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4
Age Changes in Intelligence *

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INTRODUCTION

It has long been thought that intellectual powers peak in early adulthood and then show an inexorable decline. This thinking has been based upon public stereotypes about the elderly, perhaps with the implicit assumption that there ought to be isomorphism between decline of physical vigor and intellectual abilities. Some of the earlier psychological research literature, based primarily on cross-sectional data, seemed to support the stereotype. Nevertheless, there has always been a discordant note, because folk myth also tells us that wisdom comes with age and that the elderly are a repository of those values which provide societal stability and quality of life. Recent theoretical analyses (Flavell, 1970; Schaie, 1977/78) moreover suggest that while there may be isomorphism between biological structure and psychological function in childhood, such isomorphism ceases when

* This chapter represents an integration and summary of material, parts of which have been previously discussed elsewhere. Expanded versions of parts of this chapter may be found in Schaie (1977/78, 1978, 1979a, 1979b) and Schaie and Schaie (1979).

maturity is reached. Data from longitudinal studies and from replications of cross-sectional work have further questioned what we thought we knew about adult intelligence. In fact there has been much recent controversy regarding the "myth" of intellectual decline (Baltes and Schaie, 1974; Schaie, 1974; Horn and Donaldson, 1976) as well as what has become a "myth" about the "myth" (Botwinick, 1977; Baltes and Schaie, 1976; Horn and Donaldson, 1977; Schaie and Baltes, 1977).

In this chapter I will try to sketch the problem as succinctly as possible, but the reader should be warned to begin with, that although I will attempt to present a balanced view, it will primarily be an account of my own position. That is what I was commissioned to do, and that is what this chapter is all about.

I will begin with a historical review of the study of adult intelligence and will then deal with certain theoretical and methodological issues which cannot be overlooked if one is to understand this topic. In this context I will need to talk about models or meta-models for the description of changes in adult intelligence, the nature of the alternate data bases upon which our knowledge is built, and the issue of construct validity of findings across ages and cohorts. I will then give a brief summary of findings on age changes for the commonly used Wechsler test, and a more detailed summary of our findings with the Primary Mental Abilities Test. The latter will be qualified by what we have learned about the impact of health and environmental factors on maintenance or decline of intellectual functions. I will then summarize what I think to be the current status of the question of intellectual decline with age, and finally will comment on the problem of studying intelligence in the old with tests developed for the young.

Why Study Intelligence in Adulthood?

Early empirical work on intelligence was directed toward investigating 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 on the Army Alpha 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).

All these matters would be of historical interest only, if it were not for the fact that omnibus measures of intelligence are quite useful in predicting a person's competence in dealing with our society's educational system and in succeeding in vocational pursuits which require educationally based knowledge and skills. Certain ability measures have also had some use in predicting competence in meeting specific situational demands. And the analysis of patterns of intellectual performance has been found helpful by clinicians in the diagnostic appraisal of psychopathology. In work with the elderly, moreover, it is apparent that some determination of intellectual competence may be directly relevant to such issues as mandatory retirement, educability for new careers and life roles, maintenance of individual living arrangements, and the conservation and disposition of property (Matarazo, 1972; Schaie and Schaie, 1979; Schaie and Willis, 1978).

If we are to address the above issues intelligently, we must then know the developmental patterns of different aspects of mental ability and the ages at which developmental peaks occur. We can then differentiate age from cohort differences, can distinguish between obsolescence and decrement, and will perhaps be able to understand what variables contribute to the apparent fact that some individuals show intellectual decrement beginning with early adulthood while others maintain and increase their functioning until advanced old age.

Intelligence and Competence: A Brief Historical Contemplation

Measures of intellectual functioning, of course, are useful only inasmuch as they can help us predict criteria of social consequence. Indeed, the beginning of the mental test movement almost aborted when Wissler's (1901) classical study showed that the kind of measures of ability suggested by the early work of Galton (1883) and J. McK. Cattell (1890) showed only trivial correlations with measures of social consequence such as success in formal educational situations. The successful takeoff of intelligence testing began when Binet and Simon (1908) showed that objective measures of intellectual ability could be applied to the useful task of screening for uneducable children in public schools. Paradoxically, the earlier unsuccessful attempts were indeed proper ways of measuring intelligence as a set of multiple unitary traits, while the latter presented us with a combination of such traits which tended to assess situation-specific competence. But before we go any further let us attempt to distinguish properly between the concepts of intelligence and competence.

In the introduction to their monograph, Connolly and Bruner (1974) suggest that the term competence refers to intelligence in its broadest sense, that is, in its aspect of "*knowing how* rather than simply *knowing that* (authors' italics)." They distinguish between a narrow definition of intelligence as a passive structure of intellect à la Guilford (1967), whether inherited or acquired, and a much broader delineation of competence as a construct implying action which may change the environment as well as adapt to the environment. Three attributes of competence are said to be the ability to select features from the total environment that are required information for initiating a course of action, to initiate a sequence of movements designed to achieve the planned objectives, and to learn from successes and failures in order to formulate new plans.

It follows then that competent behavior will involve the application of the structure of intellect in specific situations, the attributes of which may well interact with the developmental level of the individual

under study. When discussing intelligence we must, of course, distinguish between the observed or phenotypic measures of a particular construct, and the latent trait or genotypic construct in itself. This means that phenotypic measures of unitary traits of intelligence, 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 with respect to the intellectual process utilized. A measure of intellectual ability which assesses a single trait, no matter how elegant, will not suffice fully to assess the expression of competence in a given situation. Hence, optimal combinations of unitary traits will always be required to elicit competent behavior within as well as across situations (Schaie, 1978).

