Handbook *of* Mental Health *and* Aging

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Intelligence and Problem Solving

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Some of the major characteristics of the well-adapted person, considered to be in optimal mental health during the prime of life, relate to the concepts of intellectual competence and the ability to solve complex problems. Indeed, failure to perform within the average range of measured behaviors deduced from these concepts at least implicitly raises questions as to the presence of psychopathology. The popular stereotype, however, suggests that with advancing age, decline in intellectual abilities and problem-solving capabilities is a commonly observed phenomenon, even if not universal or inevitable. This stereotype is supported by a substantial research literature most recently reviewed by Botwinick (1977) and Rabbitt (1977). The mental health professional, in attempting diagnostic assessment of the elderly, is therefore in the position not only to identify apparent deficit of function by comparison to appropriate normative data, but also to specify what proportion of behavioral deficit must be attributed to the "normal" ravages of time and tide, and what proportion should be attributed to psychopathology, which may or may not be age-related.

It is frequently forgotten that older individuals are prone to all the physical and psychological trauma which might face younger individuals, in addition to those more specific problems which are concomitant with the increasing fragility and role restrictions occurring with advanced age. In addition we must note that the older client has an experiential history which is much longer than for other life-stage groups, often extending beyond the personal experience of the professional serving that client. As a consequence, it becomes important to differentiate ontogenetic changes occurring within the individual (whether related to normal aging or individual pathology) from obsolescence

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phenomena which reflect the individual's inability to keep pace with the rapid sociocultural and technological changes of the past half century (cf. Schaie, 1977b). The former must, of course, be noted for their limitations upon the client's effective behavior, the latter call for appropriate programs of remediation.

In this chapter I will try to sort out the myths and realities about intellectual decline and decreasing problem-solving abilities with aging. I will also attempt to show how a reasonable view of the current state of the art affects assessment and diagnostic practice for mental health professionals working with the elderly. To do so, it will first be necessary to characterize certain methodological issues related to the internal and external validity of the data base to be reviewed (cf. Baltes, Reese, and Nesselroade, 1977; Schaie, 1977b, 1978b). Next, the evidence on intellectual decline will be reviewed for the period from middle age to early old age, where there seems to be little evidence of serious decline in most, and for the period of advanced old age when decremental change becomes all too real. Before taking such changes too seriously, I will examine the issue of the practical significance (in contrast to statistical reliability) of observed age decrement, and contrast such decrement with the much more serious problem of the intellectual obsolescence of the elderly. A similar analysis will be made for problem-solving ability, with an immediate extension to the question of how problem-solving ability seems to apply to the everyday problems of the elderly, and to the necessary concerns of mental health personnel with the attributes of specific criterion situations within which intelligent behavior is thought or desired to occur.

METHODOLOGICAL ISSUES

I will not bore the reader here with a detailed account of the various design problems which bedevil the research literature on the psychology of aging. Nevertheless, attention needs to be called to a number of matters essential to understanding why certain research findings must be heeded with respect while others can be dismissed as interesting but trivial. More detailed accounts of such matters which are relevant to this chapter may be found in chapters by Birren and Renner (1977), Botwinick (1977), and Schaie (1973, 1977a).

Campbell and Stanley (1966) have distinguished for us two major types of design problems. The first is concerned with the internal validity of studies, that is, whether or not there are equally plausible explanations for the utcomes of experiments which have not been properly controlled for. In our case, for the study of intellectual processes and problem-solving behavior in old age, such alternatives are presented in particular by the noncomparability of young and old with respect to formal education and many socioeconomic variables, but also because of the differential effects of assessment practices in modifying the behavior to be assessed, and the tricky matter of nonrandom attrition in panel studies used to describe normal age functions.

The second type of problem, called external validity, deals with the question of generalizability of findings from specific samples to other population groups. For the mental health practitioner, such issues revolve often about the applicability of sample-specific norms to individual clients having different population characteristics, the generalizability of findings across different behavioral settings, conditions under which assessment occurs, and the appropriateness of the task used to measure the constructs of interest to the clinician (Schaie, 1978b).

INTERNAL VALIDITY ISSUES

Descriptive and normative studies of age changes or differences in cognitive processes are special cases of the traditional pretest-posttest paradigm, where the "treatment" is assumed to be the aging of the individual. In such studies Campbell and Stanley (1966) suggest the possibility of eight different threats to internal validity. These are the effects of history, maturation, testing, instrumentation, statistical regression, mortality, selection, and the selection-maturation interaction.

History. Longitudinal findings of age changes may be suspect because environmental events occurring between successive longitudinal measurements may either mask true age changes, if such intervenors are favorable, or create the impression of age changes where there are none if the intervention is unfavorable. Because of the potency of changing environmental circumstances upon performance on cognitive tasks, we have therefore questioned whether data from unreplicated, single-cohort, longitudinal studies can be accepted as meaningful evidence for behavioral age functions (cf. Baltes *et al.*, 1977; Schaie, 1972).

Maturation. This variable is no threat to aging studies per se. However, we need to worry about cross-sectional studies in which the effects of aging are unwittingly controlled by equating groups for such variables as response speed, educational attainment, or other variables where there is a strong relationship between the covariate and chronological age. It might be mentioned in this context also, that since maturational effects are to be expected in an aging study, the proper hypothesis to be tested quite often is not the null, but rather an alternative hypothesis specifying a given magnitude of the expected age difference.

Testing. In longitudinal studies, experience gained on the first test occasion may result in gain or compensate for maturational decrement due to practice effects. Although this effect is particularly serious over short time periods, it may also impair the validity of results from intermediate-range longitudinal studies (cf. Schaie and Parham, 1974). In addition, however, experience gained in testing, relatively new for many older individuals, may well generalize to performance on other cognitive tasks. Examples of these kinds of testing transfer effects have been found in a number of recent cognitive training studies (e.g., Labouvie-Vief and Gonda, 1976; Plemons, Willis, and Baltes, 1978).

Instrumentation. In both cross-sectional and longitudinal studies, the assumption is made that the measurement instrument or process is identical for all age groups or all occasions. Such equivalence may not often be possible over wide age ranges because of simple logistic reasons as well as differences in response sets and the differential efficiency of peripheral sensory and motor systems at different ages. Less obvious, when whole test batteries are given, are the possible shifts in the latent constructs (factors) estimated by the same observable operations at different ages. Similar concerns are, of course, equally applicable in cross-sex comparisons (e.g. Cohen, Schaie, and Gribbin, 1977).

