THE EFFECT OF AGE AND ABILITY LEVEL ON A BATTERY OF NEUROPSYCHOLOGICAL TESTS

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ABSTRACT

The purpose of the present study was to investigate the relative roles of age and ability level on the performance of a battery of neuropsychological tests called the Halstead Battery. The design of the study also allowed two theoretically important questions to be examined: the generality of the differentiation-integration hypothesis, and the possibility of differential effects of aging in different ability groups. One hundred and twenty-nine subjects were selected on the basis of age and I.Q. so that there was an adequate representation of high, medium, and low ability ranges, and young, middle-aged, and old adults. Statistical analysis of the Halstead Battery scores of these subjects revealed significant age and I.Q. effects on nearly all of the indicators in the Battery. In order to determine whether there was differential aging in different ability groups, the scores of the young and old subjects were submitted to analyses of variance. These analyses indicated that there was significant interaction between age and I.Q. on some of the tests. Correlational matrices and factor analyses for the young and old groups were compared in order to determine the tenability of the differentiation-integration hypothesis. It was concluded that: a) The Halstead Battery is sensitive to both age and ability level. These findings were discussed in relation to previous studies which did not adequately control for the latter variable, and the need for revised Halstead Battery norms. b) The tenability of the differentiation-integration hypothesis is greatly augmented by the present supportive findings.

c) There are different effects of aging in different ability groups and these effects correspond to an a priori ranking of the tests along the dimension of immediate adaptive ability vs. stored information.

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CHAPTER I

INTRODUCTION

Perhaps the most obvious psychological aspect of human aging is the performance deficit evidenced on many sensory, motor, perceptual, and cognitive tasks. Until little more than a decade ago, studies on human aging were mainly concerned with documenting the performance decrement of older people on these various tasks. As the science of gerontology progressed, greater emphasis was placed on the discovery of possible influences of the performance decrement and the role that one or more correlates of the aging process played in the resulting decrement.

In keeping with the present trend of multi-variable studies which attempt to determine the relative contribution of two or more independent variables to age-related performance deficits, the present study attempts to determine the relative roles of chronological age and intelligence on performance of a group of neuropsychological tests.

There are numerous correlates associated with the process of aging. These can be grouped under health changes, social changes, personality changes, and biological changes. Each of these changes have been proposed by various investigators to explain age-associated decrements in psychological test performance.

Anatomical, physiological, and biochemical alterations associated with the aged nervous system have been well documented. Despite many methodological difficulties, several investigators have found that diminished brain weight and size are a consistent age-associated event (Appel & Appel, 1942; Grünthal, 1936; Hoff & Sietelberger, 1957). Cell

counts indicate a loss of neurons accompanied by gliosis (Brody, 1955; Critchley, 1942; Harms, 1944) although this finding has not been replicated by Moyer (1959). Certain electrophysiological changes such as slowing of the alpha rhythm (Obrist, 1954) and elevation of the threshold to electroshock (Holmberg, 1954) have been definitely shown to accompany the aged nervous system. Age changes in neural integration and synaptic transmission in the central nervous system have been inferred from knowledge of peripheral nerve function. Birren (1959) found that the electrophysiological characteristics of old peripheral nerves are normal. They conduct at least as rapidly as young ones, and show no rise in threshold, fall in action potential, or rise in refractory period. This has led many investigators to the conclusion that the frequently observed increased latency in the performance of older people on simple tasks is the result of alterations in central synaptic and integrative mechanisms. Therefore, even though no unequivocal statement can be made about a loss in central nervous system cells, all evidence indicates altered function of central processes in the aged individual.