The intelligence-competence distinction may be summarized by proposing that competence be viewed as the phenotypic expression of a particular combination of genotypic intelligence factors which, given minimally required levels of motivational incentives, will permit adaptive behavior within a specific situation or class of situations. Intelligence, on the other hand, would be viewed as that spectrum of genotypic factors which might be abstracted from phenotypic expressions of adaptive behavior measured *across* situations.

Given the above distinction, it appears that we have been shifting back and forth historically from a competence model to an intelligence model. Which is to be preferred obviously depends upon one's predilection for construct purity and elegance (the intelligence side) or for application to practical assessment issues (the competence side). But different theoretical models and data bases will also have much influence upon the direction chosen. We will next proceed to examine the latter issues.

THEORETICAL AND METHODOLOGICAL ISSUES

In this section we will first consider models of intelligence and then examine the different data bases which are available or needed for the investigation of adult intelligence. Attention will also be given briefly to the problem of the generalizability of construct validity across cohorts and ages.

Models of Intelligence

The discussion of intellectual development ought to begin by specifying the nature of the construct whose development is to be understood. We have already distinguished between the concepts of intelligence and competence. It will now be helpful to engage in a brief historical analysis of different models of intelligence to see whether and how this distinction has been operationalized. Four basic approaches will be considered: (1) the notion of intelligence as a general construct, (2) multifactor theories of intelligence, (3) the distinction of fluid and crystallized intelligence, and (4) stage theories about adult intellectual development.

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 intercorrelations 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 noneducational situations or, for that matter, in nontraditional educational situations.

Multifactor theories of intelligence. Tests designed to measure a number of factors related to intelligence include test items which have variance on significant aspects of intellectual performance as well as general factors. Resulting test batteries (the Wechsler tests are a prominent example) have only moderate correlations between their 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.

Fluid and crystallized intelligence. 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 from then on while the fluid abilities show early decline (Horn, 1970) has recently been subjected to serious challenge (Plemons, Willis, and Baltes, 1978).

Stage theories of adult development. The Genevan model of intelligence (Flavell, 1963) places emphasis on the development of biologically based cognitive structures which produce qualitative changes in the way cognitive operations are conducted as the individual matures. By the time adulthood is reached, the final stage of formal operations should have been attained and should be maintained from then on (Flavell, 1970). However, Piaget (1972) has recently suggested that not all adults attain the stage of formal operations, and that formal operations are not applied uniformly to all substantive areas of cognitive behavior (see also Schaie and Marquette, 1975).

A recent extension (Schaie, 1977/78) considers the possibility of three adult stages: an *achieving* stage during which the young adult strives towards goal orientation and role independence, a *responsible* stage involving long-term goal integration and increased problem-solving skills, and a *reintegrative* stage during which there is relinquishment of occupational and familial responsibilities accompanied by the simplification of cognitive structures through selective attention to meaningful environmental demands. This conceptualization is quite compatible with stage theories of adult moral development (Kohlberg, 1973), of ego development (Erikson, 1964), and with Havighurst's (1972, 1979) developmental task approach.

Data Bases for the Study of Adult Intelligence

A better understanding of the research literature on intellectual development as well as the recent controversies sparked by this literature will require brief consideration of: (1) the differentiation of age changes and age differences which is so important in understanding the discrepancies of findings from cross-sectional versus longitudinal studies; (2) the effect of subject dropout (experimental mortality) in longitudinal studies; and (3) the issue of relating the effect of physiological pathology, such as cardiovascular disease, to normal age change in cognitive function.

Age differences versus age changes. The issues related to interpreting data obtained from cross-sectional, longitudinal or the newer sequential data-collection strategies cannot be presented here in detail (see Baltes, Reese, and Nesselroade, 1977; Friedrich and Van Horn, 1976; Schaie, 1970, 1973, 1977). Nevertheless, we would be remiss if we did not attend at least briefly to the research designs commonly used in the literature on intellectual development.

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. Single-cohort 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). Consequently, many age differences reported in the literature should be interpreted as generational differences, and results from single-cohort longitudinal studies of human behavior as primarily historical accounts of the life history of a particular generation (Schaie, 1972; Schaie and 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. But we wish to leave the reader with the notion that results of studies which do not use the appropriate sequential method have only limited generalizability. That is, cross-sectional studies do not necessarily tell us how individuals have changed in the past, and simple longitudinal studies do not predict with certainty how people are likely to change in the future.

Experimental mortality. What we know about adult intellectual development is further limited by the problem of nonrandom dropout from panel studies upon which most of our better research findings are based. Two types of attrition seem to occur. One is related to the investigator's skill in sample maintenance as well as psychological and sociological reasons such as lack of interest, active refusal, change of residence or disappearance. The other, over which the investigator has no control, involves biological factors such as physical disease and individual differences in longevity. Studies of attrition caused by biological factors suggest that survivors excel on many positive attributes with regard to interest, attitudes, education and social status (Baltes, Schaie and Nardi, 1971; Schaie, Labouvie and Barrett, 1973).

