of adults, by age and sex: United States, 1960-1962" by U.S. Public Health Service, Vital and Health Statistics, 1964, (Series 11, No. 4), 9.

^aPercent of adults.

errors made on the Category Test ($\underline{r}$ (12) = .52, $\underline{p}$ = .028). In addition partial correlations were calculated between diastolic pressure and the Category Test scores with the effects of age partialled out ($\underline{r}$ (11) = .48, $\underline{p}$ < .05), and between diastolic pressure and Category Test with IQ partialled out ($\underline{r}$ (11) = .57, $\underline{p}$ < .02). The correlational relationships remained significant with both of these effects partialled out.

Birren and Spieth (1962) conducted a factor analytic study on 161 healthy air pilots and air traffic controllers between the ages of 23 and 60 years (mean age 40.3 years) in an attempt to correlate psychological and vascular functions in a healthy group of employed men. They examined the variables of age, response speed, and cardiovascular functioning and found a very small loading of the blood pressure variable on the psychomotor speed factor. This suggested that the slowness of psychomotor performance with advancing age was not a direct result of the trend toward elevated blood pressure in healthy adult men.

In a subsequent study by Spieth (1964) again using air traffic controllers and pilots, inconclusive results were found with regard to the effects of hypertension on performance of tests involving speed functions. The untreated hypertensives performed rather poorly. However, they also had reason to be under considerable situational emotional stress due to concern about the outcome of their physical examinations. The group of subjects whose blood pressure was being kept within normal limits by drug treatments, and were tested under more relaxed circumstances, performed as well as the healthy control group.

The above studies suggest that systolic and diastolic blood pressures tend to increase with age, though there is a good degree of variability within any age group. When diastolic pressure exceeds 105 mm. Hg. for an extended period of time decrements in cognitive performance have been shown to occur. However, in older adults, mild elevations in the range of 95 to 105 mm. Hg. may be adaptive in maintaining adequate cerebral circulation, which in turn may result in

higher performance scores on a number of neuropsychological measures. Finally, hypertensives who maintain normal blood pressure levels by taking medication do not seem to exhibit deficits in reaction time functioning. Thus, only extreme elevations in diastolic and systolic blood pressures have been shown to interfere with normal cognitive functioning.

Summary

The performance of normal older adults on psychological measures which tap psychomotor speed and the ability to learn and recall new information have been shown to decline with advancing age. Measures which tap stored information and verbal ability indicate that these functions tend to be relatively well-maintained until about the age of 70 years.

The HRB has proven to be a sensitive indicator of the integrity of the cerebral hemispheres. A number of studies have shown that the performance of normal adults on these tests tends to decline with age. The TMT maintains its validity as a neuropsychological measure with older populations if norms and cut-off scores are used which adjust for the effects of age. While level of education has been found to be correlated with performance on a number of HRB tests, a four to eight year difference in mean formal educational level between groups is required for this variable to exert a significant effect on performance.

The results of both cross-sectional and longitudinal studies indicates that on the WAIS, most Verbal test scores tend to be maintained relatively well up to the age of 70 years, while Performance test scores tend to decline starting in the late thirties. Sex was not found to be a significant determinant of performance on the WAIS; however, education was found to be significantly correlated with performance.

The WMS has proven to be a valid measure of short-term memory, concentration, and particular long-term (recent) memory functions. Most of its tests have been shown to be negatively correlated with age in a normal population. Age-corrected norms for performance on

the tests by mostly non-normal reference groups of older subjects have been made available.

While many types of memory show decline with advancing age, some preliminary evidence suggests that important distinctions can be made in terms of differential rates of decline or relative maintenance of various functions. Short-term memory for new information seems to suffer more than distant memory for well-learned information. This age decrement appears to occur at the point at which the information is being registered in the CNS.

Marked elevation in diastolic blood pressure has been shown to be correlated with decrements in cognitive performance for older normal subjects. Mild elevations in blood pressure may be beneficial in maintaining normal levels of cognitive functioning.

Statement of Problem

The state of the art in assessing neuropsychological functioning in terms of brain-behavior relationships is in its infancy. Only small pockets of established information exist regarding the behavioral correlates of normal brain functioning. Consequently, the neuropsychologist is faced with the task of stringing together inferences in an attempt to diagnose dysfunction. As is the case with any new discipline, gaps exist in the body of basic information required to properly assess dysfunction from a level of performance perspective. Elementary information concerning the neuropsychological functioning of various normal adult groups has yet to be gathered such that level of performance comparisons can be made with suspected dysfunctional individuals. Numerous instances exist in which diagnoses need to be made in the context of a lack of information as to the nature of normal functioning in the population of which the target individual is a member.

A large number of studies using correlational measures have shown that a relationship exists between age and neuropsychological test performance on the HRB for older normal adults, which would suggest to the neuropsychologist that differential standards need to be applied when interpreting the test results of older individuals.

Reitan (1955c) also cautions that older normal individuals exhibit performance decrements on his test battery. Yet the majority of neuropsychologists currently have to make qualitative, subjective interpretations as to the degree of performance decrement which should be exhibited by an individual of a certain age before his behaviors are to be considered dysfunctional, because of the paucity of investigations which have treated age as an independent variable and looked at its effects on performance for the various tests which comprise the HRB.

What little information does exist concerning age-related declines in HRB performance is incomplete and has been transmitted in the form of symposium presentations, as is the case with the data gathered by Pauker (1977). His subjects were Canadian and his upper age groups consisted of individuals from 46 to 57 years, and from 58 to 76 years respectively. The data on normative test performance gathered by Leuthold, et al. (1975) utilized a heterogeneous group of VA Hospital patients, some of which had diagnoses of chronic brain syndrome secondary to alcoholism. The use of these norms would be highly suspect when applied to normally functioning, healthy, self-sustaining individuals in the community.

The need to gather age-corrected level of performance data for various referential groups due to a lack of generalizability of results across settings has been underscored by the findings of Goul and Brown (1970) in their work with the TMT. Published data related to the various HRB tests does not exist with regard to the performance levels of older American, healthy, active individuals who are managing well on their own in the community, which is the most salient reference group for a neuropsychologist in order to make an accurate diagnosis regarding presence or absence of pathological levels of dysfunction.

The purpose of the present investigation is to gather data and look at differences in neuropsychological levels of performance functioning across and within two older groups of healthy, active individuals who are maintaining adequately in the community. This method has the added advantage of being consistent with the most frequent approach taken by studies appearing in the Journal of Geron-

tology for the past five years which were interested in making samples homogeneous with respect to extraneous variables and simultaneously allowing for maximum generalizability of results (Elias & Wright, 1976).

Experimental Rationale

As stated earlier, the overall purpose of this investigation is to examine changes in neuropsychological functioning in an older normal population. This will be done by examining differences in functioning between and within two groups of subjects as measured by a number of highly "brain sensitive" tests (HRB) and allied measures of neuropsychological functioning (WAIS, WMS). A cursory analysis would suggest that an explication of the experimental rationale should be organized, therefore, according to various hemispheric and lobe functions. However, while these distinctions in function can be easily made at a theoretical level, the tests used to tap these functions very frequently overlap in terms of the functions measured and the specific brain areas that these functions represent. For example, the Block Design test measures components of visual-motor coordination, analytic and synthetic functions with respect to novel information, spatial relations aptitude, and level of concentration. Many of these functions are usually interpretively associated with the right posterior temporal, parietal, and occipital lobes of the brain.

Therefore, in order to avoid having to artificially separate the various components and areas allegedly tapped by a given test into separate sections, and thus, referencing the same test numerous times in each section, the preceeding literature review and the following explanation of rationale have been organized according to the various tests utilized. However, the reader is reminded that the foci of interest are the neuropsychological functions being measured and not the specific test itself. Thus, attention should be focused on the various functions listed under each test heading.

