# MAINTENANCE AND DECLINE OF ADULT MENTAL ABILITIES

## I. Empirical Data and Explanatory Models

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## INTRODUCTION

One of the major variables studied by psychologists over the adult life-span has been the topic of psychometric intelligence. The principal questions asked in different contexts have been whether or not intelligence is maintained or declines, and further, whether intellectual performance can be modified by behavioral interventions. We will address these issues in two related papers. The first will deal with a discussion of the descriptive data on intelligence over the period from young adulthood into old age. The second will focus on the issue of the modifiability of intellectual performance and the implications of the manner in which modification may be possible for the remediation of cognitive deficit and/or obsolescence by means of educational technology.

In this first paper, we will begin our discussion with a brief historical contemplation of the manner in which intelligence has been conceived and studied. Next, we will review some exemplary data from the current literature on adult intelligence. Some interpretations of these findings will then be offered, illustrating the complexity of the topic and its methodological pitfalls. Finally, we will discuss some new directions in the study of adult intelligence.

## HISTORICAL OVERVIEW OF ADULT INTELLIGENCE

There have been a variety of approaches to the study of intelligence over the life-span. These include an experimental-analytic approach (Simon, 1976; Sternberg, 1977), the Genevan (Piagetian) cognitive-structural approach (Hooper & Sheehan, 1977; Piaget, 1972), and the traditional psychomtric approach (Cattell, 1971; Matarazzo, 1972). Although the two first mentioned approaches have achieved some recent prominence, particularly in work with children, it is the latter, psychometric approach which has had the longest history of research, particularly with regard to adult development. The psychometric approach will therefore be the focus of our attention in this presentation.

Early study of psychometric intelligence was stimulated by the need to detect the children in the public school system who could not benefit from regular classroom instruction due to developmental disabilities. To identify such children, measures were needed which would be predictive of overall function in the school context. Later work in education was more concerned with describing profiles of differential mental abilities which might be helpful in prescribing more specific programs of remediation. As a consequence, a number of different models of psychometric intelligence have been generated across the years. We will here consider three such models: (1) the notion of intelligence as a general construct; (2) simple multi-factor theories of intelligence; and (3) hierarchical factor models, as illustrated by the concept of fluid and crystallized intelligence.

Intelligence as a general construct. Spearman (1927) believed that all intellectual activities contained something of a common element which he labeled the "g" factor. He observed that when one studies the intercorrelatins among test items one can find high agreement among items which appear to be measures of intellectual functions. Omnibus tests of intelligence (such as the Binet test and its successors) have tended to be quite successful in predicting performance in certain educational situations. A variety of "g" factors might be found, however, if one were to examine test items predictive of performance in non-educational situations or, for that matter, in non-traditional educational situations.

Multifactor theories of intelligence. A more appropriate model for the description of profiles of ability can be obtained when we select test items which have variance on significant aspects of intellectual performance in addition to loading on a general factor. Resulting test batteries (the Wechsler tests are a prominent example) have only moderate correlations between its parts, although their sum (as expressed in a total IQ) will measure competence for situations for which the particular component parts are important.

Thurstone (1938) studied the correlations among approximately 60 different measures of intelligence and concluded that one can identify a number of factors which have little or no relationship with one another. Thurstone's factors (as well as the structure-of-intellect model of Guilford, 1967) represent latent variables which can be measured only indirectly. These factors may indeed be the building blocks of intelligence, but paradoxically knowledge of an individual's standing on any one of them will not help predict competence in a specific situation or across classes of situations, except in the unusual case where a single factor accounts for most of the reliable variance in an observance behavior. Although it is not likely that new factors accounting for much variance will appear late in life, it is still possible that some intellectual abilities may account for much variance early in life but not later on and vice versa.

Hierarchical factor models of intelligence. An extension of the multifactor model is to conceive of several levels of factors, the first of which would be rather ability-specific while higher order factors would describe larger domains of variables. The variables included in any of the higher-order factors share common attributes and developmental histories. An example of a hierarchical factor model is the fluid-crystallized theory of intelligence proposed by Cattell (1963). Two broad second-order factors of intelligence are identified by this theory. Abilities which depend most on sociocultural influences form one class called the crystallized abilities. Examples of this class would be number facility, verbal comprehension and general information. Other abilities may be quite independent of acculturation, and their function may depend more on genetic endowment, the neurophysiological state of the individual and perhaps on incidental learning. These latter abilities are called fluid and are represented by such variables as memory span, inductive reasoning, and figural relations (cf. Cattell, 1963). The contention that crystallized abilities reach an early adult optimal level and remain stable henceforth while the fluid abilities show early decline (Horn, 1970) has recently been subjected to serious challenge (cf. Plemons, Willis & Baltes, 1978; Schaie, 1978b).

Each of the above models was first explored in work with children focusing on the acquisition of functions and skills in early life. But theoretical writers such as G. Stanley Hall (1922), H. L. Hollingworth (1927), and Sydney Pressey (1939) soon awakened interest in some of the complexities related to attainment of peak performance level, transformations of intellectual structure and decremental changes occurring in late middle age and in the elderly.