Statistical Regression. Unless our test instruments have nearly perfect reliability, it is probable that high scorers at the first test will show lower scores upon the subsequent test with the opposite true for low scorers. Such regression effects, depending upon the range of talent sampled, as well as whether individuals were examined under optimal or marginal conditions, may either enhance or mask true maturational change (cf. Baltes, Nesselroade, Schaie, and Labouvie, 1972; Furby, 1973).

Mortality. Longitudinal panel studies must contend with the problem of dropouts. In aging studies experimental mortality includes death, disappearance, and failure to cooperate for the second and subsequent test (cf. Baltes, Schaie, and Nardi, 1971; Riegel, Riegel, and Meyer, 1967; Schaie, Labouvie, and Barrett, 1973). Fortunately, attrition effects seem to be most pronounced after the first test, and fairly random with respect to the dependent variables thereafter, but the relationship of the residual sample to the structural characteristics of the parent population is always problematic (Gribbin and Schaie, 1978). Differential mortality, of course, is a problem also for cross-sectional and independent random-sample sequential studies because cohorts sampled at older ages, by definition, must have a proportionately greater number of long-lived members.

Selection. Most normative studies of aging are based on volunteer samples. In addition to the general problems in obtaining comparable samples of volunteers (Rosenthal and Rosnow, 1975), there is evidence of differential recruitment rates by age (Schaie, 1959). On the other hand, there do not seem to be any sampling effects by age upon cognitive variables, whether or not monetary incentives have been used in participant recruitment (Gribbin and Schaie, 1976).

Selection-Maturation Interaction. Although one would not consciously control for maturation in aging studies, there is again the possibility that differential selection at particular ages might have the effects of masking or enhancing maturational effects. Indeed much of the controversy in the literature to be discussed in this chapter hinges upon the fact that normal aging effects can or cannot be demonstrated, depending upon the conditions under which study samples were selected.

External Validity Issues

The observations upon which the results of any particular study must be based always represent a unique combination of a person, a treatment variable, the setting, the measurement variables, and the specific point in time when the observations were taken. When normative data are to be applied to individuals other than those included in the normative study, each of the variables listed above poses obstacles, and limits valid interpretations (cf. Baltes *et al.*, 1977). We will briefly identify the implications of each of these threats to the applicability of the current research literature on cognitive functioning.

Experimental Units (the person variable). Psychologists have often been accused of basing their behavioral principles upon the study of the albino rat and the college sophomore psychology major. Similarly, studies of human aging have often been based on readily available populations such as the members of senior centers, residents of nursing homes, or V.A. domiciliaries, and the like. But a more pressing issue for the study of intellectual functioning in old age is the question of the generalizability of age functions across cohorts. The question simply asks whether there can be any reasonable permanence in age norms under circumstances where there are rapid changes in population and environment characteristics. The problem is complicated by the facts of differential pathology across cohorts (Hertzog, Schaie, and Gribbin, 1978), and of differential levels and slopes of ontogenetic change for successive generations (Schaie, 1979). Explicitly, since cross-sectional studies typically used for the development of age norms (cf. Matarazzo, 1972) must compare individuals belonging to different cohorts at *one* point in time, one cannot be sure that the next cohort when it reaches the next age bracket in the table of norms will indeed perform at the the same level as did the former cohort. Longitudinal data, on the other hand, are not terribly useful for the development of age norms for adults, since the test's usefulness will likely have become seriously impaired by sociocultural obsolescence before data over long time intervals become available (cf. Gribbin and Schaie, 1977). What is needed then is information from either short-term longitudinal or replicated cross-sectional studies over many adult age intervals. Once cohort trends are known, it is then possible to provide estimates of how normative data are likely to change in the proximal future because of changes in level and slope across successive cohorts (for an example of such data see the *Manual for the Test of Behavioral Rigidity* [Schaie and Parham, 1975]).

Experimental Settings. In contrast to studies with children where the prediction of educational attainment may be the most important goal for the use of intelligence tests, we find that for adults there are always multiple criteria for the expression of behavioral competence. We would expect therefore that the validity of intelligence measures will be limited by the behavioral setting towards which one wishes to predict. Although it might be argued that such criterion settings are as many as there are opportunities for the expression of competent behaviors, nature is fortunately more parsimonious. Scheidt and Schaie (1978), in an analysis of over 300 different situations generated by elderly individuals, were able to identify four bipolar dimensions along which situations could be classified. These dimensions order situations as to whether they are common or uncommon, supportive or depriving, involve solitary or social activities, and whether they require an active or passive role by the individual. A total of sixteen classes were thus found sufficient to index situations in which older individuals engage in intelligent, problem-solving behavior.

Treatment Variables. Formal intelligence tests or structured laboratory paradigms used to measure problem-solving capability in themselves serve as treatments which may obscure or magnify developmental changes in performance. Several recent studies suggest that intelligence test performance can be affected by manipulating reinforcement schedules. For example, Hoyer, Labouvie-Vief, and Baltes (1973) showed that the speed with which older adults performed on ability tests could be increased markedly by rewarding participants with trading stamps. And Birkhill and Schaie (1975) demonstrated substantial effects on performance on the Primary Mental Abilities test in individuals in their seventies by introducing reinforcement schedules which minimized or maximized risk taking and guessing behavior.

Not to be overlooked are the incidental effects upon performance by anxiety-arousing aspects of the test situation or laboratory setting, which may interact with differential levels of autonomic nervous system integration (Eisdorfer, Nowlin, and Wilkie, 1970), or with personality traits known to be related to various learning parameters (Schaie and Goulet, 1977).

Measurement Variables. Here we are concerned with the fact that measures which may be most appropriate for the assessment of a particular construct in the young (e.g., visuo-spatial behavior) may become nothing more than a measure of test-taking behavior in the old (cf. Marquette, 1976). In addition we know that the old tasks must be meaningful to elicit their best performance (Schaie, 1977/78; Sinnott, 1975). The latter issue is certainly not a new one. Some twenty years ago, Demming and Pressey (1957) pioneered a number of interesting procedures which they selected in terms of their relevance to the life experience of older individuals. However, if different measures are to be valid for comparision of individuals across age, they must not only be relevant to the population to which they are applied, but they must also be relevant to a structure or intellect model which can at least in theory extend across ontogeny. This is an approach which has best been demonstrated in the area of personality development by the successive series of questionnaires assessing the same latent factors by instruments suitable at appropriate age levels (Cattell and Kline, 1977). In the area of intellectual ability, similar work has been done only for single factor models (e.g., Terman and Merrill, 1937), but we know that single factor models have little promise in adulthood (cf. Reinert, 1970, regarding differentiation-de-differentiation of intellectual structures). However, work in this author's laboratory is progressing to develop alternate test forms for the Primary Mental Abilities which are specifically designed to deal with the requirements of older adults while maintaining relevance to established frameworks of ability measurement. An early report on these studies was presented by I.K. Krauss and K. W. Schaie at the 1976 meeting of the American Psychological Association in Washington, D.C..