Although one can control for attrition by comparing successive samples from the same birth cohort, each tested only once, there remain compelling reasons to continue panel studies. Only by repeatedly measuring the same individuals can one study patterns of intra-individual change, and moreover the characteristics of survivors of panel studies may well be typical for populations of special interest in settings such as adult education or professional enrichment programs.

Pathological versus normal aging. Cumulative effects of pathology are noted in aging individuals, and it is not reasonable to trace pathology-free psychological processes, except in those instances where one can demonstrate that the occurrence of a given pathology does not increase with age. When we describe intellectual development with advancing age, we would not arbitrarily exclude individuals suffering from the mild chronic conditions so common with increasing age, but we would certainly exempt from our discussion individuals suffering from acute but reversible illness. We do know that cardiovascular disease affects cognitive behavior and that such disease increases in frequency with age (Hertzog, Schaie, and Gribbin, 1978). Nevertheless, one must keep in mind that except for the very old, the majority of older adults do not suffer from significant cardiovascular disease, and that the effect of such disease upon behavior, while qualitatively and quantitatively important, does not necessarily preclude meaningful activities. A similar line of argument may, of course, be made for other less prevalent chronic diseases which increase in frequency as we age.

How Do We Measure Intelligence in Adults?

The often heard statement that intelligence is what intelligence tests measure is quite simplistic. Nevertheless, it is still important to know in what manner a person's intellectual functions are examined. In this section we will discuss what kind of norms one should use in appraising adults, the role of speed versus power tests, and differentiating performance from potential.

Age-corrected versus absolute level norms. Most intelligence tests published commercially, such as the Wechsler Adult Intelligence Scale (Matarazzo, 1972), use age-corrected norms. There are several problems with this approach if such tests are to be utilized as estimates of intellectual competence in various life situations. The most important of these is that 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 is whether the performance is at a level appropriate to the criterion of interest. Thus, 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. On the other hand, it does not make sense to compare young and old adults on the same norms, if given test variables have differential importance in predicting the same criterion at different life stages.

All age-corrected norms found in the literature have been developed from cross-sectional studies and are thus cohort-specific. That is, as the norms age, they will overestimate level of performance on tests where there are positive generational trends and underestimate performance on tests where there are unfavorable trends over time. It is to be hoped that test manuals developed in the future will begin to provide adult norms in terms of the birth years for which specific norms were developed, rather than the age range, in order to overcome this problem. (See Schaie and Parham, 1975, for an example of cohort-specific norms.)

Speeded versus power tests. Tests of intelligence have traditionally utilized two different format approaches. Power tests contain a series of items scaled in increasing order of difficulty, and items are presented to the examinee until a prescribed number of successive items are failed. For practical purposes, however, and particularly in group-administered tests, some time limit is generally imposed. In the latter case one speaks of a slightly speeded power test. Speeded tests present the examinee with a large number of items of approximately equal difficulty, all within the scope of performance of the examinee. The examinee's performance measured on such tests is the number of items completed within a specified period of time.

One of the well-documented facts of adult development is the slowing of response speed (Welford, 1977). This phenomenon should not have any effect upon pure power tests, and some have argued that therefore older adults should only be examined by means of power tests. Nevertheless, one aspect of competent intellectual performance is the ability to make an organized response with reasonable temporal contiguity to the stimulus which requires the response. The question in ability testing, therefore, is to ask whether or not speed of response, and how much speed, is required for adaptive behavior in a particular situation. Obviously speeded tests should be used with older individuals 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 test. Some of the factor-analytic work with the WAIS has shown that a given subtest which was a good measure of the intended construct for young adults may become a measure of response speed for the old (Reinert, 1970). Time limits in this case must be relaxed sufficiently to permit the aged 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 should be developed where speed of response is not a critical element of successful performance, and we ought to consider, as well, removing those constraints which will tend to decrease speed of response, such as inappropriately small type size, anxiety-inducing instructions, and so on.

Performance versus potential. 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. But a more important question may often be whether or not older persons are likely to gain and show growth as a consequence of participation in some intervention program. Although determination of a minimally acceptable level of current performance may be essential, it may also be important to know what can be expected in terms of further intellectual development. Such determination would ordinarily require longitudinal data about individuals, but inferences from other sources may be possible. Some work has been done on the prediction of stability or change in intellectual functions from knowledge of individuals' life styles (Schaie and Gribbin, 1975b). Other promising avenues are concerned with the assessment of individuals' responses to brief experimental paradigms involving cognitive training (e.g., Labouvie-Vief and Gonda, 1976; Plemons, Willis, and Baltes, 1978).

EMPIRICAL FINDINGS

We are now ready to consider the empirical literature on age changes in intelligence. I 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. I will then, in an admittedly parochial manner, give a much more extensive presentation of the work on the Primary Mental Abilities Test conducted by myself and my associates (See Schaie, 1979a, for a more detailed account). This section will be concluded by describing briefly how health and environmental factors interact with cognitive change.

But 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 (e.g., Baltes and Schaie, 1976; Botwinick, 1977; Horn and Donaldson, 1976). This issue is concerned with the age range to be reviewed when dealing with age decrement and intelligence. The house of gerontology encompasses both scientists who are interested in the process of adult development and those interested in the end product of this development, the elderly. It is not surprising, therefore, that the first group of investigators would be interested in changes occurring past a maturational asymptote, say in the early twenties, and would pursue such changes until that stage, perhaps no later than the early seventies, where study populations can be found that are reasonably free from confounding pathology. The second group, on the other hand, would perhaps wish to start with individuals in their fifties and continue to that 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 propose that "decline" is to be found.