An early finding of interest to students of intellectual development came from Yerkes' (1921) study of World War I soldiers. He reported that the apparent level of mental function for young adults was only at about 13 years of age. Terman's original standardization of the Binet Intelligence test for American use also assumed that intellectual development peaked at age 16 and then remained constant (Terman, 1916). Such assumptions were soon questioned, however, by data from other empirical work. Jones and Conrad (1933), for example, on the basis of cross-sectional studies in a New England community, showed substantial age differences across adulthood on some, but little differences on other subtests of the Army Alpha Intelligence Test.

Similar findings were obtained in the standardization studies connected with the development of the Wechsler-Bellevue intelligence test. This work emphasized the fact that growth of intelligence does not end in early adolescence, that peak ages are not the same for different aspects of intellectual functioning, and that age differences are not uniform across the full spectrum of abilities tapped by most of the major batteries measuring intellectual development (Wechsler, 1939).

Matters were complicated further by the findings of Bayley and Oden (1955) and of Owens (1953, 1959) that when individuals are followed longitudinally, growth of intelligence, or at least stability, pertains into midlife.

The discussion on whether and when decrement in intellectual functioning in older adults occurs is often blurred by a lack of understanding of the kind of information that is to be gleaned from different data sets. Most of the older studies have involved the cross-sectional method where, at one point in time, individuals are compared from two or more age groups who, by definition, must belong to different birth cohorts and consequently will differ somewhat in life experience. Longitudinal studies, by contrast, compare the same individuals over two or more points in time. The former method confounds ontogenetic change with generational differences; the latter confounds ontogenetic change with the effects of sociocultural change occurring between times of measurement. These confounds are substantial for most behavioral variables and it is unlikely that findings of cross-sectional age differences will agree with longitudinal age changes (Schaie, 1965, 1967, 1977). Consequently, many age differences reported in the literature should more parsimoniously be interpreted as generational differences and results from single-cohort longitudinal studies of human behavior are primarily historical accounts of the life history of a particular generation (Schaie, 1972; Schaie & Gribbin, 1975a).

To deal with the above problems, a number of alternative strategies have been suggested which have become known as sequential methods. These methods make it possible to estimate the effects of age, cohort and period effects more precisely. The interested reader will want to consult the references cited above for more detail. Here we wish to convey the notion that results from studies which do not use the appropriate method have only limited generalizability. That is, cross-sectional studies are not likely to tell us how individuals have changed in the past and simple longitudinal studies do not project accurately how people are likely to change in the future.

## EVIDENCE ON MAINTENANCE OR DECLINE OF ADULT INTELLIGENCE

We are now ready to consider the empirical literature on age changes in intelligence. We shall proceed to do so by providing a brief summary of the work with the familiar Wechsler Intelligence Test and then indicate that much of the literature is methodologically deficient and thus scarcely useful for broad inference. In an admittedly parochial manner a much more extensive presentation will then be given of the work on the Primary Mental Abilities conducted by the first author and his associates (see Schaie, 1979, for a more detailed account).

Before we examine the research literature, there is one other issue that must be commented on, because it may well explain the hidden agenda behind some of the current discussions on the reality or myth of intellectual decrement in old age (cf. Baltes & Schaie, 1976; Botwinick, 1977; Horn & Donaldson, 1976). This issue is concerned with the age range to be reviewed when dealing with age decrement and intelligence. Gerontologists seem to be divided among those whose primary interest is in the process of adult development and others whose major concern is the end product of such development, the elderly. The first group of investigators, therefore, tend to be interested in changes occurring past a maturational asymptote, say in the early twenties, and pursue such changes until that stage, perhaps no later than the early seventies, where samples of individuals can be found that are reasonably free from confounding pathology. The second group, on the other hand, is more likely to begin studying individuals in their fifties and continue to whatever age level where any assessable subjects at all can be found. Botwinick (1977) therefore suggests that those who focus on the earlier "developmental" ages will also argue for "no decline," while those who focus primarily on the later years will proposed that "decline" is to be found.

The above formulation may be too simplistic, however, because the question is not just whether decline can be demonstrated on some variables for some individuals. Instead it must be recognized that there may be some variables on which there is little or no decrement and that there are some individuals who show no decrement on most variables into very old age(Baltes & Schaie, 1976; Schaie, 1974). Considering the latter statement, it becomes clear why it is most difficult to obtain data on normative aging beyond the late sixties, since most available samples will not be comparable to younger populations in terms of education, health status and other demographic variables. Separate studies, with measures validated for the old are therefore needed to build appropriate normative bases (cf. Schaie, 1978a), but such studies have only begun and do not as yet allow firm conclusions. With respect to currently available data then, a conservative position needs to be adopted and normative "decline"must be regarded with some suspicion.