Time of Measurement. What has been well described as a period effect in sociology (Riley, Johnson, and Foner, 1972) seems equally important in the measurement of intellectual abilities. Any single behavioral observation is, of course, simply a reflection of the person-environment interaction prevalent at a particular historic point in time. From a dialectic point of view (cf. Riegel, 1976), individuals shape the influences that affect the expression of intelligent behavior, and such environmental influences in turn affect all or most individuals present in the environment. This effect is different from the cohort succession referred to above, in that it affects equally all individuals exposed to the particular influences occurring during a given period. In intelligence measurement, this variable is particularly important with respect to the obsolescence of tests, and to the introduction of environment support systems which will compensate for developmental changes which in the past would have been described as deficit phenomena.

DOES INTELLIGENCE DECLINE IN OLD AGE?

The reader has now been prepared to understand why it is necessary in the following section to interpret the research literature most cautiously, to reinterpret the conclusions drawn by some, and to ignore the work of others outright, either because it is based on inadmissible data bases or because the data are not really relevant to the questions to be asked. We will now carefully examine the evidence, first for the limited changes which occur in midlife and then for the more important ones occurring in old age. In both instances we will distinguish between age changes within individuals and generational (cohort) differences. We will then try to come to some conclusions regarding the practical significance of statistically reliable findings with particular emphasis upon what such changes might mean to the mental health professional.

Some Prefatory Comments

In his chapter in the *Handbook of the Psychology of Aging,* Botwinick (1977) alerts us that the controversy regarding the facts of intellectual decline with age depend upon inconsistencies in five areas: (1) what part of the age spectrum are we looking at; (2) what kind of tests do we use; (3) how do we define intelligence; (4) what are the sampling techniques; and (5) what are the pitfalls of the specific research designs used? The last two topics have already been addressed in the methodologic introduction to this chapter, but the remaining three items deserve some attention.

The Age Period of Interest. 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 former 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 latter, on the other hand, would perhaps wish to start with individuals in their fifties and continue to that age level where any assessable subjects can still be found. Botwinick (1977) suggests therefore that researchers 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 it is possible to demonstrate decline for some variables for some individuals, for indeed it is. What we need to recognize instead is that there may also 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). Unfortunately it is most difficult to obtain data on normative aging beyond the late sixties, since most available samples will not be comparable in terms of education, health status, and other demographic variables to younger populations. Separate studies with measures validated for the old are therefore needed to build appropriate normative bases (cf. Schaie, 1978b), 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" data with a due amount of suspicion.

Types of Tests Used. The answer to our question whether or not decline occurs will differ markedly depending upon the tasks employed. There is no question that speed of response declines with age on almost any performance measure (Welford, 1977), and some authors argue that speed is an important component of intellectual performance (e.g., Botwinick and Storandt, 1974). But there is a serious question whether speeded tests can be justified in the assessment of adult intelligence, unless speed of response is an essential component of the criterion situation to be predicted (cf. Green, 1969; Schaie and Parr, 1979b). Normative data from cross-sectional studies are affected by different generational change patterns for those variables which involve knowledge acquisition and utilization (crystallized intelligence) and for those which involve the study of relationships (fluid intelligence). Complex tests such as the Wechsler Adult Intelligence Scale (WAIS), moreover, may measure different constructs at different ages (Reinert, 1970).

Particular caution should be exercised in interpreting linear composites of various subtest scores, and in particular the so-called global IQ scores obtained from tests developed for children or young adults. For all of its advantages over a mental-age measure, Wechsler's deviation IQ still has the property of being a composite of apples and oranges. As such it may have some meaning within a single reference group, but it is of no use whatsoever in comparing individuals across age groups or for monitoring changes within individuals. Currently available IQ measures most certainly do not even come close to matching the requirements for any meaningful assessment of functional age (see Schaie and Parr, 1979a, for a detailed discussion of the latter concept).

Definitions of Intelligence. What is it that we seek to measure? We surely have overcome the illusion that we can ever assess what may be the biologic limits of adaptive intelligent behavior, or intellectual capacity. What we do measure is the individual's ability to perform on a set of tasks which are our operational definition of the expression of intellectual ability. Nevertheless, we must still make one further distinction and that is between intellectual ability and competence. Connolly and Bruner (1973) define competence as that aspect of intelligence which involves "*knowing how* rather than simply *knowing that* (authors' italics)." What we often wish to predict is this competence which refers to specific behaviors in specific situations, but what we measure, of course, are laboratory tasks of intellectual ability which are hopefully generalizable across situations, although some specific permutation of abilities might best predict competence in a given situation. As indicated above it is these building blocks of intelligence, the profile of abilities which would best be able to characterize the performance of a given individual (cf. Schaie and Schaie, 1977a), rather than a measure of general intelligence which would be indicative of very little and predictive of less.

In contrast to Botwinick (1977), we hold that ability tests which are useful measures must refer directly to a given construct and not to the manner in which the construct is measured in confound. Thus it becomes quite critical to know and to apply appropriate adjustments in clinical situations for the fact that educational level accounts for a greater proportion of variance in major measures of intelligence than does age (Birren and Morrison, 1961; Granick and Friedman, 1973; Green, 1969). And other ability-extraneous variables, such as test fatigue (Furry and Baltes, 1973), are not implicit either in intellectual performance on a particular construct. They are implicated only in the particular way in which a particular construct is measured. That is, test fatigue is an implicit part of test performance only if the criterion variable is affected by fatigue as well.

MIDLIFE CHANGES

I will follow Botwinick's (1977) lead and ignore the earlier cross-sectional studies (for reviews see Botwinick, 1967; Jones, 1959). My analyses will deal primarily with cross-sectional work conducted as part of the WAIS standardization studies (Doppelt and Wallace, 1955) and my earlier cross-sectional studies with the Primary Mental Abilities test (PMA) (Schaie, 1958), and I will then try to clarify the results by further reference to my longitudinal-sequential work with the PMA (Schaie, 1970; 1979).