Matters are not quite that simple, however, because the question is not just whether decline can be established for some variables for some individuals, for indeed it can. What we need to recognize instead is 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 and 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 (e.g., Schaie, 1978), but such studies have only begun and do not as yet allow firm conclusions. With respect to currently available data then, we must perforce take a conservative position and regard normative "decline" with a due amount of 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 11 factorially complex measures. Six involve primarily verbal behaviors and are called a Verbal Scale, and five involve some manipulative performance of a primarily nonverbal nature which are summed to arrive at a Performance Scale. Although the Wechsler tests first appeared in 1939, normative data for individuals beyond age 60 did not appear until 1955 (Doppelt and Wallace, 1955). Table 4.1 (adapted from Matarazzo, 1972, p. 354) presents age differences from early adulthood to late middle age. Considering that the mean of the standardization reference group is 10 and its standard deviation 3, none of the differences are particularly remarkable, but they are consistent indeed. All of the differences which approach significance involve measures which are speeded; that is, a constant time interval will with successive age groups become more and more inadequate to assess the psychological construct of interest in an equitable manner. For the power tests: Information, Comprehension, Arithmetic, Similarities and Vocabulary, there are obviously no significant changes over the entire mid-life period. Note that until 60 or so there is virtually no drop for the Verbal Scale. On the other hand, there is quite a sharp drop on the Performance Scale.

Norms for the WAIS for ages 65 and older were reported by Doppelt and Wallace (1955). These norms do show significant decline, even for verbal scales, past the age of 70. Substantial decline is most

Table 4.1. Mean Scores By Age for Subtest Performance on the WAIS During Middle Adulthood.*

SUBTEST	AGE RANGE 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

NOTE: Each mean is based on $n = 200$.

* Adapted from *Wechsler's Measurement and Appraisal of Adult Intelligence* by Joseph D. Matarazzo, 5th and enlarged edition.

noteworthy again for the performance (speed-implicated) measures. This discrepancy incidentally seems well replicated and has been found across the sexes, racial groups, and different socioeconomic levels (Eisdorfer, Busse and Cohen, 1959). Greater than average decline in performance IQ has been implicated as a predictor of survival (Hall et al., 1972). In another study, 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 group of persons in their sixties, Information, Comprehension and Vocabulary scores were higher than for the matched young, in which Digit, Symbol, Picture Completion, and Picture Arrangement were lower. The same pattern held for the group in their seventies except that now Object Assembly as well was lower than for the young adult controls. But for some elderly, relaxation of time limits may change this pattern (Storandt, 1977).

While cross-sectional comparisons of the WAIS clearly implicate speed-related age decrements beyond the fifties, it has generally been maintained that verbal performance continues unimpaired into old age. This notion was challenged by Botwinick and Storandt (1974) who gave the WAIS Vocabulary Test to individuals ranging in age from 62 to 83 years who were matched on quantitative scores for that test. Qualitative scoring then revealed that the younger subjects excelled in superior synonyms (the only scoring category yielding an age difference). But in a similar later study (Botwinick, West, and Storandt, 1975) the authors concluded that qualitative and quantitative age differences in Vocabulary performance did not differ except for fine nuances of meanings.

Eisdorfer and Wilkie (1973) have reported longitudinal data on changes in WAIS scores over a 10-year period for groups of subjects in their sixties and seventies, each tested four times. A small number of subjects had three further tests over an additional 5-year period. The 10-year loss between the sixties and seventies was statistically significant but amounted only to an average of 2 score points for the Performance and 0.6 for the Verbal Scales. From the seventies to the eighties there was a total loss of 7.3 score points about equally divided between Verbal and Performance Scales. Similar declines from the mid-sixties into the eighties were reported in a 20-year study by Blum, Fossnage and Jarvik (1972). By contrast, there have been some reports on highly selected groups which show little or no drop on Vocabulary even into very advanced age (Gilbert, 1973; Green, 1969). Further comprehensive studies involving short-term longitudinal follow-up conducted with psychiatric and community samples are reported in a monograph by Savage, Britton, Bolton, and Hall (1973). Their findings generally echo those reviewed above but, in addition, 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 seen as a specific predictor of lessened longevity, while changes in the Verbal Scale have primarily individual nonnormative significance.

Age Changes on the Primary Mental Abilities Test

The Wechsler subtests are factorially complex. A clearer picture may therefore be obtained by considering age differences for the factorially

less complex Primary Mental Abilities Test (Thurstone and Thurstone, 1949). Results of the first parametric study of this test covering the age range from early adulthood to early old age (Schaie, 1958) are shown in Figure 4.1. These data come from a study of 25 men and 25 women in each 5-year interval from ages 20 to 70 who were randomly selected from the membership of a large metropolitan prepaid health-care plan. This sample also provides the base for the sequential studies to be discussed in this section. Five abilities were systematically sampled: Verbal Meaning (V), a measure of recognition vocabulary; Space (S), the ability to visualize mentally the rotation of geometric objects; Reasoning (R), a measure of the ability to identify rules and serial principles; Number (N), a test of numerical skills; and Word Fluency (W), a measure of vocabulary recall.