### Wechsler Test Data on Intellectual Changes with Age

The Wechsler Adult Intelligence Test (most research on which has been done with the form known as the WAIS) is a battery of eleven factorially complex measures, six of which involve primarily verbal behaviors and are called a Verbal scale, and five involve some manipulative performance of a primarily non-verbal nature and are summed to arrive at a Performance scale. The Wechsler tests first appeared in 1939, but normative data for individuals beyond age 60 were not published until 1955 (Doppelt & Wallace, 1955). Table 1 (adapted from Matarazza, 1972, p. 354) lists age differences from early adulthood to late middle age. None of the differences are particularly remarkable considering that the mean of the standardization reference group is 10 and its standard deviation 3, but they are consistent indeed. Those differences which approach significance involve measures which are speeded. Constant time intervals become less and less adequate to assess the psychological construct of interest in an equitable manner in successive age groups. No significant changes over the entire mid-life period occur for the power tests Information, Comprehension, Arithmetic, Similarities, and Vocabulary. Until 60 or so there is virtually no drop for the Verbal Scale, but quite a sharp drop prevails on the Performance Scale.

Table 1

Mean Scores by Age for Sub-Test Performance on the WAIS During Middle Adulthood (Each Mean is based on N=200

| Sub Test | 20-24 | 25-34 | 35-44 | 45-54 | 55-64 |
|---|---|---|---|---|---|
| Verbal Scale | | | | | |
| Information | 9.8 | 10.3 | 10.3 | 9.9 | 9.9 |
| Comprehension | 10.0 | 10.2 | 10.2 | 9.9 | 9.6 |
| Arithmetic | 10.0 | 10.1 | 10.2 | 9.8 | 9.4 |
| Similarities | 10.2 | 10.1 | 9.2 | 9.0 | 9.0 |
| Digit Span | 9.9 | 10.0 | 9.6 | 9.0 | 8.4 |
| Vocabulary | 9.6 | 10.3 | 10.4 | 10.1 | 10.1 |
| Performance Scale | | | | | |
| Digit Symbol | 10.1 | 9.9 | 8.5 | 7.5 | 6.3 |
| Picture Completion | 10.1 | 10.0 | 9.8 | 8.6 | 8.0 |
| Block Design | 9.9 | 10.0 | 9.4 | 8.5 | 7.7 |
| Picture Arrangement | 10.5 | 9.7 | 9.1 | 8.0 | 7.3 |
| Object Assembly | 10.1 | 10.0 | 9.3 | 8.5 | 7.8 |

Adapted from Table 12.11 from Matarazzo (1972, p. 354) by permission of the author and publisher.

Norms for the WAIS for ages 65 and older were reported by Doppelt and Wallace (1955). These norms do show significant drop, even for verbal scales, past the age of 70. Substantial drop is most noteworthy again for the performance (speed implicated) measures. The verbal/performance discrepancy seems well replicated and has been found across the sexes, racial groups, and different socio-economic levels (Eisdorfer, Busse & Cohen, 1959), and greater than average drop in performance IQ has been implicated as a predictor of survival (Hall, et al., 1972). Harwood and Naylor (1971) matched a group of subjects in their sixties and seventies with a young adult control group in terms of the overall WAIS IQ. For the sixtyish group Information, Comprehension and Vocabulary was higher than for the matched young, while Digit Symbol, Picture Completion, and Picture Arrangement were lower. The same pattern held for the older group except that now Object Assembly as well was lower than for the young adult controls. Relaxation of time limits, however, may change this pattern for some elderly (Storandt, 1977).

Although cross-sectional comparisons of the WAIS clearly imply speed-related age decrements beyond the fifties, it has generally been maintained that verbal performance continues unimpaired into old age. Botwinick and Storandt (1974) have recently challenged this notion by giving the WAIS vocabulary test to individuals ranging in age from 62 to 83 years who were matched on quantitative scores on that test. Qualitative scoring revealed that the younger subjects excelled in superior synonyms (the only scoring category yielding an age difference). In a similar later study (Botwinick, West & Sotrandt, 1975) the authors concluded, nevertheless, that qualitative and quantitative age differences in Vocabulary performance did not differ except for fine meaning nuances.

Longitudinal data on changes in WAIS scores over a ten-year period have been reported by Eisdorfer and Wilkie (1973) for persons in their sixties and seventies each tested four times. The ten-year loss between the sixties and seventies, while reliable, amounted only to an average of 2 score points for Performance and 0.6 score points for the Verbal Scales. A total loss of 7.3 score points from the seventies to the eighties was about equally divided between Verbal and Performance Scales. Similar magnitudes of decline from the mid-sixties into the eighties were reported in a 20-year study by Blum, Fosshage and Jarvik (1972). Other studies on highly selected groups, by contrast, report little or no drop on Vocabulary even into very advanced age (Gilbert, 1973; Green, 1969). Comprehensive studies involving short-term longitudinal follow-up conducted with psychiatric and community samples in England (Savage, Britton, Bolton, & Hall, 1973) echo the findings reviewed above. In addition they call attention to both quantitative and qualitative differences in age changes in normal community-dwelling individuals and those with identified psychopathology. Performance scale deficit is reported to be a specific predictor of lessened longevity, but changes in the Verbval scale have primarily individualized non-normative significance.