Let us first examine the work with the commonly used Wechsler tests, a battery comprising 11 measures, six of which involve primarily verbal behaviors and are called a Verbal Scale, and five of which involve some manipulative performance of a primarily nonverbal nature and are summed to arrive at a Performance Scale. Although the

Wechsler tests first appeared in 1939, normative data for individuals beyond age 60 were not published until 1955. Figure 12-1 illustrates several points. First, it may be noted that the Verbal Scale shows less of an age trend than does the Performance Scale. The full scale score, being a sum of the two components, is a rather meaningless average and should best be ignored. 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. A more analytic picture is presented by Table 12-1 (adapted from Matarazzo, 1972, p. 354) which 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 midlife period.

The Wechsler subtests themselves are factorially complex. An even 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

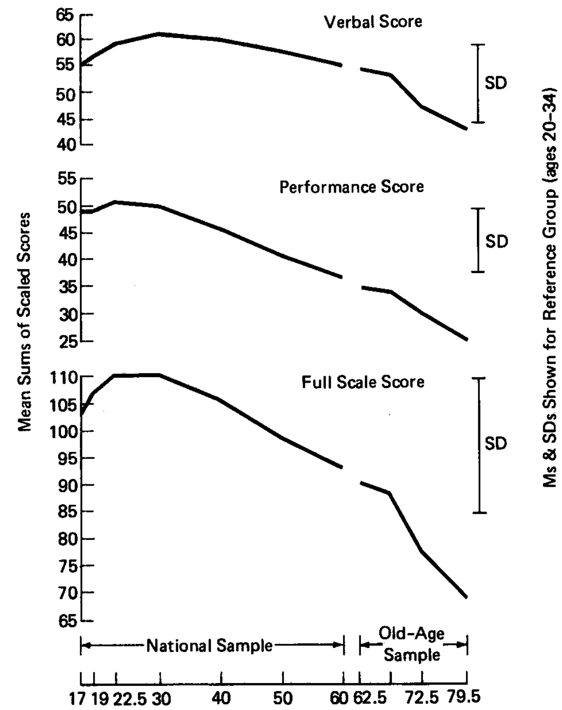

Figure 12-1 Verbal, Performance and Full Scale scores as a function of age. (From: Doppelt and Wallace, 1955. Copyright © 1955 by the American Psychological Association. Reproduced by permission).

Table 12-1 Mean Scores by Age for Subtest Performance on the WAIS During Middle Adulthood (Each mean is based on N = 200)

	Age Range				
Subtest	*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

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the age range from early adulthood to early old age (Schaie, 1958) are shown in Figure 12-2. These data 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 health-care plan. This sample also provides the base for the sequential studies to be presented later on. Five abilities were systematically sampled. These were *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 12-2 once again shows only insubstantial age differences until about age 50 for Space, Reasoning, and Verbal Meaning and until about age 60 for Number and Word Fluency. For the latter abilities, even at age 70 the drop from peak does not exceed one standard deviation. Note also that peaks are obtained for most abilities in the 31- to 35-year-old group.

As was pointed out earlier, the basic flaw of cross-sectional studies is the fact that they confound age changes with generational differences. It behooves us therefore to look at age trends determined from samples of individuals who have been followed over time, duly minding the fact that such attrited samples are likely to yield findings characteristic for the more stable and environmentally favored segments of the total population.

Of relevance here are a number of intermediate-range longitudinal studies. Bayley and Oden (1955) followed children who had been included in Terman's study of gifted children (Terman and Oden, 1947), over the age range from 29 to 41 and showed increment in performance. Similar findings have been reported by Kangas and Bradway (1971) for both WAIS Verbal and Performance scores from ages 30 to 42. But in a study of the Army General Classification Test (AGCT) from ages 30 to 43, Tuddenham, Blumenkrantz, and Wilkin (1968) found minor decrement in one nonverbal subtest. Over an even longer period of time, Owens (1953; 1966) reported follow-up findings on the Army Alpha Test given in 1919 to 363 Iowa State College students at age 19. Owens was able to retest 127 of these students at age 49 and of the latter 96 at age 61. Most of the Army Alpha subtests are speeded tests of a largely verbal nature. At age 49 all but one arithmetic problem test showed significant increments, and by 61 there were few further changes suggesting a plateau, with some further increment for the verbal and minor decrement for the numerical components of the battery. Cunningham and Birren (1976) followed a group of 143 USC alumni first tested at age 20 and retested

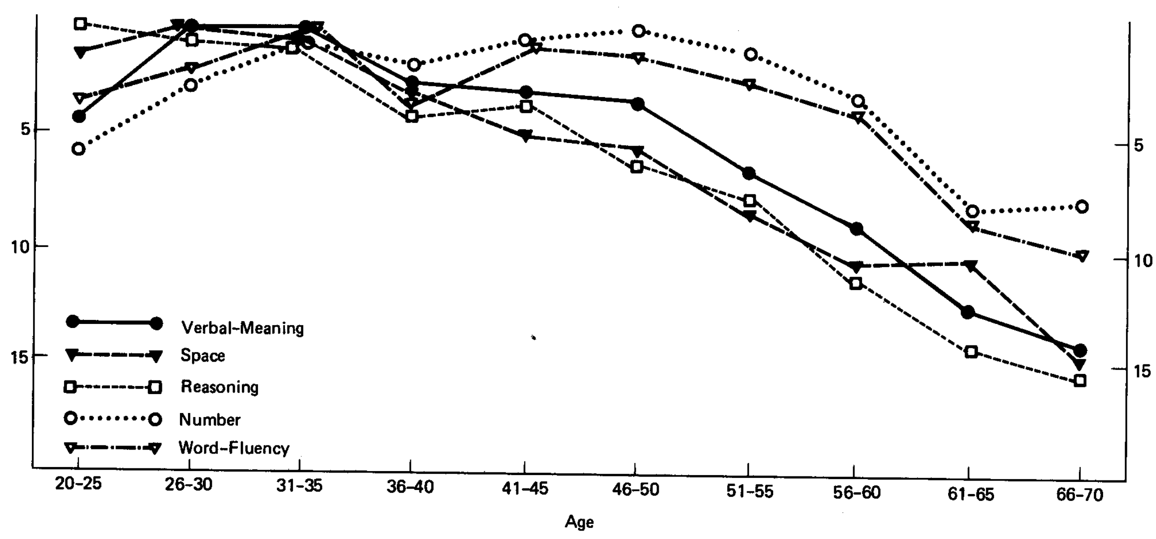

Figure 12-2 Cross-sectional performance differences on the Primary Mental Abilities Test from young adulthood to early old age. (From Schaie, 1958. Copyright © 1958 by the American Psychological Association. Reproduced by permission).

at age 47. In this study there was gain for the Verbal factor, stability for the Number factor and decrement for the Relations factor. In addition, cohort effects were detected for the variables influenced by educational experience, and a period effect for the Relations factor.