These biological alterations of the central nervous system perhaps bear a more fundamental relationship to the behavioural aspects of aging than any other area of psychology (such as motivation, or personality changes). However, due to prohibitive ethical and methodological problems the direct relationship of these changes to test performance is not amenable to empirical investigation. In any scientific discipline, the ideal model for determining the relationship which one variable

exerts on another is to either hold constant or measure all other pertinent variables while the investigator actively manipulates the variable under study and measures the resultant change in the dependent variable(s). In research with human beings, direct manipulation or mutilation of the brain in order to create the desired independent variable is not ethically possible. Indeed, even the direct measurement of biological variables in living aged subjects is not possible. Thus the degree to which biological transformations modify behaviour remains largely unevaluated.

However, Halstead (1947) has devised an indirect method for assessing the functional condition of the brain. He developed a battery of neuropsychological tests (called the Halstead Battery) which satisfied the criterion of successfully differentiating between individuals having brain damage and those who did not. Halstead concluded that these tests are maximally sensitive to the organic condition of the brain.

Another methodological problem associated with the study of human aging concerns the time scale of age-related changes in performance. The ideal method for studying aging is the logitudinal method. Since age changes in individuals are being studied, these individuals should be followed in time (follow-up method). However, longitudinal studies although methodologically ideal have practical disadvantages which obviate this method as a frequently employed research design. Problems of investigator time and commitment, continued subject participation, antiquation of methods, and uncertain financial support lead many investigators to choose the compromise to the longitudinal study, the cross-sectional study. However, the cross-sectional design, involving the

comparison of two or more groups of different ages, is often confounded by secular changes. This is a serious disadvantage since if subjects are not comparable in all respects except chronological age, any differences between groups cannot be unequivocally attributed to the effects of age - they may be due to gradual cumulative historical effects such as educational or cultural changes. Research terminology reflects the basic assumptions underlying each design. In general, the term "age change" is used to refer to the results from longitudinal studies, since the same persons actually have changed their scores from one testing to the next. The term "age difference" is used to refer to the results from cross-sectional studies and reflects the less equivocal conclusions feasible due to the possible presence of confounding secular variables.

The Halstead Battery has demonstrated validity for detecting cerebral pathology (Halstead, 1947; Reitan, 1955b, 1959). In a series of studies (Reed & Reitan, 1936a, 1963b; Reitan, 1955a), Reitan uses the argument that if these measures also detect age-associated ability changes in normal older subjects, then such age-associated ability changes may be due to undetected cerebral pathology in the older subjects.

In the first of the series of studies, Reitan (1955a) chose the Halstead Impairment Index, which is a composite score obtained by counting the number of tests on which a subject's performance falls into the range characteristic of brain damage, for study of biological changes involved in aging. The Halstead Battery was administered to a group with unequivocal evidence of brain damage and to a group with no neurologic evidence of brain damage. The relationship between age and test

result was relatively low for the former group, but was significantly higher for the latter group. The significant correlation between age and Impairment Index in the normal group was the result of the fact that many subjects over the age of 45 years obtained a high Impairment Index characteristic of brain damage. These results indicate that besides the similar performance of many old subjects and of many brain-damaged subjects, age is an important variable in assessing the performance of older subjects on the Halstead Battery.

It is a well established fact that age affects the performance of different psychological tests differentially. However, generalizations are made difficult by the diversity of psychological tests, and differences in the composition of samples. It appears that tests requiring active problem-solving behaviour are more influenced by age than tests which require the recall of stored information (Heston & Cannell, 1941; Jones, 1959; Willoughby, 1927). Also, the related aspect of complexity of response required of the subject has been shown to be a relevant variable (Welford, 1959). Reitan (1963a) decided to study these dimensions with respect to the Halstead Battery. Twenty tests which included the tests from the Halstead neuropsychological Battery and 11 subtests of the Wechsler-Bellevue Intelligence Scale, Form 1, were rated by three judges. The judges were instructed to order the tests on the dimension of immediate adaptive intelligence vs. stored memory. The raters were also instructed to consider the dimension of complexity of response. The prediction that the performance of young subjects would exceed that of the old subjects to a relatively greater degree on those tests which

required immediate adaptive intelligence was supported. The young and old groups were most clearly separated by those measures which previous research had demonstrated to be most sensitive in differentiating patients with diffuse or heterogeneous brain lesions from non-damaged control subjects. Reitan concludes that "The results of the present investigation add support to the possibility that age-associated changes in abilities may be conceived in terms of the adequacy of brain functioning (p. 273)."