The HRB is the most widely used instrument to assess brain dysfunction via the measurement of brain-behavior relationships. It

has also been established that there is a need to gather data regarding the performance of older normal individuals on various HRB tests. It is important that data which are being collected in an area which does not have an established basis of comparative findings in its own right, be coordinated with other established and related measures. This anchoring process allows for 1) the greater ease of interpretation of the new data obtained, 2) pattern analysis across test measures, and 3) the ability to determine potential peculiarities of performance which are a function of the particular sample of individuals chosen. This third determination is made via the comparison of scores obtained on allied measures with established age-corrected norms for a comparable population. Thus, results obtained in this investigation can be anchored to and interpreted within a more general context of level of performance across a number of test measures.

Two groups of older individuals will be examined, in which the ages of the first group will range between 50 and 62 years (Group I), and the ages of the second group will range between 67 and 86 years (Group II). The four year age gap between groups was introduced to insure a substantial difference in mean age between groups. The sample of subjects was chosen to begin at the age of 50 years primarily because a large number of studies have used HRB tests and have gathered various types of performance data with subjects under this age, but very few have used subjects older than this age. In addition, Reitan (1955c) noted that the performance of normal subjects between the ages of 45 and 50 years starts to consistently spill over into the range characteristic of brain dysfunction with regard to the Impairment Index. Finally, Reitan (1955c) also noted that the 45 to 50 year age interval is the point at which neurologic surgeons become hesitant to perform cerebral angiograms or carotid artery ligations unless clearly necessary, thus suggesting the presence of clinical evidence that a substantial decline in cerebral vascular integrity starts to occur at this point.

In so far as some hypotheses will be suggested which are based on inferential comparisons of tests which allegedly tap distinct brain

functions, and therefore, sometimes distinct cortical areas, only right-handed individuals will be used in this study. This allows for the additional accuracy of inferences involving areas of function in light of the fact that almost all right-handed individuals have their verbal functions represented in their left cerebral hemispheres and performance functions in their right hemispheres.

Males and females will be represented in both age groups. While sex-related differences have been found in other areas, what little research exists does not indicate that this is the case in the areas of neuropsychological functioning tapped by the measures employed in this investigation. Kear-Colwell and Heller (1978) found that while females were found to be more distractible (Factor II) on WMS measures of this function, no differences were demonstrated between the sexes in terms of learning and short-term recall (Factor I), recall of simple, well-established information, and orientation. Doppelt and Wallace (1955) found in the WAIS Kansas City Study that only three of 44 comparisons of test scores made between the sexes attained statistical significance. This led them to conclude that in their older population, differences in any age group were not large enough to justify separate treatment of the data by sex. Finally, Pauker (1977) found that in comparing males and females in his study of HRB test performance levels, only Speech Sounds Perception and Finger Tapping (Right-hand) evidenced significant differences when eight distinct comparisons were made. Thus, the above studies indicate that an insignificant amount of test score variability has been accounted for by sex-related differences and therefore, does not warrant that this variable be controlled for in the present investigation.

All subjects will be given a number of the tests from the HRB. The TPT (Right-hand, Left-hand, Both hands, Memory, Localization, Total Time), Finger Tapping (Right-hand, Left-hand), Seashore Rhythm, Speech Sounds Perception, and Trails A and B from the standard battery will be administered.

The Category Test is a portion of the HRB which contributes to the overall Impairment Index. This test was not administered for a

number of reasons. It is extremely time consuming, often requiring an hour or more to administer, and has not proven to be cost-effective in terms of the amount of information obtained. This is witnessed by the fact that it currently is not being routinely given by many practicing neuropsychologists (Farr, 1979). Secondly, the standardized administration of this measure requires that an extremely cumbersome device involving a carousel projector, projection screen, and accompanying box which houses bell and buzzer devices be employed. The device is practically impossible to transport from place to place with ease. In light of the fact that limits of accessibility to the target population needed may require that subjects from a number of cities in disparate areas of the country be used, incorporation of this test measure into the present study would be impractical. The Indiana Aphasia Screening Test was not given because it surveys sensory and language functions in an unquantified fashion. It is a qualitative rather than a quantitative screening instrument which has more utility in making discriminations within obviously brain-damaged groups of subjects than within normal groups.

In an attempt to coordinate the findings involving HRB test performances with other well-established, allied brain-behavior measures, select tests from the WAIS were administered to all subjects. The entire test was not given to subjects because 1) of time considerations (the investigator did not want to fatigue or lose subjects' interest and cooperation by having them take an unreasonable number of tests), 2) it was not the intent of this investigation to replicate the entire body of findings of Doppelt and Wallace (1955), and 3) many of the tests do not provide measures of functions which were of interest to this investigation.

The Information test was given because 1) it is a measure of distant verbal memory (a function allegedly associated with the left hemisphere), 2) has been shown to be relatively resistant to the effects of aging up to about age 70, and 3) has been found to correlate highest or second highest across all older age groups with Full Scale Score as compared to other Verbal tests. The Arithmetic test was

administered because it 1) allegedly taps left hemisphere function, 2) is a measure of concentration and long-term rote numerical memory, and 3) is an additional measure which has been shown to evidence minimal decline with advancing age.

The Digit Symbol test was given because 1) Reitan indicates that it is the most "brain sensitive" measure of all the WAIS tests to brain dysfunction regardless of location, 2) it is a measure of immediate, new spatial-associative learning, psychomotor speed, and visual-motor coordination, 3) it shows the greatest age-related decline in performance of all eleven WAIS tests, 4) it is an alleged measure of right hemisphere functioning (also some left functions in so far as symbol recognition is involved), and 5) it has been shown to correlate second highest across all older age groups with Full Scale Score as compared with the other Performance tests. The Block Design test was administered because 1) it has been shown to be very sensitive to the effects of aging, 2) it taps visual-motor coordination, analysis and synthesis of novel information functions, spatial relations aptitude, and concentration, and 3) is related to functions allegedly represented in the right posterior temporal, parietal, and occipital lobes of the brain.

It was felt that the administration of the above mentioned four WAIS tests resulted in the maximization of various cost-effectiveness considerations. These ranged from the minimization of potential subject fatigue effects to the acquisition of maximal discriminatory information regarding various types of brain functioning.

In an attempt to tap various aspects of memory function and further coordinate the data being gathered concerning HRB test performance with an additional established, allied, brain-behavior measure, three of the WMS tests were administered to all subjects. Various factor analytic studies suggest that a primary factor exists which is composed of the Logical Memory, Visual Reproduction, and Associate Learning tests. This group measures learning and short-term recall of new information. Russell (1975) extended the utility of the Logical Memory and Visual Reproduction tests by devising and validating a new scoring method in which the tests are readministered after a half-hour time interval. Thus, long-term (recent) memory functions are measurable. Additionally,

Logical Memory is thought to be a measure of left temporal lobe, auditory-verbal memory, while Visual Reproduction is thought to be a measure of right temporal lobe, figural memory.

While Russell (1975) coordinated his new data with the Halstead-Reitan Average Impairment Index, he did not gather any referential data with regard to performance levels of various older normal groups. Since it has been well-established that various memory functions decline with age, the determination of these performance levels is necessary before the new scoring method and consequent measures can be accurately applied to aging individuals. The present investigation will attempt to add data to the minimal existing information in this area by administering the above mentioned tests to all subjects.

Additionally, the same half-hour readministration procedure will be employed with the Associate Learning test, which Russell did not consider in his investigation. Thus, this procedure will hopefully be productive of data which will represent a preliminary first step in the development of an additional measure of long-term (recent) verbal-auditory memory. Thus, by administering the above mentioned WMS tests, six memory measures (three short-term and three long-term (recent)) can be obtained using Wechsler's, Russell's and Bak's scoring methods.

Finally, the data gathered in this investigation with regard to the performance of these healthy, normal older subjects on the WMS will be a new addition to the literature in so far as previous studies have not used this population. The reference data generated by Hulicka (1966) 1) did not have a group between the ages of 50 and 60 years of age, and 2) used a heterogeneous sample of hospitalized veterans, residents in homes for the aged, and members of Golden Age Clubs. The only known additional data for older subjects between the ages of 50 and 80 years was generated by Osborne and Davis (1978). They used as a reference group patients seen at the Mayo Clinic for a wide range of neurologic and psychiatric problems. Thus, the data gathered by the present investigation will be a unique contribution in this area.