The apparent discrepancies between some of these studies, notably, the cross-sectional and longitudinal findings, can be addressed directly when sequential studies following several cohorts over the same age range are employed. An example of such data is given in Figure 12-3 for the Space subtest of the Primary Mental Abilities test (Thurstone and Thurstone, 1949). This figure combines results from three stages of our longitudinal-sequential studies of adult intelligence (Schaie, 1979; Schaie and Labouvie-Vief, 1974). The upper left quadrant of Figure 12-3 provides data on 301 individuals first tested in 1956 and retested in 1963; the lower left quadrant has similar data for 409 individuals first tested in 1963 and retested in 1970. In both instances the cross-sectional data (solid lines) show linear decrement from young adulthood on, but the seven-year longitudinal data (dotted lines) show substantial change in both studies only beyond age 67. The right side of Figure 12-3 shows data for 161 subjects tested in 1956, 1963, and 1970. The upper right quadrant pictures the cross-sectional comparisons at those three points in time while the lower quadrant gives the 14-year longitudinal data for the seven cohorts sampled in this study. Note that for comparable ages there is an upward trend for successive cohorts, but that changes within cohort are quite trivial until the age interval from 74 to 81 years.

Further detailed analyses to which we shall return in the next section make it clear that the normal midlife pattern is stability or increment until the sixties for measures where speed is not substantially implicated, with a possibly slight drop in the sixties for measures involving the induction

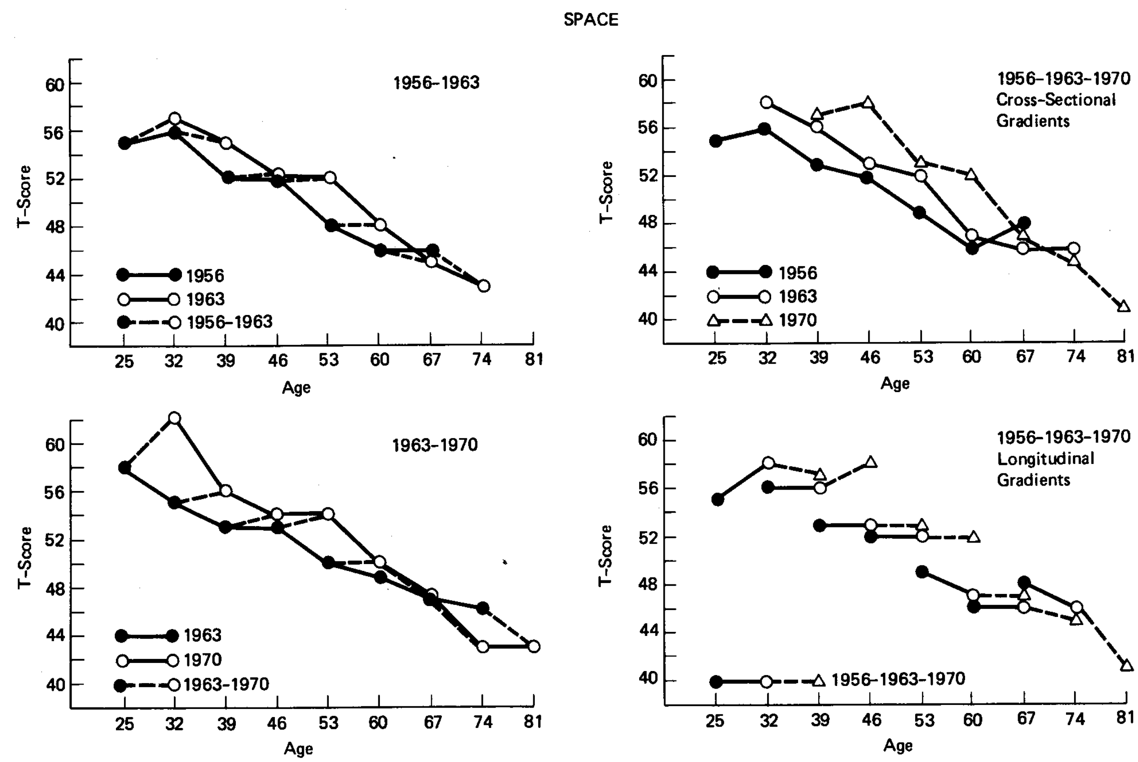

Figure 12-3 Cross-sectional age differences and seven- and fourteen-year longitudinal age changes from ages 25 to 81 on the Primary Mental Abilities Space test. (From: Schaie and Labouvie-Vief, 1974. Copyright © 1974 by the American Psychological Association. Reproduced by permission).

of relationships and a modest drop in the fifties for measures which are highly speeded.

CHANGES IN OLD AGE

When we turn to intellectual change beyond the sixties we begin to see evidence of apparent decline. Again we must alert the reader to the fact that many measures used in past research may well be inappropriate and invalid for the comparisons made. And more important, attention must be given to the practical significance of what may be statistically reliable decrements. In this section we will briefly review the pertinent empirical literature and then return to the question of the practical significance of the decremental findings which have been reported.

Wechsler Adult Intelligence Scales. Norms for the WAIS for ages 65 and older were reported by Doppelt and Wallace (1955). These norms do show a significant drop, even for the verbal scales, past the age of 70. Substantial drop is most noteworthy again for the performance (speed-implicated) measures. The discrepancy between verbal and performance measures seems well replicated and has been found across the sexes, racial groups, and different socioeconomic levels (Eisdorfer, Busse, and Cohen, 1959). Greater than average drop in performance IQ has been implicated as a predictor of survival (Hall, Savage, Bolton, Pidwell, and Blessed, 1972). In another study Harwood and Naylor (1971) matched a group of subjects in their sixties and seventies with young adult control groups 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 Object Assembly was also lower than for the young adult controls. But for some of the 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 has recently been challenged by Botwinick and Storandt (1974) who gave the WAIS Vocabulary test to individuals ranging in age from 62 to 83 years matched on quantitative scores on 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 meaning nuances.

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 2.6 for the Verbal Scales. From the seventies to the eighties there was a loss of 7.3 score points, equally divided between Verbal and Performance Scales. Similar decline from the mid-sixties into the eighties was reported in a 20-year study by Blum, Fosshage, 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).