## Age Changes on the Primary Mental Abilities

The Wechsler sub-tests are factorially complex. A clearer picture may therefore be obtained by considering age differences for the factorially less complex Primary Mental Abilities (Thurstone & Thurstone, 1949). Results of the first parametric study of this test over the age range from early adulthood to early old age (Schaie, 1958) are shown in Figure 1. Data in this figure come from a study of 25 men and 25 women in each five year interval from 20 to 70 who were randomly selected from the membership of a large metropolitan prepaid healthcare plan. This sample also provides the base for the sequential studies to be discussed in this section. Five abilities were systematically sampled. These are Verbal Meaning, a measure of recognition vocabulary; Space, the ability to visualize mentally the rotation of geometric objects; Reasoning, a measure of the ability to identify rules and serial principles; Number, a test of numerical skills; and Word Fluency, a measure of vocabulary recall.

Inspection of Figure 1 reveals only insubstantial age differences until about 50 for Space, Reasoning, and Verbal Meaning and until about 60 for Number and for Word Fluency. For the latter even at 70 the drop from peak does not exceed one standard deviation. Note also that adult peaks obtain for most abilities from the 31 to 35 year old group.

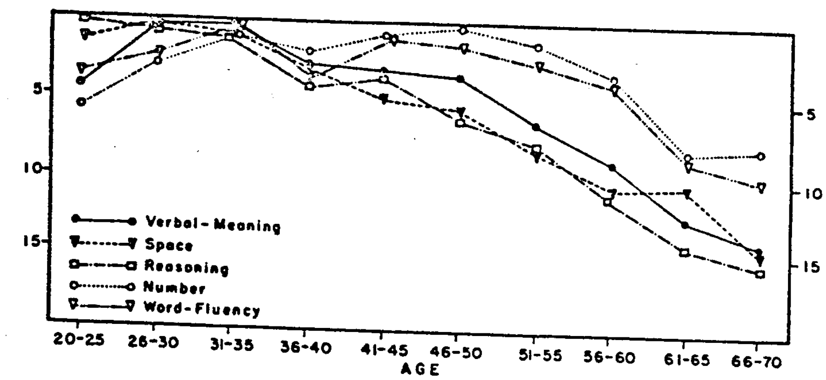


Figure 1. Mean Decrement in the Primary Mental Abilities from Mean Peak Levels in T-score points. (From: Schaie, 1958. Copyright by the American Psychological Association. Reproduced by permission.)

As was pointed out earlier, cross-sectional studies confound age changes with generational differences. It becomes important therefore to examine age trends determined by following samples of individuals over time supplemented by longitudinal studies based on independent samples, i.e., successive samples drawn from the same birth cohort at different ages but tested only once. Such data were obtained by retesting members of our 1956 samples after seven, fourteen and twenty-one years and obtaining new panels in 1963 and 1970 from the same population frame. The 1963 panel has been retested in 1970 and 1977, and the 1970 panel was retested in 1977.

Data from Panel Studies

The first longitudinal follow-up. In this study 303 persons from the 1956 panel were re-examined in 1963. While there was substantial replication of cross-sectional findings, means at comparable ages were systematically higher in 1963 than in 1956 for all variables except for Word Fluency, where the opposite pattern prevailed. The longitudinal data clearly indicate that ontogenetic changes were minimal until the sixties. Even then they appear to be largest, in contrast to the cross-sectional findings, for Word Fluency and are quite small for Reasoning, Space, Number and Verbal Meaning (Schaie & Strother, 1968a).

The second longitudinal follow-up. Of the panel members retested in 1963, it was possible to re-examine 162 in 1970. In addition, seven-year data were obtained on 418 of the individuals who had first entered the study in 1963. Two separate issues could now be addressed on the basis of short-term longitudinal data. Once again, we were in a position to describe within-subject age changes for a series of seven successive seven-year cohorts, but now over a fourteen-year time period (Schaie & Labouvie-Vief, 1974). Replication of seven-year changes within-subjects for two independent samples carried during two successive time periods, moreover, permits application of the cohort-sequential method, and thus a direct test of the relative contribution of age and cohort variance (Schaie & Parham, 1977).

The fourteen year data can be conceptualized as the simultaneous longitudinal study from 1956 to 1970 of seven cohorts, successively differing by seven years in average birthdate. The oldest cohort with average birth year 1889 is followed from mean age 67 to mean age 81; the youngest cohort with average birth year 1938 is followed from mean age 25 to mean age 39; and so on. An example of this analysis plotted along a chronological age scale is provided by Figure 2 for Space.

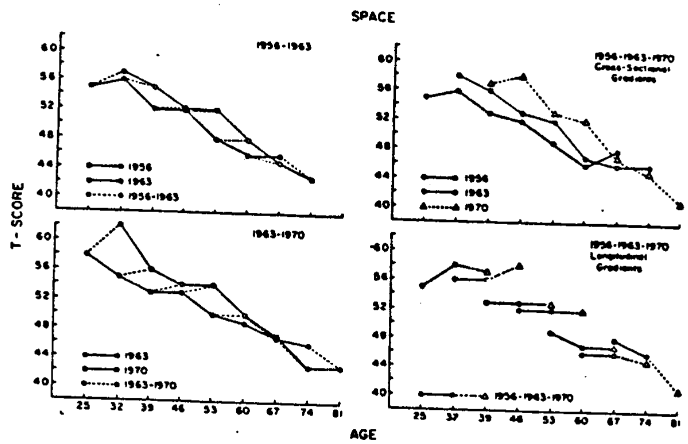


Figure 2. Mean Scores by Cohort for Space from the Fourteen-year Longitudinal Study. (From: Schaie & Labouvie-Vief, 1974. Copyright by the American Psychological Association. Reproduced by permission.)