Hypotheses

The following research hypotheses were posited and evaluated within the present investigation.

Hypothesis I The mean performance levels of Group I subjects will be significantly higher than the mean performance levels of Group II subjects on all HRB test measures (TPT, Finger Tapping, Rhythms, Speech Sounds Perception, Trails A and B).

Hypothesis II No significant differences ($p > .20$) in mean scores will be found between Group I and Group II subjects in terms of performance on the WAIS measures of Information and Arithmetic.

Hypothesis III The mean scores of Group I subjects will be significantly higher than the mean scores of Group II subjects on the WAIS measures of Digit Symbol and Block Design.

Hypothesis IV The mean scores of Group I subjects will be significantly higher than the mean scores of Group II subjects on the measures of Logical Memory, Visual Reproduction, Associate Learning, R-Logical Memory, R-Visual Reproduction, and B-Associate Learning.

Hypothesis V There will be a significantly greater difference between the scores of Group I and Group II subjects on the Visual Reproduction test (a measure of short-term figural memory) than between the scores of Group I and Group II subjects on the Information test (a measure of distant verbal memory).

Hypothesis VI As compared to the performance of Wechsler's standardization group of subjects between the ages of 20 and 29 years, Group II subjects will evidence a significantly greater degree of decline in performance on the Visual Reproduction test than on either the Logical Memory or Associate Learning tests, neither of which will show a significantly different degree of decline as compared to the other.

Hypothesis VII A significant positive relationship will be found to exist for both Group I and Group II subjects between 1) the one-half hour semantic score (R-Logical Memory) derived by Russell's (1975) method and the B-Associate Learning score derived by this investigator (see Appendix A).

CHAPTER II

Method

Subjects

Participants in this investigation were recruited from the general population of normal, right-handed males and females who were 50 years of age or older. Only relatively healthy, active individuals who were managing well on their own in the community were used in this study. All subjects were fluent in English, reported no history of CNS disorders, had no serious medical illnesses or incapacities which would bias their taking of the tests given, and had no sensory deficits which interfered with the proper administration of the test instruments.

Group I was composed of 15 subjects, six males and nine females, between the ages of 50 and 62 years (born 1916 to 1929) inclusive. Their average age was 55.6 years, average education was 13.7 years, and average socio-economic status (SES) was 3.1 (Hollingshead, 1957). Their average estimated Full Scale IQ was 116. (Estimated WAIS IQ's were obtained by standard prorating procedures using two verbal and two performance subtests.)

Group II was composed of 15 subjects, five males and ten females, between the ages of 67 and 86 years (born 1892 to 1912) inclusive. Their average age was 74.9 years, average education was 14.9 years, and average SES was 2.1. Their average estimated Full Scale IQ was 129.

Five subjects (two males and three females) in Group I were from Lubbock, Texas. The remaining ten subjects were from Miami, Florida. All Group II subjects were from Lubbock, with 14 of 15 residing in the John Knox Village retirement community. The remaining subject was from the general community.

Instruments

A number of different test instruments were used to assess level of neuropsychological functioning. The Speech Sounds Perception Test, Rhythms, Finger Tapping Test, Tactual Performance Test, and Trails A and B were given from the HRB. Information, Arithmetic, Block Design, and Digit Symbol were given from the WAIS. Logical Memory, Visual

Reproduction, and Associate Learning were given from the WMS, Form I. R-Logical Memory and R-Visual Reproduction were given using Russell's (1975) scoring method. B-Associate Learning was given using Bak's scoring method. The above tests are described in Appendix A.

Procedure

A brief explanation of the experimental procedures and the purpose of the investigation was contained in the subject's explanatory information and informed consent sheet (Appendix B). An attempt to elicit the full cooperation of each subject was also made after they read this form. A brief interview was then conducted for the purpose of screening out ineligible subjects (Appendix C). Those subjects with less than a ninth grade education, more than a Master's degree, or in poor physical health were excluded (five subjects) from further participation. Information regarding any medications that were being used was also gathered (Appendix D). No subjects were found to be taking major or minor tranquilizers of any sort, and only seven subjects were found to be taking minimal doses of anti-hypertensive medications on a chronic basis.

Subjects were then administered all the tests in the same sequence as follows: Information, Logical Memory, Visual Reproduction, Associate Learning, Trails A and B, Rhythms, Finger Tapping, R-Logical Memory, R-Visual Reproduction, B-Associate Learning, Digit Symbol, Arithmetic, Block Design, Speech Sounds Perception, and the Tactual Performance Test. All tests were given at one sitting and administration times ranged from 1 1/2 to 3 hours. All tests were given either at the subject's home or the investigator's home in a room free from disturbances and productive of a proper testing atmosphere. After all the tests were administered, debriefing, feedback, and the answering of all questions were handled by the investigator.

CHAPTER III

Results

An initial overall test of significance was conducted on a linear combination of the 20 relevant test measures using a multivariate analysis of variance. The resultant approximate F -statistic was found to be insignificant ($F(20, 9) = 1.96, p > .15$). A further analysis of the data was conducted since this insignificant result was most likely a reflection of the large number of dependent variables employed (20) as compared to the number of subjects (30), rather than in indication of a spurious pattern of significant individual findings (Gorsuch, 1974).

All raw score means, standard deviations, t -test comparisons, and strengths of association (η^2) across all measures for both Group I (young) and Group II (old) subjects are presented in Tables 3 and 4. Significant differences are discussed when the individual comparisons indicated that less than a .05 level of chance probability of occurrence existed. The t values required to meet more stringent standards of chance occurrence are located at the bottom of Table 4. Raw scores for each subject across all measures are presented in Appendix E.

Hypothesis one stated that the performance of Group I subjects would be significantly better (with regard to maximum achievement) than Group II subjects on all HRB test measures. An examination of the results showed that significant differences in the predicted direction were found for Trails A ($t(28) = 2.16, p = .020$), Trails B ($t(28) = 2.14, p = .021$), TPT-Right ($t(28) = 2.45, p = .010$), TPT-Left ($t(28) = 2.51, p = .009$), TPT Both ($t(28) = 3.74, p = .0005$), TPT Total Time ($t(28) = 2.99, p = .003$), Finger Tapping-Right ($t(28) = -2.85, p = .004$), and Finger Tapping-Left ($t(28) = -2.27, p = .015$). No significant differences between groups were found for TPT-Memory, TPT-Localization, Rhythms, and Speech Sounds Perception tests (see Table 4). Thus, this hypothesis was mostly supported.

Hypothesis two stated that no significant differences ($p > .20$, 2-tailed) would be found between Group I and Group II subjects in terms of their performance on Information and Arithmetic measures. No

TABLE 3
DESCRIPTIVE STATISTICS ACROSS ALL
MEASURES FOR GROUP I AND GROUP II

Test	Young Group I (n=15)		Old Group II (n=15)	
	Mean	SD	Mean	SD
Information	20.13	3.38	21.07	3.84
Arithmetic	11.87	1.92	13.60	2.97
Block Design	34.33	6.79	28.07	5.36
Digit Symbol	54.67	12.19	39.47	12.11
Trails A ^a	32.53	12.58	41.60	10.33
Trails B ^a	81.67	30.76	109.00	38.84
TPT				
Right ^a	365.20	151.49	571.60	289.36
Left ^a	306.80	161.51	514.00	276.64
Both ^a	169.80	71.03	301.20	116.14
Total ^a	841.80	326.01	1386.80	627.34
Memory	5.27	1.49	5.07	2.02
Localization	2.07	1.53	1.60	1.55
Seashore Rhythm ^b	25.27	2.68	24.60	3.31
Speech Perception ^c	4.93	2.81	7.13	4.26
Finger Tapping				
Right	44.53	6.71	38.73	4.13
Left	40.80	4.77	36.33	5.93
Logical Memory	9.63	2.00	10.30	3.06
Visual Reproduction	9.60	2.72	6.20	3.07
Associate Learning	16.33	3.19	16.53	2.75
R-Logical Memory ^d	16.13	3.89	16.33	7.08
R-Vis-Reproduction ^d	8.93	3.35	5.33	2.72
B-Assoc-Learning ^e	5.80	0.94	6.07	0.80

^aseconds. ^bnumber correct. ^cnumber incorrect. ^dRussell's measure.