Inspection of Figure 4.1 reveals only insubstantial age differences until about age 50 for Space, Reasoning and Verbal Meaning, and until about age 60 for Number and for Word Fluency. For the latter, even at age 70 the drop from peak does not exceed 1 standard deviation. Note also that adult peaks obtain for most abilities for the 31–35-year-old group.

The basic flaw of cross-sectional studies, as was pointed out earlier in this chapter, is the fact that such studies confound age changes with

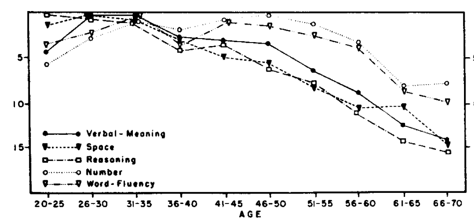


Figure 4.1. Mean decrement in the primary mental abilities from mean peak levels in T-score points. (From: Schaie, K. W. Rigidity-flexibility and intelligence: A cross-sectional study of the adult life-span from 20 to 70. *Psychological Monographs*, **72**: No. 462 (Whole No. 9), 1958. Copyright 1958 by the American Psychological Association. Reprinted by permission.)

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, that is successive samples drawn from the same birth cohort at different ages but tested only once.

We were fortunate to be able to retest members of our 1956 samples after 7, 14 and 21 years and to obtain new panels in 1963 and 1970 from the same population frame. The 1963 panel was retested in 1970 and 1977, and the 1970 panel was retested in 1977. Only initial analyses, however, are as yet complete for our 1977 data wave.

The following sections will summarize findings for the five primary abilities as well as for composite measures suggested by the Thurstones (1949, 1958). These are a composite measure of Intellectual Ability (IA = V + S + 2R + 2N + W) and an Index of Educational Aptitude (EA = 2V + R).

Data from Panel Studies

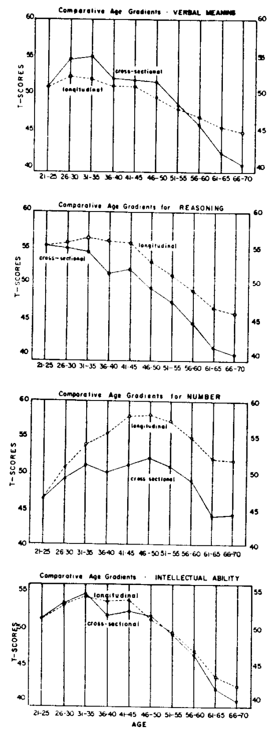
The first longitudinal follow-up. In this study 303 persons from the 1956 panel were reexamined in 1963. While there was substantial replication of cross-sectional findings, means at comparable ages were systematically higher in 1963 than in 1956 for all variables except for Word Fluency, where the opposite pattern prevailed. And, when we examined the longitudinal age changes it became clear that, again with the exception of Word Fluency, 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.

Our next concern was with the problems of constructing appropriate gradients which permit comparison between cross-sectional and longitudinal findings. We argued that the best comparison would occur by contrasting short-term longitudinal data with cross-sectional data averaged over the time interval bounding the longitudinal segments. For purposes of age-gradient construction we combined data from both sexes, and to reduce sampling variability, we calculated age changes for successive 5-year age intervals averaged over each pair of successive cohorts. Figure 4.2 provides graphic representations of the estimated average cross-sectional and composite longitudinal gradients. These graphs compare age gradients obtained on the basis of current performance of individuals at different ages who are members of *different* cohorts with the estimated longitudinal age gradient for a *single* cohort. If age differences were attributable solely to maturational or otherwise age-related causes, then gradients constructed in either manner ought to coincide. But if cross-sectional differences include differences in experience or talent between successive cohorts, then the two gradients must diverge. If generational differences go in a positive direction, then the cross-sectional, between generation difference, gradient must be below the longitudinal, within generation, gradient. Conversely, unfavorable change across generations will yield cross-sectional gradients above the longitudinal gradient.

Figure 4.2 reveals positive intergenerational differences for Verbal Meaning, Space and Reasoning, and to a lesser degree for Number. Negative generational differences are shown for Word Fluency. As is generally true for omnibus measures of intellectual ability, ours included, no differences were found between cross-sectional and longitudinal gradients on the composite Intellectual Ability measure because the effects of positive and negative generational differences have been averaged. The Index of Education Aptitude, however, showed positive intergenerational differences, being a composite of measures for which similar findings occur.

The second longitudinal follow-up. Of the panel members retested in 1963, it was possible to reexamine 162 in 1970. In addition, we were also able to get 7-year data on 418 of the individuals who had first entered the study in 1963. Two separate issues could not 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 7-year cohorts, but now over a 14-year time period (Schaie and Labouvie-Vief, 1974). Of equal interest, however, is the replication of 7-year changes within subjects for two independent samples carried during two successive time periods. It is this latter comparison which permits application of the cohort-sequential method and, thus, a direct test of the relative contribution of age and cohort variance (Schaie and Parham, 1977).