Examination of Figure 2 illustrates the substantial effects of cohort differences. Similar findings prevailed for the other abilities studied. To summarize: Reliable decrement over a fourteen year period was observed for Space and Reasoning only for the oldest cohort from mean age 67 to mean age 81. No reliable fourteen-year change was found for Number. For Verbal Meaning, however, reliable decrement is observed for both oldest and second-oldest cohort; i.e., as early as from age 60 to 74. And, for Word Fluency, decrement is found for all but the two youngest cohorts; that is, beginning from age 39 to 53.

The seven-year data in this study represent a direct replication of the first follow-up study. Even clearer patterns appeared here for the age/cohort relationships shown in our first study for Verbal Meaning, Space, Reasoning and the composite indices. For Number there is partial replication; this time without the finding of apparent negative cohort effects for the youngest cohort. However, there is apparent failure to replicate our earlier finding of substantial ontogenetic changes on Word Fluency in early middle age. It is apparent then that the longitudinal findings for the first follow-up may have reflected (for the younger cohorts) negative time-of-measurement rather than age decrement effects.

The third longitudinal follow-up. In our 1977 follow-up we were able to re-examine, twenty-one years later, 120 of the persons first seen in 1956, but also to replicate our fourteen-year study by testing 252 persons previously examined in 1963 and 1970. The results of the 21-year study remain quite consistent with the patterns described above, and the fourteen-year data are well replicated (Schaie, 1978b).

## Cumulative Age Changes

It is possible to estimate from the within-cohort changes over a fourteen-year period cumulative age changes over the range from 25 to 81 years of age. As suggested elsewhere (Schaie, 1979; Schaie & Parham, 1977) the practical significance of age change is best conveyed when we chart performance at successive ages as a proportion of performance at a base age. Table 2 provides performance indices where 100 is average performance at age 25. Note that performance does not drop below this level for Verbal Meaning until age 81, for Space, Inductive Reasoning and Number until age 74, and for Word Fluency until age 60.

Psychometric tradition suggests that performance within the middle 50 percent of the population is thought to be characteristic of average performance (cf. Matarazzo, 1972, pp. 124-126). The lower bound of this average range (25th percentile) denotes the level below which an older group should fall before it can reasonably be argued that there has been decrement of sufficient magnitude to suggest that the average member of the older group falls below the average range of the young comparison group. Table 2 indicates that a decrement of such magnitude is reached for Word Fluency at age 74, for Verbal Meaning and Number by age 81, but that the average 81-year old in our panel is still within the average range of 25-year-olds on Space and Inductive Reasoning.

Table 2

Estimated Performance Level as a Proportion of Performance at Age 25 Based on Cumulative Age Changes (Decimals omitted; 100 = Average or 25 year old comparison group)

| Variable | 32 | 39 | 46 | 53 | 60 | 67 | 74 | 81 | 25th% tile @ Age 25 |
|---|---|---|---|---|---|---|---|---|---|
| Verbal Meaning | 108 | 110 | 112 | 112 | 113 | 108 | 102 | 85 | 86 |
| Space | 109 | 111 | 112 | 113 | 110 | 101 | 94 | 85 | 78 |
| Reasoning | 109 | 110 | 108 | 108 | 109 | 106 | 94 | 85 | 81 |
| Number | 116 | 111 | 114 | 107 | [illegible] | 100 | 93 | 70 | 74 |
| Word Fluency | 101 | 103 | 104 | 100 | 97 | 92 | 84 | 74 | 86 |

# FURTHER COMPLICATIONS

## Effects of Sample Attrition

The above presented data support our contention as to the late onset and relatively limited evidence for ontogenetic decrement in healthy populations. Arguments to the contrary advanced by Horn and Donaldson (1976) involve the application of inappropriate statistical procedures and cannot therefore be taken very seriously (cf. also Baltes & Schaie, 1976; Schaie & Baltes, 1977). Horn and Donaldson do, however, correctly point to discrepancies in findings between the panel studies and the estimates derived from independent samples. The crux of the latter argument is that conclusions drawn on the basis of panel studies must be tempered by the effects of selective attrition which limit the degree to which findings from such studies can be generalized.

Two types of attrition seem to occur. One is related to the investigator's skill in maintaining samples as well as occasioned by a number of psychological and sociological reasons such as lack of interest, active refusal, change of residence or subjects' disappearance. The other, over which investigator has no control at all, involves biological factors such as physical disease and individual differences in longevity. The first type of attrition can be assessed by contrasting base scores for participants and drop-outs from the same cohorts who had entered the study in either 1956 or 1963 (Schaie, Labouvie & Barrett, 1973).