^eBak's measure.

TABLE 4

t-TEST COMPARISONS AND STRENGTH OF
ASSOCIATION FOR GROUP I AND GROUP II

Test	<u>t</u>	<u>df</u>	<u>p</u> ^a	<u>r</u> ²
Information ^b	0.71	28	0.486	.018
Arithmetic ^b	1.90	28	0.068	.114
Block Design	-2.80	28	0.004 [*]	.218
Digit Symbol	-3.43	28	0.001 [*]	.296
Trails A	2.16	28	0.020 [*]	.143
Trails B	2.14	28	0.021 [*]	.140
TPT				
Right	2.45	28	0.010 [*]	.177
Left	2.51	28	0.009 [*]	.184
Both	3.74	28	.0005 [*]	.333
Total	2.99	28	0.003 [*]	.242
Memory	-0.31	28	0.379	.003
Localization	-0.83	28	0.207	.024
Seashore Rhythm	-0.61	28	0.275	.013
Speech Perception	1.67	28	0.053	.090
Finger Tapping				
Right	-2.85	28	0.004 [*]	.225
Left	-2.27	28	0.015 [*]	.155
Logical Memory	0.71	28	0.245	.018
Visual Reproduction	-3.21	28	0.001 [*]	.269
Associate Learning	0.18	28	0.427	.001
R-Logical Memory	0.10	28	0.462	.000
R-Vis-Reproduction	-3.23	28	0.001 [*]	.271
B-Assoc-Learning	0.84	28	0.205	.025

Note: t(28) = 2.467 for p < .01 (one-tailed)
t(28) = 2.763 for p < .005 (one-tailed)

^a(one-tailed). ^b(two-tailed), see text for explanation.

^{*}p < .05.

difference was found for Information ($t(28) = .71, p = .486$), but a significant difference was found for Arithmetic ($t(28) = 1.90, p = .068$), with Group II subjects exhibiting a higher level of performance. Thus, this hypothesis was only partially supported.

Hypothesis three stated that the performance of Group I subjects would be significantly better than that of Group II subjects on the measures of Digit Symbol and Block Design. This hypothesis was confirmed as large differences in the predicted direction were found for both Digit Symbol ($t(28) = -3.43, p = .001$) and Block Design ($t(28) = -2.80, p = .004$).

Hypothesis four stated that the performance of Group I subjects would be significantly better than that of Group II subjects on the measures of Logical Memory, Visual Reproduction, Associate Learning, R-Logical Memory, R-Visual Reproduction, and B-Associate Learning. Significant differences in the predicted direction were only found for Visual Reproduction ($t(28) = -3.21, p = .001$) and R-Visual Reproduction ($t(28) = -3.28, p = .001$). No differences were found for Logical Memory, Associate Learning, R-Logical Memory, and B-Associate Learning. Thus, this hypothesis was only partially supported.

Hypothesis five stated that there would be a significantly greater difference between the scores of Group I and Group II subjects on the Visual Reproduction measure as compared to the difference between their scores on the Information measure. This hypothesis was tested using a Hotelling t -test (Guilford, 1956) and comparing the difference between the correlations of Information with age, and Visual Reproduction with age (using all subjects from both groups). A significant difference between correlation coefficients was found ($t_{dr}(27) = 3.86, p < .0005$). Thus, the correlation between Visual Reproduction and age ($r(28) = -0.61, p < .001$) was found to be significantly greater than the correlation between Information and age ($r(28) = .05, p = .40$), supporting this hypothesis.

Hypothesis six stated that as compared to Wechsler's 20-29 year old group, Group II subjects would evidence a significantly greater degree of decline in performance on the Visual Reproduction measure than on

either the Logical Memory or Associate Learning measures, neither of which would show a significantly different degree of decline as compared to the other. A lack of access to the individual raw scores of Wechsler's subjects disallowed a direct test of this hypothesis. Instead, an allied analysis indicated that a significant difference between groups in the predicted direction existed for the Visual Reproduction measure ($t(63) = -3.97, p < .0005$). In addition, no significant differences between groups were found for either the Logical Memory ($t(63) = .797, p > .05$) or the Associate Learning measures ($t(63) = .698, p > .05$). Thus, this hypothesis was indirectly supported.

Hypothesis seven stated that a significant positive relationship would be found for Group I and Group II subjects between R-Logical Memory and B-Associate Learning. No significant relationship was found ($r(28) = .138, p = .468$). The lack of support for this hypothesis was most likely due to the highly restricted range of scores (3 point range) obtained on the B-Associate Learning measure.

A post hoc analysis of the data revealed that there were no overall differences in performance between males and females for Group I. Of the 22 comparisons made, a significant difference was found only for the Associate Learning measure ($t(13) = -3.59, p = .003$), with males performing less well than females. Of the 22 comparisons made between sex for Group II subjects, five were found to be significant. Males performed significantly better than females on Information ($t(13) = 4.60, p < .001$), Arithmetic ($t(13) = 3.43, p = .004$), Trails B ($t(13) = -2.26, p = .042$), Finger Tapping-Right ($t(13) = 2.81, p = .015$), and Finger Tapping-Left ($t(13) = 3.52, p = .004$).

Group I was composed of five subjects from Lubbock and ten from Miami. Their performance was compared across all 22 measures and only performance on Trails B was found to be significantly different between the two groups ($t(13) = 2.53, p = .025$), with the Miami group performing better than the Lubbock group.

CHAPTER IV

Discussion and Conclusions

Overview

A proper discussion of the results needs to be interpreted and understood within the context of a particular set of subject characteristics. Both groups of subjects were in excellent health and generally self-sufficient. The average estimated Full Scale IQ's of Group I and Group II subjects were approximately one and two standard deviations above their general population averages, respectively. Group II subjects also had a higher average SES ranking and an average of 1.2 more years of formal education than Group I subjects. Thus, this investigation can be best understood as a conservative test of the hypothesis that aging is associated with a general decline in many neuropsychological functions, since in this study subject variables relevant to performance levels favored Group II subjects.

It should be noted that possible cohort effects are always confounded with age when a cross-sectional design is employed. Therefore strictly speaking, the effects of age in this investigation should be thought of as age/cohort effects. However it is felt that the equating of education and health variables across the two groups minimized the influence of any possible cohort effects in this investigation.

Discussion of Hypotheses

Group I subjects performed significantly better than Group II subjects on 8 of the 12 HRB measures covered by Hypothesis one. In addition, the age effect was found to account for approximately 14% to 33% of the variability between scores of Group I and Group II subjects on each of these eight measures. Effect sizes of this magnitude can appropriately be considered to be substantial (Linton & Gallo, 1975). Thus, the vast majority of HRB measures used in this investigation were shown to be sensitive and substantial indicators of aging effects.

The results of Hypotheses two and three generally replicated the patterns of maintenance and decline in functioning found by Doppelt

and Wallace (1955). No difference in performance between groups was found for the Information measure, while Group I subjects performed significantly better than Group II subjects on the Block Design and Digit Symbol measures. Though Group I and Group II subjects were above their respective population averages in terms of education and IQ, this general replication of results supports the argument that significant differences in performance found on other measures are not likely to be the result of gross sample composition peculiarities. In addition, the support found for these two hypotheses is consistent with the argument that performance related to verbal skills and stored information is maintained with age, while performance on tasks which require psychomotor speed and perceptual-integrative functions declines significantly with age.

Hypothesis four was only partially supported by the significantly better performance of Group I as compared to Group II subjects on the Visual Reproduction and R-Visual Reproduction measures. No differences were found for Logical Memory, Associate Learning, R-Logical Memory, and B-Associate Learning. While a highly restricted range of scores, due to a ceiling effect, contributed to the lack of difference between means for the B-Associate Learning measure, the maintenance of similar levels of performance in the face of a 20 year difference in mean age between groups is noteworthy.