Later, Reed and Reitan (1963b) conducted a further study with the Halstead Battery "concerned with the possibility of attributing part of the age-associated decrements in psychological test performance to change in brain functioning (p. 177)." Forty young non-brain-damaged subjects were matched in pairs with 40 brain damaged subjects on the variables of age, education, sex, and race. The Halstead Battery tests were then ranked according to the success with which each test discriminated between the brain-damaged and the non-brain-damaged subjects. The tests were then given to a group of normal middle-aged subjects (age 40-49) and to a group of older normal subjects (age 50-59). This time the tests were ranked according to the relative sensitivity of the tests to the differences associated with aging. There was a significant relationship (rho = 0.49) between the two rank order distributions, "suggesting that differences in test performances associated with aging may partially be explained on the basis of changes in the organic condition of the brain (p. 179)."

However intuitively appealing as Reitan's reasoning may be, two

major criticisms can be levelled at his methods and his conclusions. Reitan arrives at his conclusions through indirect means, since inferences about the influence of independent variables in human studies are almost exclusively limited to those derived from statistical analysis. Reitan uses essentially circular reasoning to arrive at his conclusions. His reasoning is that if a test is sensitive to brain damage and then is found to be sensitive to normal aging, then the explanation given why the test is sensitive to brain damage is the same explanation why the test is sensitive to normal aging. The possible fallacy of his reasoning is illustrated by the following analogy: Suppose an instrument is devised which can differentiate between dead leaves and leaves which are alive. The explanation given for this behaviour is that the instrument is photosynthesis-sensitive. Then it is found that this instrument also differentiates between green paint and brown paint. It is evident that it would be fallacious to argue that the green paint has photosynthesizing properties. In this case, the instrument probably is sensitive to quite a different differentiating property, just as the Halstead Battery may be sensitive to normal aging for reasons other than the one supplied by Reitan. In this case, causal inferences should be attenuated by other possible considerations for the observed behaviour. In Reitan's 1955 study and 1963a study, the quantitative similarity of the performance of aged and brain damaged subjects are established. In his 1963b study, he attempts to show that there is a qualitative similarity also. He found that the rank order correlation coefficient between the tests ranked according to their sensitivity to brain damage and the

tests ranked according to their sensitivity to aging was significant. However, with a rho of 0.49, only one-fourth of the variance in the rank order distribution of the tests of the older subjects can be explained in this way.

There is evidence from another study (Schludermann, 1966) on the question of qualitative similarity between the performance of brain damaged subjects and normal old subjects. Schludermann found that the tests which were most sensitive in separating brain-damaged and non-brain-damaged subjects were not the same tests which were most sensitive in separating old from young subjects. He concludes that "The changes following frontal brain damage do not simulate in detail psychological changes following normal aging." He interprets these findings as supporting the multiple process view of mental deterioration which holds that the decline in psychological functions associated with aging involves an essentially different process from the decline in psychological functions resulting from brain damage. However, since there is the possibility that Schludermann's control group (healthy managerial executives) was above average in ability, there is the question of whether his results are representative of human aging in general.

Another criticism of Reitan's work concerns the adequacy of his control groups. In his 1955 study, he used both paraplegics and subjects with personality disturbances for his "normal" control group. In both the 1963 studies, hospitalized subjects with unspecified medical and psychiatric complaints were used as control subjects. In the present research, only healthy subjects with no medical or psychiatric complaints

requiring hospitalization are used in comprising the normal group. Thus the effects of age should not be confounded by any possible temporary biological or motivational condition.