The 14-year data can be conceptualized as the simultaneous longitudinal study from 1956 to 1970 of seven cohorts, successively differ-



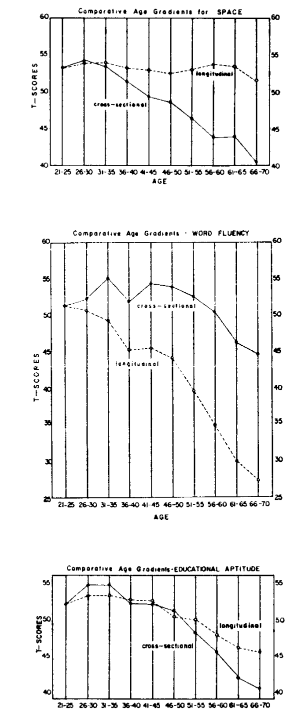


Figure 4.2. Comparison of cross-sectional and longitudinal age gradients. (From: Schaie and Strother, 1968b. Copyright by Multivariate Behavioral Research. Reprinted by permission.)

ing by 7 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. Results of this analysis plotted along a chronological age scale are provided by Figure 4.3.

The substantial effects of cohort differences become apparent immediately. But attention is focused also on the many differences in ontogenetic pattern by type of ability as well as cohort membership. Reliable decrement ($p < 0.01$) over a 14-year period is observed for Space and Reasoning only for the oldest cohort from mean age 67 to mean age 81. No reliable 14-year change is found for Number. For Verbal Meaning, however, reliable decrement is observed for both oldest and second oldest cohorts, that is, as early as from age 60 to 74. For Word Fluency, decrement is found for all but the two youngest cohorts, that is, beginning from age 39 to 53. Reliable decrement on the composite IQ measure is seen for the three oldest cohorts, from age 53, but for the measure of Educational Aptitude, only for the two oldest cohorts, from age 60. In addition, reliable 14-year increment from 25 to 39 is found for the youngest cohort for Verbal Meaning and Educational Aptitude.

The 7-year data in this study represent a direct replication of the first follow-up study. Even clearer patterns appeared here for the age/cohort relationship shown in our first study for Verbal Meaning, Space, Reasoning and the composite indexes. 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.

These data clearly support our contention of 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 be taken seriously (see also Baltes and Schaie, 1976; Schaie and Baltes, 1977). Horn and Donaldson do, however, correctly point to discrepancies in findings between the panel studies and the estimates derived from independent samples. That question will be addressed next.

Independent Samples Data

Experimental mortality. The above findings must be tempered by the effects of selective attrition which limit the degree to which findings from panel studies can be generalized. Our data base permits assessing the effect of attrition by contrasting base scores for participants and dropouts from the same cohorts who had entered the study in either 1956 or 1963 (Schaie, Labouvie, and Barrett, 1973).

Significant participation effects were found for all variables. As shown by Figure 4.4., participants consistently 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 dropouts, however, is more pronounced for the older cohorts. In fact, significant age-by-cohort interactions were found for Verbal Meaning, Number and the composite indexes. In addition, there was less pronounced participation by time-of-measurement effects for Verbal Meaning and the Index of Educational Aptitude in the direction of greater differences between retest participants and dropouts in 1963. What is apparent then is that the discrepancies between numbers of the longitudinal panel and random samples from the parent population tend to increase over time.

One way in which the issue of panel attrition can be addressed is to obtain 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 data seem to differ from panel data primarily in level of function and for some variables in the age range of onset of reliable decrement (Schaie and Strother, 1968b; Schaie, Labouvie, and Buech, 1973). It is our impression at this time that the panel data are representative of stable populations of healthy upper- and middle-class individuals, while the independent samples data may be more representative of unselected samples from the general populations. Differences between the two types of data bases may be more important when one addresses the issue of magnitude of age changes in intelligence.

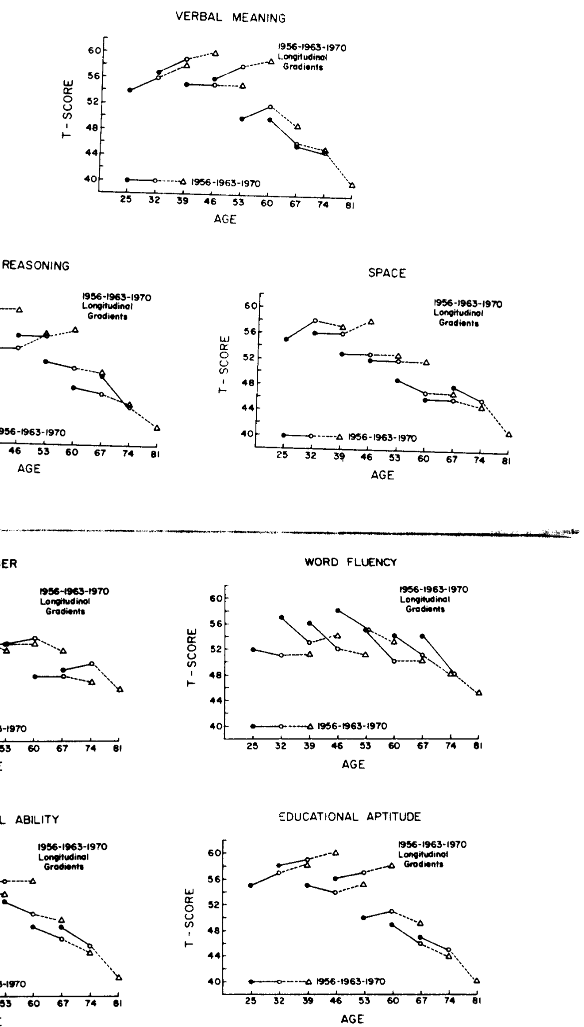


Figure 4.3. Mean scores by cohort for the 14-year longitudinal study. (From: Schaie, K. W., and Labouvie-Vief, G. Generational versus ontogenetic components of change in adult cognitive behavior: A fourteen-year cross-sequential study. Developmental Psychology, 10: 305–320, 1974. Copyright 1974 by the American Psychological Association. Reprinted by permission.)