Significant participation effects were found for all variables. As shown by Figure 3, participants cosistently get higher mean scores, with the exception of the two youngest cohorts on Number, Word Fluency and the composite intellectual ability measures. The differences between retest participants and drop-outs furthermore are more pronounced for the older cohorts.

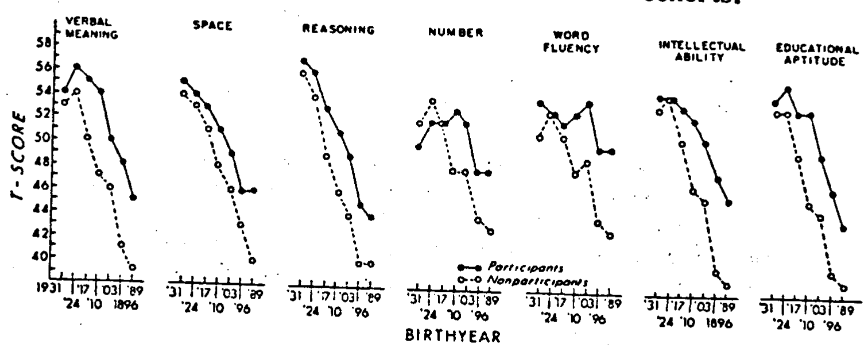


Figure 3. Cohort Differences for Retest Participants and Dropouts. (From: Schaie, Labouvie & Barrett, 1973. Copyright by the Gerontological Society. Reproduced by permission.)

The effects of the first type of panel attrition can be controlled for by obtaining independent samples at each measurement point from each cohort of interest. This requires, of course, additional draws of new cross-sectional panels as was done in our studies. Interestingly enough, such independently sampled data seem to differ from the panel data primarily in level of function and for some variables in the age range of onset of reliable decrement (Schaie & Strother, 1968b; Schaie, Labouvie & Buech, 1973). We would conclude at this time that the panel data are well representative of stable populations of health individuals with middle class or higher socio-economic status, while the independent samples data may be more representative of unselected samples from the general population.

The second type of attrition can be examined more properly by studying the relationship between demographic health and environmental factors as they impact intellectual development. However, the nature and importance of these variables will differ from generation to generation.

## Health and Environmental Factors

What is the nature of the cohort differences referred to above? Thus far we have examined some gross demographic indicators, have conducted an analysis of cumulative health trauma and have engaged in the study of interpersonal environments.

Demographic Facotrs. Soon after the initial cross-sectional study was completed we became aware of the fact that significant cohort differences prevailed on such obvious demographic variables as income, education and occupational status. ANCOVA was used to partial out the effects of these demographic variables upon the mental ability scores (Schaie, 1959). As would be expected, age difference effects were reduced by this procedure but they were not eliminated. What we are dealing with, of course, is the fact that demographic variables are differentially distributed across cohorts; that is, the level of education or income in one cohort does not have the identical meaning to that same level found in another cohort.

Health history factors. The effect of cumulative health trauma on change in intellectual functions have been investigated more recently. Clinic or hospital contacts of 150 of our participants were charted by the appropriate code from the International Classification of Diseases (ICDA) (U.S. Public Health Service, 1968). To our initial surprise, we found only limited relations between cumulative health trauma and mental abilities. Most fruitful in this context were investigations on individuals with known cardiovascular disease. At first glance cardiovascular diseases appears to result in lowered function on all intellectual abilities monitored. However, when we control for cohort (age), the effect is no longer significant for either Space or Word Fluency; and when socio-economic status is taken into consideration, the effect is found only for Number and a composite index of intellectual ability. This finding means that cardiovascular disease is more prevalent in members of older cohorts and those of lower socio-economic status, who also perform lower on the Primary Mental Abilities. Therefore, cardiovascular disease is likely to affect intelligence in a quite circuitous manner. For example, the disease may lead to changes in life style which more directly affect cognitive function (cf. Hertzog, Schaie & Gribbin, 1978). It is conceivable moreover that less healthy life styles shown by individuals of low education and intellectual ability might have modest causal effect upon the development of cardiovascular disease.

Environmental Factors. The effect of environmental factors upon both level of performance and change across age on the mental abilities was studied further by examining our participants' micro-environment. A Life-Complexity Inventory (LCI) was administered. Initial analysis of the LCI yielded eight item clusters that represent: 1) subjective dissatisfaction with life status 2) level of social status; 3) a noisy environment; 4) family dissolution; 5) disengagement from interaction with the environment; 6) semi- or passive-engagement with the environment; 7) maintenance of acculturation; and 8) female homemaker activities.

Positive correlations were found between all ability variables and the social status cluster, and similarly negative correlations occurred throughout with the disengagement cluster. In addition, Verbal Meaning, Word Fluency and Educational Aptitude related positively to maintenance of acculturation; family dissolution correlated negatively with Reasoning and Educational Aptitude;

female homemaker role correlated negatively to the Intellectual Ability Index and Number; and noisy environment correlated positively with Word Fluency (Gribbin, Schaie & Parham, 1980). An additional analysis showed that high disengagement and family dissolution cluster scores were associated with cognitive decrement over a fourteen year period (Schaie & Gribbin, 1975b).