Also, Reitan attempts to make comparisons between individuals who are comparable in ability level by selecting subjects who have the same number of years of formal education. However, the change in educational opportunities is an important secular variable. Whereas the average educational level for persons now 65 years and over is about the equivalent of the seventh grade, that of the 21 to 31 year old population is at the eleventh grade level. Thus, the amount of education of old people living today is not a reliable indicator of the person's ability. Not only has the amount of education changed, but also the quality of education has been improved, so that studies which use young and old groups comparable in years of formal education do not provide the most adequate control of this secular variable. Since I.Q. is a more reliable indicator of ability than educational level, comparisons in the present research were carried out between groups comparable in this respect.

By making comparisons between old and young groups of different ability levels, a question of considerable theoretical importance can be examined - that is, whether there are differential effects of aging in different ability groups. This question has been examined in several ways. Bromley (1966) poses the logical argument that "if the range of individual differences increase with age, if the mean score on tests is steadily reduced, and if each person maintains his position relative to other people in his age group, then it follows that the rate

of intellectual decline must be faster for the initially less able (p. 243)." Since there is evidence for each of the above assumptions, he feels that the conclusion is a reasonable one.

Using another approach to the problem, Vernon (1947-48) compared cross-sectional age differences in the performance of the Progressive Matrices Test for different occupational levels. The Progressive Matrices Test (Raven, 1948) is a non-verbal test requiring logical reasoning by analogy and therefore is relatively independent of language and of specific acquired knowledge. He found that the age-associated decline in the Progressive Matrices Test was related to occupational level and that this decline was greatest at the lowest occupational levels. He found that high scores remained relatively constant up to 25-30 years. These results are in close agreement with similar occupation studies by Gilbert (1941) and Sorenson(1933, 1938).

Owens (1956) attempted to answer the related question of whether age is kinder to the initially more able by means of a longitudinal study. One hundred and twenty seven males who took the Army Alpha Test as a college entrance examination in 1919 were retested 31 years later. He found no relationship between initial ability and subsequent test scores. However, it can be argued that Owens' group was too homogeneous to reveal differential effects, since all were prospective college students. Also, the study investigates age changes only until the relatively young age of 50 years. It is possible that if the restricted range of both dependent and independent variables was increased, the results would be more in line with the cross-sectional studies.

Where a relationship between ability level and age changes are found, the disuse theory is used to explain the results. This theory holds that persons with high levels of mental ability enjoy and practice mental functions more than those who are less proficient. This theory, then, would apply to tests where it is possible for the subject to utilize overlearning such as in tests of vocabulary or general information. Although a cogent argument can be made for the novelty of the tests in the Halstead Battery, Reitan has ranked the tests according to whether they depend on a relatively greater amount of stored memory than immediate adaptive ability. Using Reitan's ranking of the tests, the prediction is made that high ability subjects will be relatively more proficient on those tests which require stored memory; on those tests requiring immediate adaptive ability, intelligence level will not interact with the effects of age.

There is one theory, the theory of differentiation which attempts to account for the change in intelligence with age. This theory was developed by Garrett (1946) and Burt (1954), and was later extended by Lienert and Crott (1964) to explain the changes in intelligence in adults. According to this theory, intellectual development in the early years involves a process of differentiation of intelligence from a fairly unified and general ability to a loosely organized group of abilities or factors. The theory of differentiation is supported by studies on children (Balinsky, 1941; Burt, 1954; Garrett, 1946) where it was shown that increasing age is accompanied by a decrease in average test intercorrelations, by an increase in the total number of factors, and by a

decrease in the contribution of the first centroid factor which is interpreted as the general factor or g of intelligence. In testing whether the theory of differentiation explained adult test performance, Lienert and Crott (1964) found that, contrary to the early developmental trend to differentiation in the factor structure of intelligence from childhood to adolescence, the trend was toward integration from adolescence to old age. There was an increase in test intercorrelations and a decrease in the number of factors. Since the theory of differentiation adequately describes only the first part or ascending portion of the age curve of intelligence, Lienert and Crott proposed the differentiation-integration hypothesis to account for the entire curve.