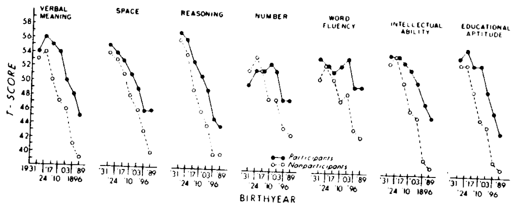


Figure 4.4. Cohort differences for retest participants and dropouts. (From: Schaie, Labouvie, and Barrett, 1973. Copyright by *Journal of Gerontology*. Reprinted by permission.)

Magnitude of age changes. As scientists, we are concerned about demonstrating the presence or absence of reliable differences or relationships. What is frequently ignored, however, is the question of whether or not such differences are substantial enough to warrant our advice to those who wish to implement public policy or other practical matters on the basis of our findings. In this section we will examine specific estimates of age changes within cohorts over 7-year intervals from 25 to 81 years and similar estimates of cohort differences for cohorts with average birth years from 1889 to 1938 (see also Schaie and Parham, 1977).

The issue of practical consequence was addressed more directly by summing cumulative age changes as proportions of performance level for the samples tested at age 25. This was done by adding successive within-cohort changes averaged across the two 7-year intervals for which data were available. In the case of the repeated measurement data, this would tend to yield rather conservative estimates favoring decrement finding because of the expected tendency of a panel consisting of favorably selected members (because of nonrandom attrition) to regress toward the sample mean (see Baltes, Nesselroade, and Labouvie, 1972).

A convenient and reasonable approach to appraising the practical significance of cumulative age changes and/or cohort differences is to take recourse in the traditional assumption that 1 Probable Error (PE) about the mean defines the middle 59% (average) range of performance on mental abilities, assuming normal distribution within the population (Matarazzo, 1972, pp. 124–126). Using this criterion, cumulative decrement in performance could be judged to be of practical importance in that instance where such cumulative loss reduces the performance of the older sample to a level more than 1 PE below the mean (i.e., drop to the lower quartile) of the young adult base.

Table 4.2 charts performance in 7-year intervals for ages 32 to 81 as a proportion of performance at age 25. Note that in the first study, based on panel members who remain after some of the less favorably endowed individuals have dropped out, within-cohort level of performance was found to be below the mid-range of 25-year-olds at age 67 for Word Fluency and at age 81 for Inductive Reasoning and the Index of Intellectual Aptitude, with no drop below this point for the remaining variables. By contrast, when projecting from the inde-

Table 4.2. Index of Age Change Rounded to Integers.*

		AGE (YEARS)								
VARIABLE		32	39	46	53	60	67	74	81	−1 PE AT AGE 25
Verbal meaning	R	107	112	116	119	120	117	110	103	84
	I	102	102	100	95	95	89	80	74	83
Spatial visualization	R	113	114	117	118	117	110	97	77	71
	I	98	90	89	82	81	68	58	55	71
Inductive reasoning	R	94	97	97	95	96	91	82	74	80
	I	97	90	84	76	72	64	58	53	79
Number	R	110	114	115	116	120	116	103	89	71
	I	116	119	121	115	115	106	98	85	74
Word fluency	R	100	96	95	89	86	74	63	52	83
	I	96	89	85	77	74	60	50	46	82
Intellectual ability	R	107	106	110	109	109	103	93	81	84
	I	103	99	97	90	88	79	70	63	84
Educational aptitude	R	107	112	116	117	118	115	108	101	85
	I	101	100	97	92	91	84	76	70	83

NOTE: Base: age 25 = 100; R = repeated measurement panel; I = independent sample.
* From: Schaie, K. W., and Parham, I. A. Cohort-sequential analysis of adult intellectual development (extended version of Schaie and Parham, 1977), NAPS No. 03170.

pendent samples, which are, of course, more representative of the population at large, performance has already dropped below the 25-year average range at age 53 for Inductive Reasoning and Word Fluency, at age 67 for Space and the Index of Intellectual Ability, and at age 74 for Verbal Meaning and the Index of Educational Aptitude.

Health and Environmental Factors

Thus far, we have demonstrated that age decrement is not as great or uniform as popular stereotypes would have us believe and that generational (cohort) differences must be taken seriously. But what is the nature of these cohort differences? One can identify a variety of intrinsic and extrinsic variables by which generations, however defined, do differ. Thus far, we have seriously looked at some gross demographic indicators, have conducted an analysis of cumulative health trauma and have engaged in the study of interpersonal environments.

Demographic factors. These issues were first addressed after the initial cross-sectional study when we became aware of the fact that there were significant cohort differences on such obvious demographic variables as income, education and occupational status. Analysis of covariance was used to partial out the effects of these demographic variables on the mental ability scores (Schaie, 1959). As could be expected, age-difference effects were reduced but not eliminated. The fact we are dealing with, of course, is that the demographic variables are differentially distributed across cohorts; that is, the level of education or income in one cohort does not have the identical meaning of that found in another.