Primary Mental Abilities. Major data here come from our longitudinal-sequential studies begun in 1956, which involve the study of persons from the twenties to the eighties arranged in 7-year age groups over 7-year intervals. Although 21-year follow-up data have now been collected, data thus far have been reported on replicated 7-year and 14-year intervals (Schaie, 1978a, 1979). Data have been reported for groups in which the same individuals were measured repeatedly (Schaie and Labouvie-Vief, 1974) as well as for the comparison of random samples of individuals from the same birth cohorts sampled over successive 7-year periods (Schaie, Labouvie, and Buech, 1973).

These data have been critically analyzed by Botwinick (1977), who argues that our findings show that cross-sectional and longitudinal data differ quantitatively but not qualitatively, but that decrement occurs for most abilities at an advanced age. He also argues that the repeated measurement data must be taken with particular caution because successive measurement points involve ever more favorably selected subjects, leading in some instances (cf. Botwinick, 1977, Figure 3) to age difference reversals. Botwinick also argues that the observed cross-sectional differences may be larger than the longitudinal differences simply because we have followed the same subjects longitudinally for only 14 years while our cross-sectional comparisons extend over more than 40 years (also see Botwinick and Arenberg, 1976).

While some of Botwinick's points are well taken, exceptions must be raised to others. Contrary to Botwinick's assumptions, selective dropout appears to effect *level* of performance primarily rather than slope of change (cf. Schaie, Labouvie, and Barrett, 1973). And our data on changes within panels involve the same individuals at all comparison points (albeit, of course, the group of persons surviving to the last comparison points). As to the disparity in time span for cross-sectional and longitudinal data, we have addressed this issue in a recent reanalysis utilizing the cohort-sequential approach, in which we have compared two successive 7-year cohorts over each 7-year age range from 25 to 81 (Schaie and Parham, 1977). Table 12-2 identifies the ages (for both panel and independent sample data) where reliable 7-year age decrements are first detected. Note that for the panel data reliable decrement is first found for Word Fluency (the most highly speeded task) at 53; for Space, Reasoning and Number at 74; and for Verbal Meaning no reliable decrement occurs even between the ages of 74 and 81. Earlier decrement occurs for the random samples comparison. Here Word Fluency shows early decrement at 39, but once again for the other variables decrement onset is late and for one variable (Reasoning) no reliable decrement is detected at any age in the study.

What about the discrepancy between the panel and random sampling data? The first involves, of course, a more highly selected panel with better health and education, but the data obtained from the panel are probably quite characteristic of middle-class and above individuals. The random sample data on the other hand might provide us with more useful guidance for a less well educated, average lower-middle-class population.

Adult-relevant tests. Although work on such tasks is only beginning to enter the literature there is one recent study which deserves special attention. Gardner and Monge (1977) conducted a cross-sectional study of a large sample of men and women between the ages of 20 and 79 years who were given specially devised, adult-relevant tests of vocabulary and information as well as the Adult Basic Learning Examination (Karlsen, Madden, and Gardner, 1967), a test of formal educational skills. Age differences characteristic of the above-reported findings on the WAIS and PMA were reported with decrement first occurring in the sixties on the school-related tests. However, no such decrement was found on adult-relevant tests such as knowledge of transportation, facts on death and disease, and knowledge about finance. These data suggest that older individuals seem to perform better even on cross-sectional comparisons when material is presented which has some direct life relevance.

Table 12-2 Ages at Which Reliable Decrement Over a 7-year Period is First Shown

	REPEATED MEASUREMENT STUDY	INDEPENDENT RANDOM SAMPLES STUDY
Verbal Meaning	–	74
Space	74	67
Reasoning	74	–
Number	74	60
Word Fluency	53	39
Intellectual Aptitude	67	67
Educational Aptitude	74	74

From: Schaie and Parham, 1977.

Piagetian Tasks. Similar findings occur when Piagetian tasks are presented to older individuals in their classical as well as more meaningful content form. In the latter case substantially higher performance is found and age differences disappear or are substantially diminished (e.g., Sinnott, 1975). Although earlier studies have implied the possibility of regression from formal operations to lower levels of cognitive function (Papalia and Bielby, 1974; Storck, Looft, and Hooper, 1972), there is recent work to suggest that when suitable paradigms are used, such observations may be attributed to individuals never having attained the level of formal operations in the first place. In a study of 42 community-dwelling males aged 65 to 92 (Protinsky and Hughston, 1978), it was found that all subjects could conserve mass, better than three-fourths of all subjects conserved surface, and over 90 percent conserved volume. It seems then that previous attempts to apply Piaget's model to life-span development have ignored the interplay between operational structures and the individual's increasing awareness (Sinnott, 1975), a view further explicated by Schaie (1977/78).

Is Advanced Age Kinder to the More Able?

Miles and Miles, as early as 1932, suggested that age differences in intelligence increase with advancing age to the disadvantage of those less well endowed. More recently this issue was addressed by Riegel and Riegel (1972) in their study of verbal behavior. They contrasted their lowest and highest 15 percent and computed average age trends for these extremes. They concluded that the more able maintained function on tests involving relatively unfamiliar material, but that there was convergence between the two ability groups on tasks involving familiar concepts such as providing synonyms and antonyms. The former finding agrees with Raven's (1948) report of divergence between ability groups, but the latter finding goes in the opposite direction. Both of these studies are difficult to interpret because they involve cross-sectional data and therefore do not permit controlling for the effects of statistical regression.

The first objection was handled by Owens (1959) when he divided his 30-year retest group into five ability levels. He did not find any relationship between the amount of gain or loss and initial level of function. The issue of statistical regression was considered in a study by Baltes, Nesselroade, Schaie, and Labouvie (1972). Subjects ranging in age from 21 to 70 and retested after seven years were divided into three ability groups at first test. Data were analyzed for three derived factor scores: crystallized intelligence, cognitive flexibility, and visualization. For crystallized intelligence, all three groups went up, but the lowest ability group showed the greatest increment. However, for both cognitive flexibility and visualization, there was sharp increment for the low ability group, but sharp decrement for the high ability group. To test the regression model, data were rearranged by dividing subjects into three ability levels in terms of scores at the second measurement point and then computing group averages for the first test occasion. When this was done patterns remained quite similar for the crystallized intelligence score, but reversal occurred for cognitive flexibility and visualization factors; that is, in the time-reversed analysis the low ability group showed loss while the high ability group showed gain. The middle group on the other hand had very similar patterns for both analyses. These results suggest that reported differences in ability pattern-related ontogenetic change are due primarily to error of measurement and not to the graceful aging of the more able (cf. also Berkowitz and Green, 1963).