Hypothesis five stated that there would be a significantly greater difference between the scores of Group I and Group II subjects on the Visual Reproduction measure as compared to the difference between their scores on the Information measure. This hypothesis was supported. The lack of a significant correlation between Information and age reflected the lack of decline in performance across age for aspects of long-term verbal memory functioning.

Hypothesis six was indirectly supported since the appropriate direct comparisons with Wechsler's 20 to 29 year old group could not be made due to a lack of access to his raw data. This hypothesis stated that as compared to Wechsler's 20 to 29 year old group, Group II subjects would evidence a significantly greater degree of decline

in performance on the Visual Reproduction measure than on either the Logical Memory or Associate Learning measures, neither of which would show a significantly different degree of decline as compared to the other. The indirect support for this hypothesis was based upon the following line of reasoning. No significant differences were found between the performance of Group II subjects and Wechsler's group on Logical Memory and Associate Learning. Group II subjects, in fact, performed slightly better than Wechsler's subjects on both measures. A highly significant difference in the predicted direction was found for the Visual Reproduction measure. Therefore, a significantly greater degree of decline must have occurred in performance on Visual Reproduction as compared to Logical Memory and Associate Learning. Additionally, since a slight increase in mean values was noted for Group II subjects on Logical Memory and Associate Learning, it can safely be assumed that neither measure evidenced a significantly greater degree of decline as compared to the other.

Conceptually, Hypothesis seven was an attempt to show that R-Logical Memory and B-Associate Learning both tapped aspects of short-term verbal memory functioning which would be maintained with age, and therefore, would be highly correlated with each other. A ceiling effect for B-Associate Learning resulted in a lack of support for this hypothesis due to the particular manner in which it was stated. However, the underlying concept itself was indirectly supported. Group II subjects performed slightly better than Group I subjects on R-Logical Memory, indicating a maintenance of functioning. A ceiling effect in performance was found for both Groups I and II on the B-Associate Learning measure, indicating a maintenance of the amount of functioning that this test was capable of measuring. Therefore, while the concept underlying this hypothesis was indirectly supported, the presence of a ceiling effect for B-Associate Learning mitigated against finding a significant positive correlational relationship between the two measures.

Overall, specific or indirect conceptual support was found for six of the seven hypotheses examined in this investigation. In addition,

significant differences found between groups were usually accompanied by large strengths of association. Thus, strong support was found for most hypotheses and the general perspective that aging results in a decline of many neuropsychological functions.

Interpretation of HRB Results

Pauker's (1977) Canadian study is the only appropriate one with which to make comparisons of results regarding performance on HRB measures for healthy older adults (see Tables 5 and 6). His 46 to 57 year old group (mean age 51.96 years, mean education 11.58 years) was compared with Group I, and his 58 to 76 year old group (mean age 67.13, mean education 12.86 years) was compared with Group II. In comparing the five common test measures given in both studies across both groups, none of the 10 comparisons made were found to be significantly different from each other. Thus, this replication of Pauker's findings lends validity to this investigation's overall pattern of findings.

The results of this investigation can also be compared with the cut-off scores established by Reitan for the expected performance levels of young and middle aged adults. The mean scores of Group I subjects did not meet the cut-off score standards for acceptable performance on TPT (Memory and Localization) and Finger Tapping. Approximately 40% or more of these subjects also did not meet the cut-offs for Trails B, TPT-Total Time, and Seashore Rhythm. The mean scores of Group II subjects barely met or were less than the standard cut-off scores for all HRB measures administered. Given that these subjects were functioning normally for their age and in good health, it can be concluded that a large portion of these subjects would be misclassified as dysfunctional on individual measures based on Reitan's current non-age-corrected cut-off scores. ✓

In this regard a number of implications arise from an analysis of these results. If a cut-off score approach is to be maintained with older individuals, then separate cut-offs must be established for five or ten year age intervals, taking education and IQ into account. An inherent problem with this approach when applied to older people

TABLE 5
PAUKER'S RESULTS

Test	Age			
	46-57 (n=24)		58-76 (n=8)	
	Mean	SD	Mean	SD
WAIS Full Scale IQ	114.25	2.88	126.88	3.40
Finger Tapping				
Right	40.45	5.81	38.00	9.74
Speech Perception ^a	5.50	2.57	7.00	4.40
TPT				
Total ^b	1055.63	395.84	1307.13	491.05
Memory	6.74	1.63	6.63	2.13
Localization	3.61	2.19	2.13	2.95

Note: From Adult norms for the Halstead-Reitan Neuropsychological Test Battery: Preliminary data. by J. D. Pauker, Unpublished conference paper, Albuquerque, N. M., 1977.

^anumber incorrect.

^bseconds.

TABLE 6
t-TEST COMPARISONS BETWEEN
PAUKER'S AND BAK'S DATA

Test	Young Groups		Old Groups	
	df=37		df=21	
	<u>t</u>	<u>p</u> ^a	<u>t</u>	<u>p</u> ^a
Finger Tapping				
Right	-1.39	>.10	-0.16	>.10
Speech Perception	0.45	>.10	-0.05	>.10
TPT				
Total	1.26	>.10	-0.23	>.10
Memory	2.02	>.05	1.21	>.10
Localization	1.75	>.05	0.36	>.10

^atwo-tailed.

is the increased variability of individual scores encountered with this population. Acceptable cut-offs may not exist such that false positives and false negatives of group membership are kept within tolerable limits. This possible lack of acceptable separation between functional and dysfunctional performance is conceptually consistent with the view that normal aging is correlated with decreased cortical integrity and an associated progressive loss of functioning.

A compromise solution to this dilemma, consistent with the results of this investigation, would be to develop means and standard deviations for normal older adults based on age, education, and IQ groupings. The raw scores of the older individual being tested could then be converted into normalized T-scores based on the above mentioned norms. Finally, these T-score results could be averaged and the cutting score of one standard deviation below the mean could be used as one indication of dysfunctional performance. Those individuals whose average T-score is within one standard deviation of their reference group could be considered to be functional, and those who score more than one standard deviation below the mean could be considered dysfunctional. Kiernan and Matthews (1976) have shown that this type of approach is vastly superior to a Halstead Impairment Index approach since it simultaneously 1) markedly reduced the false positive rate of misdiagnosis, and 2) optimally separated the performance of non-neurologically impaired versus brain-damaged older adults. While this normative approach would still misclassify some small percentage of normally functioning older individuals as dysfunctional, it would do so to a much smaller extent than the current practice of using non-age-corrected cut-off scores.

Interpretation of WMS Results

Appropriate statistical comparisons with other studies with regard to WMS measures could not be made due to differences in design and a lack of reported information concerning basic parameters of group composition (mean age and education). However, a logical-conceptual analysis of the data reveals that the performance of subjects in this

investigation was consistent with the pattern of results reported by other investigators taking differences in age, health, and education into account.

Group II subjects performed better than the generally older and substantially less educated (seven years average education) subjects in the Klonoff and Kennedy (1965) study on the WMS measures of Logical Memory, Visual Reproduction, and Associate Learning. The same results were found when Group II subjects were compared with the less educated (8.64 years average education) 70 to 79 year old subjects in Hulicka's (1966) study.

Subjects in Cauthen's (1977) 70 to 79 year old group had a Full Scale IQ range of scores from 119 to 140 with no reported educational levels. His subjects performed only slightly better than Group II subjects on Logical Memory and Visual Reproduction, and they did not perform as well as Group II subjects on Associate Learning. Cauthen's 50 to 59 year old group had a Full Scale IQ range of scores from 107 to 118. His subjects only did slightly better than Group I subjects on Logical Memory (the only common score reported).

Wechsler (1945) did not report level of education data for his 40 to 49 year old standardization group. Given the era and the facility at which his data was collected, it can probably be assumed that their educational levels were less than those of either Group I or Group II subjects. Group I subjects performed better than Wechsler's subjects on all three WMS measures. Group II subjects (who are from the same cohort as Wechsler's 40 to 49 year old subjects in 1945) performed better than Wechsler's subjects on Logical Memory and Associate Learning measures. However, they did substantially less well on Visual Reproduction, even though they probably had a much higher average educational level.