Health history factors. More recently, we have investigated the effect of cumulative health trauma on change in intellectual functions. 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). Although the ICDA contains over 8000 classifications, only about 820 were actually encountered. Collapsing overlapping categories permitted further reduction to 448 classifications, which were then Q-sorted by 12 physicians (six internal medicine and six psychiatry residents) on an 11-point scale ranging from benign to extremely severe, in terms of the impact of each disease entity upon the future health and well-being of the patient (Parham, Gribbin, Hertzog, and Schaie, 1975). To our initial surprise, we found only minor relations between cumulative health trauma and mental abilities. These low-level effects occurred for Verbal Meaning and Word Fluency, but only when severity-weighted disease episodes were considered. It is of interest to note that at least some variance in verbal behavior decrement can be accounted for on the basis of physical disease.

Further investigations were pursued on individuals with known cardiovascular disease. Several interesting findings occurred as we engaged in the detailed analysis of 155 panel members who had been followed over a 14-year period. At first glance cardiovascular disease results in lowered function on all variables monitored. However, when we control for cohort (age), the effect is no longer significant for either Space or Word Fluency; and when socioeconomic status is taken into consideration, the effect is found only for Number and the composite Index of Intellectual Ability. What this means is that cardiovascular disease is more prevalent in members of older cohorts and those of lower socioeconomic status, who also perform lower on the Primary Mental Abilities Test. While cardiovascular disease, therefore, does indeed contribute to cognitive decline, the variance accounted for is not large, and there are likely to be indirect rather than specific causal effects. For example, cardiovascular disease may lead to changes in life-style which more directly affect cognitive function (Hertzog, Schaie, and Gribbin, 1978). It is conceivable also 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' microenvironment. A Life-Complexity Inventory (LCI) was used to interview 140 individuals who had been followed for 14 years. Initial analysis of the LCI yielded eight item clusters representing: 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.

Correlations were computed between LCI cluster scores and the level of intellectual performance at each of our three data points. Positive correlations were found between all ability variables and the social status cluster, and similarly negative correlations occurred throughout 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 with Space; dissatisfaction with life status related negatively to the Intellectual Ability Index and Number; and noisy environment correlated positively with Word Fluency (Gribbin, Schaie, and Parham, 1975). An additional analysis showed that high disengagement and family-dissolution cluster scores were associated with cognitive decrement over a 14-year period (Schaie and Gribbin, 1975b).

CONCLUDING COMMENTS

In the final section of this chapter I would like to summarize my evaluation of the present status of the question of intellectual decline with age and alert the reader to the fact that we have thus far studied intellectual changes in old age with instruments designed for the young.

The Current Status of the Question of Intellectual Decline with Age

When all the evidence presented in this chapter is weighed and due consideration is given to recent reanalyses of some of these data by others (Botwinick, 1977; Horn and Donaldson, 1976), it is hoped that the reader will come to agree with certain conclusions I will now attempt to summarize. First, it is clear that reliable decrement until very old age (and by that I mean late eighties) cannot be found for all abilities or for all individuals. Second, it is equally clear that for most individuals there is decrement on those abilities which require

speed of response, and for those abilities whose measurement is particularly sensitive to relatively modest impairment of the peripheral nervous system. Third, decrement is also likely to be found on most abilities for individuals with severe cardiovascular disease at any age, and for individuals living in relatively undifferentiated or socially deprived environments beginning with the late fifties and early sixties.

Fourth, data from independent random samples (including cross-sectional studies) will tend to overestimate "normal" age decrements for those variables where ontogenetic changes indeed occur, because sampling procedures will tend to include individuals performing at lower levels not because of age, but because of ability-related disease and/or life-style variables. Data from longitudinal and repeated-measurement sequential studies will accurately estimate age changes for individuals living under relatively favorable environmental conditions and in above-average health, but will overestimate performance maintenance for those living under less favorable conditions and in less than average health.

Fifth, I maintain the position that variance for ontogenetic change for most abilities is small relative to that demonstrated for cohort differences. It should be emphasized, however, that while cohort differences account for most cross-sectional age-difference variance into 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.

Finally, I would like to state once again that in healthy, well-educated populations ontogenetic change on intellectual-ability variables is proportionally small, such that many individuals perform with the middle range of young adults. Generational differences in such samples also are not as pronounced as in the general population, but they do persist. And due note should be taken of the tremendous range of individual differences. Some adults show decrement on some abilities quite early in life, but others maintain their function into old age.

On Studying Intelligence in the Old with Tests Developed for the Young

A major issue we have not thus far addressed (Schaie, 1978) is the question of ecological validity. 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 Test (Schaie, 1979a), 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 then is to be done? First, we must learn more about situations in which adults are required to display competence, and this requires a taxonomy of adult situations (Scheidt and Schaie, 1978). Next, we must construct new measures of intelligence, based upon what we now know of the structure of intellect, but which do not require that novelty be the impetus for the subject's adaptive response. Instead, the tasks to be used must be meaningful and embedded in the life experience of the adult, and moreover attuned to the need for cohort as well as age relevance (Schaie, 1978). Third, we must examine the mediating role of motivational variables and especially the effect of caution and risk taking in response to cognitive tasks (Birkhill and Schaie, 1975). And finally, we must investigate the potential generalizability of our new tasks across classes of situations and types of individuals, if we are to attain a technology which is to be scientifically valid and suitable for application to real life problems. All that has been said in this chapter, therefore, is at best a prologue and a statement reflecting the state of the art. Work in progress at some of the major gerontological centers may well change our conclusions, and much exciting work lies ahead.

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