While age may not be kinder to the more able per se, there are other conditions often related to high ability level which do seem to relate to the maintenance or loss of intellectual functioning (cf. Hertzog, Schaie, and Gribbin, 1978; Schaie and Gribbin, 1975; Wilkie and Eisdorfer, 1973b). Thus, we do know that cardiovascular disease seems implicated in modest intellectual decrement, as does low socioeconomic status, and even more important, low active involvement in activities which are intellectually stimulating.

PRACTICAL SIGNIFICANCE OF AGE DECREMENT

Whatever the evidence on the statistical reliability of age changes and differences in intelligence, the mental health professional will have to apply some criteria as to the practical importance of the magnitude of change observed within a given client, or his difference from a younger criterion group. I have given this issue considerable thought and will here attempt to provide some simple guidelines and examine the consequence of such guidelines for some group data (cf. also Schaie and Parham, 1977; Schaie, 1979).

Neither absolute raw score changes nor changes on standardized measures will be of help here, because what we really want to know is the absolute amount of change on a variable of interest as a function of the performance of a specific reference group. We think that we have solved this problem by first computing cumulative age changes (within-cohort age changes averaged across two seven-year cohorts) for each seven-year interval from 25 to 81, and then expressing these cumulative changes as proportions of performance level at age 25. As stated above, regression effects tend to point changes in a downward direction when scores are fallible. Changes cumulated without regard to the reliability of difference terms will therefore result in conservative estimates favoring decrement, particularly since older cohorts will also be at disadvantage from greater interference by construct-extraneous variables affecting their test performance (Schaie, 1979).

The practical significance of the cumulative age change can then be evaluated by applying as our standard the traditional psychometric assumption that one Probable Error (P.E.) about the mean constitutes the middle 50 percent (average) range of performance, under the assumption that mental abilities are normally distributed in the population (Matarazzo, 1972). I shall now argue that a decrement in performance across age attains practical importance whenever the cumulative loss for the older sample brings the performance of that sample below the level at one P.E. below the mean (25th percentile) of the young adult reference base.

Table 12-3 provides values for an Index of Age Change (IAC) with a standard of 100 for the average performance at age 25 for mean ages 32 to 81 as well as the 25th percentile level for this index (lower bound of average range) at age 25. Estimates are provided in that table from data yielded by a favorably attrited panel measured repeatedly (R) and from independent random population samples measured only once (I). It will be noted from this table that average within-cohort performance drops below the midrange of 25-year-olds in the panel study only at 67 for Word Fluency and at 81 for Inductive Reasoning and the Index of Intellectual Aptitude. No such drop was observed for Verbal Meaning, Space, or Number. The independent random samples study by contrast showed drops below the 25-year-old midrange for Inductive Reasoning and Work Fluency at age 53, for Space and the Index of Intellectual Ability at 67, for Verbal Meaning and Educational Aptitude at 74, but again no such drop for Number.

The above data can provide some guidelines for clinicians in evaluating whether or not a particular client's performance is both below the expected normal change at the client's age, as well as whether it should be considered of practical significance in having fallen below the average range of a young normal comparison group.

Practical Significance of Intellectual Obsolescence

Comparison of cross-sectional and longitudinal data bases in sequential studies has suggested that a major proportion of observed differences in test performance between young and old must be attributed to their difference in experiential backgrounds and other population characteristics which have changed across generations. It is possible to provide some guidelines for the extent of these cohort differences pretty much in the same manner as described above for the evaluation of age changes. To do so it is necessary to estimate cumulative cohort differences as a proportion of the performance of an appropriate young adult reference cohort. Once again we suggest that an older cohort should be considered suffering from obsolescence if its average performance drops below the value which is one P.E. below the mean (25th percentile) of the reference cohort.

Table 12-4 presents data for an Index of Cohort Differences which indicates the proportion of performance of seven-year cohorts with mean birth years from 1889 to 1931, expressed as the proportion of performance for each cohort with respect to a standard cohort with mean birth year 1938. As for the age data, cohort differences are more pronounced for the random samples from the general population than for the better educated and more favorably endowed repeated measurement panel. By our criterion (25th percentile of the reference cohort), cohort obsolescence was observed in the panel data for as recent a cohort as that born in 1924 for Inductive Reasoning. Evidence of significant cohort obsolescence was found for all other variables except for Word Fluency (and Number in the panel data).

The above data may be useful in appraising the extent to which lower levels of performance found in older persons may be attributable to obsolescence (or failure to acquire certain skill levels in the first place) rather than age-related decrement. Such obsolescence is most likely that portion of behavioral variance which is amenable to intervention strategies involving both formal and informal educational processes (cf. Plemons, *et al.* 1978; Schaie and Willis, 1978).

Table 12-3 Index of Age Change (Base: Age 25 = 100) Rounded to Integers

		AGE								−1 P.E @ Age 25
		32	39	46	53	60	67	74	81	
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	108	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

From: Schaie, K. W., and Parham, I. A. Cohort-sequential analysis of adult intellectual development (extended version of Schaie & Parham, 1977). NAPS # 03170.

Table 12-4 Index of Cohort Differences (Base: Cohort 1938 = 100) Rounded to Integers

		MEAN BIRTH YEAR							
		1931	1924	1917	1910	1903	1896	1889	−1 P.E @ BASE YEAR 1938
Verbal Meaning	R	93	96	90	92	88	81	73	87
Meaning	I	100	101	94	86	78	70	70	83
Spatial	R	85	87	81	75	68	59	57	74
Visualization	I	87	86	81	73	66	58	57	75
Inductive	R	85	82	70	72	71	65	62	84
Reasoning	I	90	87	76	68	60	52	55	80
Number	R	84	82	80	85	88	79	79	76
	I	100	101	93	83	76	67	68	72
Word Fluency	R	94	98	102	119	129	127	128	86
	I	100	106	106	106	95	95	103	83
Intellectual	R	88	89	95	90	90	84	82	88
Ability	I	97	98	92	84	80	76	74	85
Educational	R	91	95	86	87	85	78	71	88
Aptitude	I	98	92	85	77	69	60	61	84

From: Schaie, K. W., and Parham, I. A. Cohort-sequential analyses of adult intellectual development (extended version of Schaie & Parham, 1977), NAPS # 03170

Before leaving this topic it would be well to remind the reader once again that the facts of obsolescence require us to apply different yardsticks for comparisons of individuals of different ages at the same point in time (the cohort problem) than where within-client age changes are to be considered. In the first case, we need up-to-date norms for the cohort levels to be compared, while in the latter we need data appropriate to within-cohort change for the client to be assessed (cf. also Schaie and Schaie, 1977b). I have recently suggested (Schaie, 1979) that clinicians interested in the intellectual assessment of older people should include estimates of a peer comparison quotient (PCQ) and a base comparison quotient (BCQ).