The combined weight of the comparative evidence seems to indicate that higher levels of education and IQ exert a moderate and consistent elevating influence on WMS performance levels. This conclusion is arrived at based on the manner in which the results reported in the various relevant studies fit together consistently with the results

of this investigation. A second conclusion which can be derived from the comparative evidence is that given equal education and IQ levels across age groups, the functions tapped by Logical Memory and Associate Learning tend to be maintained, while those tapped by Visual Reproduction decline. Given the caution that these measures do not tap totally distinct functions represented in discrete cortical areas, in light of the evidence provided by Kimura (1963) and Milner (1968, 1970), it can be argued that aspects of verbal, short-term memory are maintained, while aspects of figural, short-term memory decline.

General Interpretive Implications

It would be tempting to interpretively view the results of this investigation as support for the differential decline of right versus left hemisphere functions position espoused by Klisz (1978). However, a number of considerations currently disallow this interpretation.

It should be remembered that the area of neuropsychology is in its infancy, and that there is a lack of common agreement regarding proper paradigms and models of brain functioning. While various patterns of test results are found to reliably recur with various populations, the interpretation of these results with regard to brain function is at this time ambiguous. Most clinical tests seem to tap a number of complex brain functions simultaneously, thus confounding clear interpretations. Given the above considerations, it becomes an even more precarious task to attempt to relate specific brain functions to specific brain areas.

When referring to various tests in previous parts of this investigation, a number of statements were made regarding "alleged" functions interpretively associated with and measured by these tests. This was done in a manner consistent with a typical clinical perspective, and in an attempt to relate the results of this investigation to that body of literature. However, some of the findings in the area of information processing need also be considered concerning their impact on any global interpretations of the results of this investigation. These findings highlight the need for interpretive discretion when dealing with patterns of test results in the area of neuropsychology.

Much of the clinical literature on neuropsychological test interpretation is based on the results of studies using brain-damaged individuals. Thus strictly speaking, it would not be appropriate to generalize any findings regarding function and alleged associated brain areas to normal groups of individuals (Gazzaniga & LeDoux, 1978). A second difficulty with much of the clinical literature is that there has been a lack of equating of procedures for components of verbal and non-verbal tasks, such as time limits and manner of task presentation. This results in a confounding of findings such that reliable interpretive statements concerning left versus right hemisphere function cannot be made.

In contrast much of the information processing literature uses normal subjects, and some studies have equated verbal and nonverbal task components across relevant dimensions (Elias, Wright, & Winn, 1977). In his review of the literature Elias (1979) noted that there does not appear to be a great decline in the ability of the left and right hemispheres to process verbal and nonverbal information as such. However, asymmetry effects were more prevalent when there was potential competition for processing time and space within a hemisphere, and this "competition" effect was greater for older than for younger subjects. Finally the functions of the hemispheres were envisioned more in terms of the strategy used to process stimuli than in terms of the verbal or nonverbal nature of the stimuli themselves.

Thus it would seem that findings for left versus right hemisphere asymmetry effects depend very much on the paradigm and measures used to test hypotheses. Since there are currently a number of diverse paradigms generating diverse sets of findings concerning brain functioning, it would seem prudent to not overinterpret any set of findings in a given area at this time. Therefore, no speculations will be offered concerning "patterns" of test findings in the present investigation, and their potential relationships to left versus right hemisphere functioning.

Suggestions for Future Research

The present investigation examined the effects of a 20 year mean

age difference between groups on various aspects of normal neuropsychological functioning in older adults. Future studies are needed to generate level of performance data for 5 or 10 year age intervals, starting at age 50, and based on specific groupings of education and IQ. This process needs to be repeated every 5 to 10 years in order to control for possible generational (cohort) effects.

The present study only offers "preliminary standards" of level of performance for two groups of healthy, older subjects. The results of this study and future studies need to be pooled so as to establish reliable standards of performance based on a larger sample of subjects. Once this is accomplished according to the above mentioned age intervals, results of the various tests should be plotted by age and IQ to determine patterns or trends in maintenance or decline of functions (e.g., linear, asymptotic, etc.).

Finally, attempts should be made to see if a cut-off score approach to functional versus dysfunctional performance can be made viable with an older population. Ample evidence has been provided to show that currently established HRB cut-off scores are not appropriate for older individuals. The performance of groups of older individuals with established areas of cortical dysfunction needs to be compared with the performance of appropriate control groups in order to make this determination.

CHAPTER V

Summary

This investigation was designed to examine patterns of change in the neuropsychological functioning of two groups of healthy, older adults between the ages of 50 to 62 (Group I), and 67 to 86 years (Group II) inclusive. Preliminary level of performance data was gathered and compared for each group using Halstead Reitan Test Battery (HRB) measures, Wechsler Adult Intelligence Scale (WAIS) measures, and Wechsler Memory Scale (WMS) measures. All subjects were given the same measures and a number of a priori hypotheses were examined regarding various patterns of maintenance and decline across groups according to function.

Five of the seven hypotheses posited were completely or mostly supported. The results indicated that on eight of the twelve HRB measures, Group I subjects performed significantly better than Group II subjects. No difference was found between groups for the WAIS test of Information, and Group I subjects performed significantly better than Group II subjects on the WAIS tests of Block Design and Digit Symbol. Group II subjects performed significantly better than Group I subjects on the WAIS test of Arithmetic. No significant differences between groups were found for the WMS measures of Logical Memory and Associate Learning. Group I subjects performed significantly better than Group II subjects on the WMS subtest of Visual Reproduction. The half-hour readministration of variations of the above three WMS measures produced the same pattern of results.

Age was shown to be a factor in performance with older subjects performing more poorly than younger subjects on a number of measures. However, areas of maintenance of performance were also noted. It was concluded that certain aspects of cortical function seemed to be relatively well-maintained with age, while other aspects appeared to decline significantly. Auditory-verbal memory and stored information seemed to be maintained, while visual-figural memory, psychomotor speed, and immediate problem solving skills seemed to decline. The preliminary level of performance data gathered for HRB measures indicated that

current standard cut-off scores employed for determining functional versus dysfunctional performance could not be properly applied to older adults. Finally, a cautionary note was made that the general lack of information in the area of neuropsychology currently disallows speculation concerning "patterns" of test results in this investigation, and their potential relationships to left versus right hemisphere functions.

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APPENDIX A

DESCRIPTION OF TESTS AND VARIOUS INSTRUCTIONS

Halstead-Reitan Battery Tests for Adults

Note: Descriptions from Klisz (1978)

The Tactual Performance test measures the subject's ability to adapt to a novel problem-solving situation. The subject is blindfolded and instructed to fit wooden blocks of common geometric shapes into a formboard. The subject performs the test first with the preferred hand, next with the nonpreferred hand, and finally with both hands. A measure of the time to complete the test is taken each time the test is performed and their sum yields the total time scores.

The Tactual Performance Test Memory Component measures incidental memory. After the subject has fit the blocks into the formboard under the three response conditions, the formboard is hidden and the subject's blindfold is removed. The subject is required to draw the blocks placed in the formboard but never seen on a blank piece of paper. This score is the number of shapes correctly drawn.

The Tactual Performance Test Localization Component measures the ability to remember spatial relationships. When the subject draws the blocks he is also instructed to orient the drawings so that the placement of the blocks in the drawing corresponds to the placement of the blocks in the formboard. This score is the number of shapes that are drawn in their correct position.

The Rhythms Test measures ability to concentrate and to perceive differences between rhythmic sequences. Recorded pairs of tone sequences are played. After each sequence the subject judges whether the two sequences were the same or different. The score is the number of correct identifications.

The Speech-Sounds Perception Test measures ability to concentrate on verbal stimuli and to relate auditory verbal information to visual verbal information. A taped sequence of 60 nonsense words is presented. The subject selects the nonsense word presented from the four choices on the answer sheet by underlining the correct choice. The score is

the total number of errors in identification of the nonsense words.

The Finger Oscillation Test measures index finger tapping speed. In this test a special finger tapping key is used. An average of five consecutive 10 second finger tapping trials that are within five taps of each other is computed for the preferred hand and for the non-preferred hand.