In this section we have illustrated some of the limitations and complexities associated with the study of adult intelligence. Clearly, sophisticated methodologies and new explanatory models are required to further progress. From a methodological perspective, longitudinal studies must attend to the changing nature of samples and the fact that ontogenetic phenomena may be represented differentially in population sub-groups with unique characteristics. From a theoretical view, it is necessary to go beyond simple description of intellectual change to examining explanatory principles associated with such change. Traditionally, global indices such as chronological age or socio-economic status have been used as causal principles. These "empty" indices need now be substituted for by process-oriented psychological variables. Our preliminary analysis of life complexity and selected health factors may be a beginning of such an explanatory process.

## NEW DIRECTIONS IN THE STUDY OF ADULT INTELLIGENCE

This paper was begun with the observation that past study of intelligence had been focused on childhood and conceived of intelligence as a global construct with a single developmental pattern. The data examined here suggest that such an approach is not appropriate during the period of adulthood. At least three major issues may be suggested that we think require future attention. These are the need for multiple-differential models of intellectual development, the importance of adult-appropriate measures of intelligence, and the utilization of multiple criteria appropriate to the adult life experience.

### Alternate Models of Adult Intellectual Development

During childhood intellectual development can generally be viewed as unidirectional, with the direction representing the emergence of more differentiated from less differentiated behavior. No such assumption seems reasonable for most behavioral variables past adolescence. In our previous writings we have therefore called attention to at least three different models, all of which fit at least some available data sets for some portion of adult lifespan (Schaie, 1973).

The first of these models, adult stability, states that once maturity is reached adult behavior will remain stable until death. This is a model which must be seriously considered for the so-called crystallized abilities (Cattell, 1963), if one assumes that in this case information made available by the environment has been mastered. If the stability assumption is indeed valid, then data from cross-sectional studies comparing different age groups become direct estimates of cohort or generational differences. Examples of this approach were noted earlier in the discussion of the PMA data where there was little change within individuals that could be attributed to aging on ability variables which did not depend upon highly speeded tasks for measurement.

The model which seems to underlie most traditional discussions of adult intellectual development implies irreversible decrement past the growth peak. It focuses the researcher's attention primarily upon those few behaviors where performance is dominated by peripheral sensory functions and psychomotor speed all of which show systematic age-related decrement. The model is most appropriate for the analysis of data in populations of advanced age (say the late sixties and older), where by reason of increasing physiological pathology, irreversible decrement must be expected. This model specifies that ontogenetic changes will occur regardless of environmental input, but levels and slopes of decrement functions may be generation-specific. For data where this model applies one needs to know over what age range systematic age decrement prevails as against age differences attributable to generational shifts in level of performance.

An example of an appropriate application of methods to test these questions is provided in a study of the Primary Mental Abilities in which seven-year age changes were contrasted with seven-year cohort differences (Schaie & Parham, 1977). Results suggest that until the sixties there are no age changes on power tests, but substantial cohort differences prevail. From the sixties on both age and cohort differences are found, with age changes accounting for progressively larger amounts of individual difference variance as the eighties are reached. For highly speeded tests, however, cohort differences are relatively unimportant, while decremental age changes are detected as early as the forties.

A third model, decrement with compensation, is more likely to fit most behavioral data. Environmental input in childhood may affect growth in observed performance only minimally, since the organism as yet has not reached its behavioral asymptote. During adulthood, however, biologically determined decrement may be compensated for in part by quasi-prosthetic interventions. The decrement-with-compensation model, for example, may be quite appropriate for variables involving fluid intelligence where generational differences seem relatively unimportant, but where changes in educational technology and sociocultural processes may well obscure maturational events. When compensatory input no longer suffices to stabilize the behavior under scrutiny we may then see moderately accelerating decrement or terminal drop, i.e., severe behavioral decrement shortly prior to death (Siegler, 1975).

## Adult-appropriate Measures

Studies of omnibus measures of intellectual competence in common use appear to be most relevant for situations which rarely, if ever, are faced by the middle-aged or the elderly. Although studies of functional unities of intelligence, such as our own work with the Primary Mental Abilities (Schaie, 1979), may indeed explain most individual difference variance in early adulthood; other abilities, those relatively unimportant in youth, require more detailed assessment in later adulthood. What needs to be done here is to examine the appropriateness of content (cf. Krauss & Schaie, 1976) to design tests which are meaningful for adults. Next, we need to assess the effect of speeded tests in exaggerating performance decrement and to consider the kind of test norms which should properly be applied. The latter two issues deserve some further comment.

Speeded vs. power tests. Two different formats have generally been used for tests of intelligence. Power tests contain a series of items scaled in increasing order of difficulty presented to examinees until successive items are failed. Speeded tests present items of approximately equal difficulty, all within the performance range of the examinee. The number of items completed within a specified period of time is the performance measure.

Slowing of response speed is one of the well-documented facts of adult development (cf. Welford, 1977). This phenomenon should not have any effect upon pure power tests, and some have argued that older adults should only be examined by means of power tests. Speeded tests should be used only if the specific question to be asked requires the assessment of the rapidity of making a motor or other response.