The Halstead Battery, because of its sensitivity to the biological condition of the brain, is often called a test of biological intelligence (Halstead, 1951). If integration of the factor structure of intelligence occurs in adults with the Halstead Battery tests, then the tenability of the differentiation-integration hypothesis is greatly augmented, since confirming evidence would come from a different battery of psychological tests, and this would constitute evidence for the universality of this phenomena. The functional basis for an integration in factor structure would be that biological changes due to aging would increase the correlation between abilities, especially where the rate of aging is not the same for different individuals.

Therefore, by attempting to determine the relative roles of age and intelligence on performance of a group of neuropsychological tests, two questions of theoretical importance will be dealt with:

1. The divergence-convergence hypothesis: Does the factorial structure of adults on the Halstead Battery lend confirming support to this hypothesis? According to this hypothesis, aging would become an important source of variance in older subjects, producing an increase in average correlations and a simpler factor structure.
2. Is the course of aging the same in different ability groups? If the disuse theory holds where only a minimal amount of stored information can be utilized by the subject, the hypothesis is made that high ability subjects will do better than low ability subjects only on those tests requiring a relatively greater degree of stored memory than immediate adaptive ability.

By attempting to provide a more adequate sample of "normal" subjects and a more adequate control of the secular variable of educational opportunities, the present research also attempts to test the validity of some of Reitan's results:

1. To what extent is the Halstead Battery sensitive to differences in ability level?
2. Does the more adequate normal control group attenuate any of Reitan's results?

CHAPTER II

PROCEDURE

Experimental Design

Because of time limitations, the design of the present research utilizes the cross-sectional method, but attempts have been made to control for the possible biasing effects of secular changes by making comparisons only between groups which are comparable in ability. Since I.Q. is a more reliable indicator of ability than educational level (due to changes in the quality of and opportunities for education), comparisons in the present research were carried out between groups comparable in this respect.

Therefore, subjects were selected on the basis of two independent variables, age and I.Q., and were systematically tested on a battery of tests, the scores of which comprised the dependent variables.

Subject Selection

A concerted effort was made to ensure that there was adequate sampling of healthy normal young and old subjects who were comparable in I.Q. level. This necessitated the cooperation of several institutions.

Young and middle-aged volunteer subjects (female as well as male) were obtained from the working staff of the Winnipeg General Hospital, unemployment agencies, and the Pre-Vocational School. Older subjects were obtained from Senior Citizen's groups, the Age and Opportunity Day Centres, and from the Lion's Club Residence which is a low-rental apart-

ment block for older citizens. All subjects were normal and healthy in the sense that they were not suffering from any physical or mental disorder requiring medical or psychiatric care. None of the old age subjects were suffereing from senility, the practical criterion being whether they could care for themselves. Table 1 indicates the detailed breakdown of the subjects in the different age and I.Q. groups. Table 2 indicates the final distribution used in the statistical analyses. A total of 129 subjects participated in the study. All subjects were residents of Winnipeg and were fluent in the English language.

As can be seen from Table 2, there is an adequate representation of subjects in the extremes of both I.Q. and adult age dimensions. Subjects in the I.Q. range of 80-99 will hereafter be called the low I.Q. group, subjects in the I.Q. range of 100-109 will be called the medium I.Q. group, and subjects in the I.Q. range of 110-132 will be called the high I.Q. group. Subjects in the age ranges of 15-29 years, 30-50 years, and 51-84 years will be respectively called the young, middle-aged, and old groups.

Test Battery

All subjects were tested on 8 indicators of the Halstead Battery supplemented by the Trail Making Test (Reitan, 1958). Since a detailed description of the tests has been given elsewhere (Halstead, 1947), only a brief description of the tests is given below.

The Category Test measures abstraction ability. It consists of a series of slides projected on a screen, along with an answer panel of