The Trail Making Test measures the ability to scan a visual display and to organize sequential behaviors under time pressure. This test consists of two parts. On both parts the stimuli are a scattered arrangement of circled letters or numbers. In Part A the stimuli are circled numbers. The subject draws lines to connect the numbers in order. In part B the stimuli are circles containing either numbers or letters. The subject draws lines from numbers to letters in alternating numerical and alphabetical order. The time to complete each part is recorded as well as the number of errors in drawing the lines.

Wechsler Adult Intelligence Scale Tests

Note: Due to the widespread and common use of these tests, only a brief description will follow. For a more complete description, see Matarazzo (1972).

Information: This test measures the fund of factual knowledge available for recall in the test situation. The order in which the questions are listed approximates roughly their order of difficulty.

Arithmetic: This test measures educational arithmetic achievement within the context of the subject's ability to maintain active calculative concentration in the test situation.

Block Design: This test measures visual-motor ability to analyze into parts and synthesize reproductively a spatially represented figure. This test requires active concentration using visual matching and feedback.

Digit Symbol: This test measures psychomotor speed expressed via spatial-associative learning and visual-motor coordination. The subject is instructed to copy as quickly as possible a series of marks under their appropriate numerical designation.

Wechsler Memory Scale Tests

Note: The actual content of the various test items can be found in Wechsler (1945).

Logical Memory Test: This test consists of two memory passages similar to the memory selection of the 10th year of the Stanford-Binet and similarly scored. The subject's score is the average of the number of ideas which he produces correctly on both passages. The test is intended to measure immediate recall of logical material.

Visual Reproduction Test: This test requires that the subject should draw from memory simple geometric figures exposed for a period of 10 seconds. Two of the figures are taken from those used in the Army Performance Scale (World War I); the third is the well known pair of Binet Designs.

Associate Learning Test: This test consists of 10 paired associates, some easy and some hard, which the subject is required to learn in three trials. The items included have been derived from the paired-associates list originally used by Wechsler (1917) in his study of the retention defect in Korsakoff psychosis.

Russell's Scoring Method for the WMS

The multiple scoring method uses the WMS I as its basis. However, only the Logical Memory and Visual Reproduction tests are administered. The instructions and scoring for these tests are generally the same as those given in the WMS I manual (Wechsler, 1945). The changes that were made are as follows: The examiner writes the dictated stories so scoring can be done more accurately at a later time. The first administration provides the short-term semantic score using the Logical Memory test and the short-term figural score from the Visual Reproduction test. After the first administration, the examiner waits $\frac{1}{2}$ hour and then requests a second recall of the memory material. The interposed tests should be quite different from either of the memory tests, otherwise contamination and/or interference may occur with regard to the memory recall, especially with brain-damaged subjects. At the end of a $\frac{1}{2}$ hour period, the subject is asked to retell the stories as he remembers them. (Neither the stories nor the designs are read or shown to him again during the second phase). The examiner

writes down the stories as dictated. If the subject cannot remember either of the stories at all, he is prompted, "Do you remember a story about a washer woman?" or "Do you remember a story about a ship?" If he then recalls the story, it is scored according to the Wechsler instructions, except that the item used to remind the subject is not counted in the second score. This yields the one-half hour semantic score (R-Logical Memory). (The only other difference is that the scores for the two stories are summed, not averaged.)

The subject is then asked to reproduce the designs again. If he does not remember any design, he is given a clue such as "Do you remember a design that looks like flags?" One point is deducted if he remembers the design. This is considered the one-half hour figural test, which is the fourth score (R-Visual Reproduction). [These scores are not combined into a total memory score.] (Russell, 1975, p. 803).

Bak's Method for Obtaining One-half Hour Associate Learning Scores

This method employs the same principles as that of Russell (1975) in determining scores. The instructions for administering and scoring the B-Associate Learning test are generally the same as those given in the WMS manual (Wechsler, 1945). The changes that were made are as follows: After the first administration, the examiner waits one-half hour and then requests that the subject supply the appropriate response when given one readministration of the third presentation series of paired associates for the Associate Learning test. Only the first item in each of the pairs is read to the subject. Additionally, the correct response is not supplied for the subject if an incorrect response is given. The B-Associate Learning score is obtained by dividing the credits obtained for all easy associations by 2, and adding this score to the credits obtained for the hard associations.

APPENDIX B

INFORMATION ON NEUROPSYCHOLOGY OF AGING

Purpose of Investigation

This is a study of the effects of aging on learning and memory. We are interested in knowing how well older adults can do on a variety of these types of tasks. It is hoped that the information gathered in this study can later be used as a comparison point for the test scores of other older adults. Therefore, your help would be greatly appreciated and will provide useful new information for the field of psychology. Individual test results will be kept anonymous, but I will be glad to discuss your particular test results with you upon request.

Procedures

You will be asked to volunteer for approximately one to three hours of interviewing and testing, which will vary from person to person. This can be done at your convenience and special arrangements for testing can be made on an individual basis. None of the following tasks will involve any discomfort to you. The information gathered will not be about your personal life, and it will be kept anonymous and confidential.

An interview will be conducted, during which time you will be asked general questions concerning vital and social statistics, and specific questions regarding your past and present health status, and the type of medicines you may be taking. You will then take a series of tests (all non-medical) which will involve short ability measures, memory measures, and perceptual-motor measures. These tests will require that you answer various questions, and perform a few physical manipulations of test materials. You are free to stop participating in these tasks at any time without consequence if you so choose. You may contact Joseph Bak (investigator) at 797-9808, or Dr. Roger Greene (supervisor) at 742-3712 if you have any further questions with regard to this investigation.

If this research project causes any physical injury to you, treatment is not necessarily available at Texas Tech University or the

Student Health Center, or any program of insurance applicable to the institution and its personnel. Financial compensation for any such injury must be provided through your own insurance program. Further information about these matters may be obtained from Dr. J. Knox Jones, Jr., Vice President for Research and Graduate Studies, telephone 742-2152, Room 118 Administration Building, Texas Tech University, Lubbock, Texas 79409. I understand that I may not derive therapeutic treatment from participation in this study.

Signature of Subject: _____ Date: _____

Signature of Parent/Guardian or Authorized Representative (if required)
_____ Date: _____

Signature of Project Director or his authorized representative:
_____ Date: _____

Signature of Witness to Oral Presentation:
_____ Date: _____

APPENDIX C

GENERAL INFORMATION AND HEALTH STATUS FORM

Tested by: _____

NAME: _____ AGE: _____

BORN: _____ DATES TESTED: _____

EDUCATION (Yrs. completed): _____ SEX: _____ RACE: _____

OCCUPATION

Present: _____

Previous: _____

HOME ADDRESS: _____

BIRTHPLACE: _____ If foreign, yrs. in US: _____

EXTRACTION (Ethnic group): _____ RELIGION: _____

HANDEDNESS (Subject): _____ (Father): _____ (Mother): _____

MARITAL STATUS: S M SEP D W CHILDREN: _____

TEST-TAKING ATTITUDES:

COOPERATION: Refuse Poor Fair Adequate Good

COMMENT:

EFFORT: Poor Adequate Good

COMMENT:

SPEECH DEFECTS: Yes _____ No _____

COMMENT:

HEARING IMPAIRMENT: RE LE VISUAL IMPAIRMENT: RE LE

HAVE YOU HAD (Circle and Date):

1. Heart Attack	Heart Disease	Stroke	Encephalitis
Diabetes	High Blood Pressure	Polio	Arthritis
Rheumatic Fever	Scarlet Fever	Parkinson's Disease	
Meningitis	Pulmonary Disorders		

2. Other illnesses including childhood diseases:
3. Operations:
4. High fevers (104 or over):
5. Sunstroke or heat exhaustion:
6. Partially drowned or overcome by gas:
7. Head injury (type):
8. Epilepsy, convulsions, or seizures:
9. Fainting or black-out spells:
10. Toxic chemical exposure or systemic reactions:
11. Electrical or chemical shock treatments (insulin, metrazol):
12. Exposed to high voltages: (Lightning, high tension wires, or shock from electrical fixtures)
13. Dazed or unconscious from: (Sport, fight, fall, being struck by an object, or in an automobile accident)
14. Foot or arm (hand, wrist) injuries:
15. Other health problems:

PSYCHOLOGICAL STATUS: (Depression, Anxiety, Psychosis, etc.)