More complex issues arise with the slightly speeded power tests. Time limits in this case must be relaxed sufficiently to permit the aging individual to tell us whether or not the problem can be solved rather than whether it is solved in a time interval which may be optimal for the young but not within the response capability of the old. Tests need to be developed where speed of response is not a critical element of successful performance and we ought to consider removing constraints which will tend to decrease speed of response, such as inappropriately small type size of anxiety-inducing instructions.

Age-appropriate norms. Commercially published intelligence tests, such as the Wechsler Adult Intelligence Scale (Matarazzo, 1972), often use age corrected norms. This approach is problematic if we are to predict behaviors of any social consequence or utility. It is not sufficient to say that an individual can perform at average level for his or her age. What must be known additionally is whether the observed performance is at a level appropriate to the criterion of interest. If the criterion variable to be predicted is geared to the needs and abilities of young adults, then one should also consider the performance of the older person in terms of test norms designed for young adults. But it does not make sense to compare young and old adults on the same norms, if a given test has differential validity or importance in predicting the same criterion at different life stages.

Available age-corrected norms have typically been developed from cross-sectional studies and are therefore cohort-specific. That is, as the norms age, they will over-estimate the level of performance on tests where there are positive generational trends and under-estimate performance on tests where there are unfavorable trends over time. Test manuals developed in the future should provide adult norms in terms of the birth-years for which specific norms were developed, rather than for the age range, in order to overcome this problem (see Schaie & Parham, 1975, for an example of cohort-specific norms).

## Criteria for Ecologically Valid Measurement of Adult Intelligence

Measures of intellectual functioning, of course, are useful only to the extent that they can help us predict criteria of social consequence. What is at issue here is the matter of ecological validity (Schaie, 1978a). The successful takeoff of intelligence testing began when Binet and Simon (1908) showed that objective measures of intellectual ability could be applied to the screening of uneducable children in the public schools. Similar criterion variables unfortunately are not readily available for adults. Their development requires the application of measures of intelligence to the assessment of competent behavior.

Competent behavior will involve the application of intelligence in specific situations, the attributes of which may well interact with the developmental level of the individual. Ability measures, as represented by the more commonly used intelligence tests, ought to be situation-specific with respect to competence, even though within a given level of ontogeny they might be generalizable across different situations. A measure of intellectual ability which assesses only a simple trait, no matter how elegant, cannot therefore assess the expression of competence in a given situation. Optimal combinations of traits will always be required to elicit competent behavior within as well as across situations (Schaie, 1978a). To build ecologically valid measures for adults we must learn more about situations in which adults are required to display competence, and this requires a taxonomy of adult situations (cf. Scheidt & Schaie, 1978). The potential generalizability of new tasks can then be investigated across classes of situations and types of individuals to attain a technology which can be scientifically valid and suitable for application to real life problems.

Presently existing tools for the assessment of intellectual competence, and new techniques specifically designed for the older adult, of course, do no more than provide us with estimates of current performance. A more important question may be whether or not older persons are likely to gain and respond to participation in intervention programs. Although determination of a minimally acceptable level of current performance may be essential, it may be even more important to know what further intellectual development is to be expected. Ordinarily, such determination would require longitudinal data about individuals, but inferences from other sources may be possible. The assessment of individuals' responses to brief experimental paradigms involving cognitive training (e.g., Labouvie-Vief & Gonda, 1976; Plemons, Willis & Baltes, 1978) are, of course relevant here and will be addressed in the next paper.

## SUMMARY

This paper has tried to discuss the many complex issues which becloud the clear interpretation of the literature of intellectual development in adulthood. We have also, however, tried to convey what seem to be sufficiently clear substantive findings. These we will now summarize.

1. Intelligence in adulthood does not follow a single course. Indeed, reliable decrement for all abilities or all individuals cannot be found until very old age (the late eighties).
2. Beginning in mid-life most individuals show minor decrement on those abilities which implicate speed of response. For those abilities where measurement is particularly sensitive to relatively modest impairment of the peripheral nervous system modest decrement will be seen by the early sixties.
3. Decrement is also likely to be found on most abilities for individuals with severe cardiovascular disease at any age, and for individuals living in undifferentiated or socially deprived environments during the late fifties and early sixties.
4. Longitudinal and repeated-measurement sequential studies accurately estimate age changes for individuals in above average health and who live in favorable environmental conditions. Such studies will over-estimate performance maintenance for those living under less favorable conditions and in less than average health.
5. Cross-sectional or independent samples sequential studies tend to over-estimate "normal" age decrements because they include individuals who perform at lower levels not because of age, but because of ability-related disease and/or life-style variables.

6. Although age changes in intelligence within individuals are small compared to generational differences until the mid-sixties, from then on there is a mix of cohort and age effects, with age effects assuming increasing importance as the eighties are reached.
7. In healthy, well educated populations many older individuals perform within the middle range of young adults. Some adults show decrement on some abilities quite early in life, but others maintain their function well into advanced old age.

And finally, much of what we know about adult intelligence has been learned by studying older individuals with measures developed for the young. The complex interaction between intellectual ability and situational competence in advanced age, therefore, still remains to be explored within an ecologically valid framework.

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