SHOW ME HOW TO:

throw a ball_____	hammer a nail_____
use scissors_____	cut with a knife_____
use an eraser_____	turn a door knob_____

APPENDIX D

MEDICATION AND OTHER CHEMICAL SUBSTANCE FORM

TOBACCO CONSUMPTION: Amount _____ Duration _____

COFFEE CONSUMPTION: Amount _____ Duration _____

TEA CONSUMPTION: Amount _____ Duration _____

ALCOHOL CONSUMPTION: Amount _____ Duration _____

MAJOR TRANQUILIZERS:

MINOR TRANQUILIZERS:

ANTIDEPRESSANT MEDICATIONS:

HYPERTENSIVE MEDICATIONS:

OTHER MEDICATIONS:

APPENDIX E

RAW DATA FOR ALL SUBJECTS

	Group I Subject #						
	1	2	3	4	5	6	7
Age	62	53	50	56	50	57	57
Sex	M	M	F	F	F	F	M
Education ^a	12	12	14	16	15	12	12
S.E.S. ^b	4	4	3	1	2	4	4
Information	18	21	14	19	21	21	22
Arithmetic	13	13	08	11	13	14	12
Block Design	28	41	37	28	32	43	36
Digit Symbol	32	50	47	44	59	72	40
Trails A ^c	41	32	22	57	53	33	51
Trails B ^c	132	077	079	149	092	048	091
TPT							
Right ^c	434	211	174	552	263	340	556
Left ^c	543	136	138	325	241	162	369
Both ^c	346	053	198	181	182	133	205
Total ^c	1323	0400	0510	1058	0686	0635	1130
Memory	5	8	5	2	6	6	6
Localization	0	4	2	1	3	2	2
Seashore Rhythm ^d	26	29	23	25	21	29	27
Speech Perception ^e	6	5	7	1	5	3	8
Finger Tapping							
Right	47	47	43	40	38	43	37
Left	42	45	37	40	39	39	35
Logical Memory	10.0	11.0	7.0	12.5	12.0	10.0	6.0
Visual Reproduction	06	12	11	11	10	10	09
Associate Learning	9.0	16.0	18.0	15.5	20.0	16.0	15.5
R-Logical Memory ^f	11	18	14	15	24	19	10
R-Vis-Reproduction ^f	02	13	07	11	10	10	07
B-Assoc-Learning ^g	4.0	5.0	7.0	5.0	7.0	5.0	6.0

APPENDIX E

RAW DATA FOR ALL SUBJECTS

	Group I Subject #							
	8	9	10	11	12	13	14	15
Age	56	52	62	62	59	57	50	51
Sex	M	F	F	M	F	M	F	F
Education ^a	14	12	14	16	12	18	14	12
S.E.S. ^b	3	4	3	3	4	2	2	4
Information	24	16	16	19	19	27	23	22
Arithmetic	11	15	08	11	13	12	12	12
Block Design	38	40	28	24	26	46	30	38
Digit Symbol	64	54	68	47	47	62	60	74
Trails A ^c	25	20	26	22	25	24	37	20
Trails B ^c	072	050	057	090	054	112	077	045
TPT								
Right ^c	394	254	675	470	188	217	367	383
Left ^c	311	220	443	729	292	237	242	214
Both ^c	184	116	263	155	100	191	120	120
Total ^c	0889	0590	1381	1354	0580	0645	0729	0717
Memory	5	5	4	4	7	5	4	7
Localization	3	1	0	1	2	2	2	6
Seashore Rhythm ^d	26	26	28	20	25	23	24	27
Speech Perception ^e	3	2	6	10	8	1	2	7
Finger Tapping								
Right	56	40	49	46	31	55	47	49
Left	45	35	41	41	33	51	45	44
Logical Memory	9.0	7.5	6.5	11.0	10.5	10.5	11.0	10.0
Visual Reproduction	12	08	07	03	10	14	11	10
Associate Learning	13.5	16.0	18.0	11.5	19.5	16.5	20.0	20.0
R-Logical Memory ^f	17	11	14	16	18	19	21	15
R-Vis-Reproduction ^f	11	08	07	03	09	14	11	11
B-Assoc-Learning ^g	6.0	6.0	6.0	5.0	7.0	7.0	5.0	6.0

APPENDIX E
RAW DATA FOR ALL SUBJECTS

	Group II Subject #						
	1	2	3	4	5	6	7
Age	72	79	77	67	72	67	72
Sex	M	M	F	F	F	F	F
Education ^a	10	18	13	16	16	12	17
S.E.S. ^b	3	2	3	2	2	2	2
Information	22	25	19	21	18	15	22
Arithmetic	15	18	14	10	17	09	12
Block Design	26	28	24	29	28	27	42
Digit Symbol	36	34	52	39	48	30	50
Trails A ^c	33	39	28	39	42	44	64
Trails B ^c	076	119	153	119	084	150	102
TPT							
Right ^c	383	435	427	631	327	689	402
Left ^c	0260	0487	0260	0281	0301	1024	0482
Both ^c	194	313	098	394	198	329	238
Total ^c	0837	1235	0785	1306	0826	2042	1122
Memory	5	5	5	6	9	1	6
Localization	1	4	2	2	5	0	2
Seashore Rhythm ^d	27	23	25	20	28	28	23
Speech Perception ^e	03	10	06	04	09	10	01
Finger Tapping							
Right	46	45	37	35	38	41	31
Left	50	40	26	35	34	41	29
Logical Memory	13.0	11.0	13.0	15.0	9.0	4.5	11.5
Visual Reproduction	13	04	07	09	06	01	07
Associate Learning	16.0	12.5	20.0	18.0	20.0	12.0	17.0
R-Logical Memory ^f	21	16	21	24	14	06	23
R-Vis-Reproduction ^f	03	03	07	10	06	01	08
B-Assoc-Learning ^g	6.0	6.0	6.0	6.0	6.0	5.0	6.0

APPENDIX E
RAW DATA FOR ALL SUBJECTS

	Group II Subject #							
	8	9	10	11	12	13	14	15
Age	72	86	69	72	75	81	77	86
Sex	F	F	F	M	M	F	M	F
Education ^a	18	09	18	17	17	14	12	16
S.E.S. ^b	2	4	1	1	2	2	2	1
Information	20	17	22	27	26	21	26	15
Arithmetic	13	10	14	16	15	13	18	10
Block Design	26	28	28	36	24	28	29	18
Digit Symbol	29	10	40	51	32	47	58	36
Trails A ^c	50	51	51	23	37	34	48	41
Trails B ^c	131	185	089	059	085	065	065	153
TPT								
Right ^c	0452	0548	0258	1216	0569	0930	0253	1054
Left ^c	0426	0629	0291	0869	0541	0471	0296	1092
Both ^c	277	358	141	436	342	423	261	516
Total ^c	1155	1535	0690	2521	1452	1824	0810	2662
Memory	5	4	7	7	5	2	3	6
Localization	2	1	3	0	2	0	0	0
Seashore Rhythm ^d	24	25	26	23	16	28	26	27
Speech Perception ^e	09	08	02	17	09	05	03	11
Finger Tapping								
Right	36	37	42	36	42	38	42	35
Left	31	33	36	37	43	34	40	36
Logical Memory	9.0	8.0	10.0	14.0	8.5	10.5	12.5	5.0
Visual Reproduction	8	6	5	7	4	6	9	1
Associate Learning	12.5	18.0	14.5	17.0	16.0	20.0	15.5	19.0
R-Logical Memory ^f	11	11	16	23	15	20	24	00
R-Vis-Reproduction ^f	9	6	6	5	3	5	7	1
B-Assoc-Learning ^g	4.0	6.0	7.0	6.0	7.0	7.0	6.0	7.0

^a years. ^b Socio-economic status Hollingshead (1957). ^c seconds. ^d number correct. ^e number incorrect. ^f Russel's measure. ^g Bak's measure.