The PCQ is analogous to the well-known Wechsler deviation IQ in that it would describe how a given client compares with his age peers. However, in contrast to traditional approaches, the PCQ requires normative data not just classified by age, but by age *within* cohort for those variables where different age trends are known to exist for successive cohorts. This procedure requires, of course, that test authors provide estimates for their tests for both age and cohort trends (e.g., Schaie and Parham, 1975). If such age-cohort data are available, it is then possible to compute the PCQ by the conventional formula:

$$PCQ = \frac{X - \bar{X}_{ac}}{\sigma_{ac}} \times 15 + 100$$

where the subscript *ac* refers to cohort-specific means and standard deviations for each age of interest. I would assume that corrections for cohort change might suffice if they were made for each five- to ten-year period for age norms up to the early seventies. Because of the very rapid changes in the characteristics of the very old, more frequent updates may be required for persons in the late seventies and beyond.

The second proposed index, the BCQ, indicates how a particular individual compares with a reference cohort judged to be at the optimal performance level for a particular variable. It is similar to Wechsler's EQ, but differs in that the younger reference cohort is not fixed, but is determined at the point in time when the clinician wishes to make the comparison. Computation of the BCQ requires knowledge of the means and standard deviations of the age-cohort to be used as the comparison, e.g., those age 25 at the time the comparison is to be made, and the standard deviation of the age-cohort to which the person to be assessed belongs. The BCQ can then be computed as follows in a form comparable to the PCQ described above:

$$BCQ = \frac{X - \bar{X}_{bc}}{\sqrt{\sigma_{ac} \quad \sigma_{bc}}} \times 15 + 100$$

where the subscript *ac* again refers to the age-cohort of which the client is a member and *bc* refers to the comparison base age-cohort. Both the PCQ and BCQ can be interpreted in a fashion similar to the conventional deviation IQs; i.e., the range from 90 to 110 would represent the middle 50 percent of the comparison population, etc. A number of other additional indices which would be more useful than those currently fashionable have been proposed in relation to work on functional aging. These have recently been described elsewhere (Schaie and Parr, 1979a).

PROBLEM-SOLVING ABILITY IN OLD AGE

We began our discussion of intellectual abilities by distinguishing between intelligence and competence. We could have elected in that discussion to use the concept of problem solving as a mediator. That is, we might have argued that competence not only involves a particular permutation of intellectual abilities, but additional factors such as memory, selective attention, and rates of information processing. It is the latter set of constructs (and perhaps others) that have in the past been considered in discussions of complex problem solving (see recent overviews on problem solving such as Anderson and Bower, 1973; Gregg, 1974; and Newell and Simon, 1972). There has been some lack of continuity, however, in the aging literature between the work of those who try to relate directly to the psychometric tradition and those who extend the problem-solving literature on children into adulthood (cf. Rabbitt, 1977). It seemed best therefore to address this literature separately and in particular try to distinguish between two major trends, that concerned with problem solving along information-processing lines and the other concerned with concept formation and classification ability. We will then attempt to come full circle and try to speculate how this literature may be of relevance to the clinician in assessing and understanding everyday behavior of the elderly.

PROBLEM-SOLVING ABILITY AND INFORMATION PROCESSING

Possible difficulties encountered by the elderly in complex problem solving may be related both to changes in the rate with which information is processed and to the strategies used in integrating components of information. We shall first consider the effects of slowing of the central nervous system with respect to rates of information processing. In particular we are interested here in examining the speed with which decisions are made in terms of the units of information obtained from each decision.

Speed, Accuracy, and Perceptual Organization. There is no question that older individuals exhibit slowed reaction time (Welford, 1977) and are found to be less accurate under certain but not all conditions (Rabbitt, 1968). Clay (1954) studied the relationship between speed and accuracy with advancing age in a matrix task in which cells had to be filled with numbered counters to yield prescribed row and column totals. She found that her subjects were able to retain accuracy until about age 50 but with increasing expenditure of time. By age 70, however, there was a tendency to "give up" after a reasonable length of time at the price of accuracy. Welford (1958) interprets these findings by noting that the amount of time taken on complex problem-solving tasks interacts with memory load. That is, the longer the individual spends on a given task, the higher the probability that essential information held in memory may be forgotten, thus contributing to lack of accuracy.

In a subsequent experiment, Clay (1956) varied the perceptual organization of her matrices. She found that under some conditions there were no age differences, while other conditions put her old subjects at disadvantage. Since many everyday problem-solving tasks involve processing of information from complex displays, the issue of perceptual complexity as related to problem solving becomes of considerable importance. There is research on simple perceptual organization which may be relevant. Welsh, Laterman, and Bell (1969) showed that old people recognize words less well than the young when speech is presented through either high or low bandpath filters. Rabbitt (1977) interprets these findings to mean that old people either require additional information which is redundant for the young or that old people cannot integrate information presented in an unfamiliar way. What must be kept in mind, of course, is that with advanced age there are sensory changes as well (see Corso, 1977). This means that both quantity and quality of sensory information available to the older individual may be reduced, even if there is relatively little central change in the precision of sensory coding associated with perceptual organization.

Certain compensating strategies are, however, of benefit to the older person. Kinsbourne (1973), in a study of letter span showed that sequential redundancy improved memory for both young and old. But the older subjects were unable to make use of redundancy at fast rates of presentation. That is, older persons must be given not only redundancy of information but also the time to recognize the redundancy. Further, the old appear to benefit when the material to be organized has meaning (Cooper-Howell, 1972).

Guessing Behavior and Willingness to Respond. Rates of information processing may also be affected by certain motivational variables. A number of studies have shown that older people tend to evaluate probabilities of success differently from the young and thus tend to be more cautious and less willing to respond quickly in situations where they perceive the risk of failure or loss to be high. An interesting study by Botwinick (1966) presented both young and old adults with a variety of life situations that were described either as rewarding and risky or as less rewarding but safe. The older adults (ages 67–80) were found to prefer the safer alternative. In a follow-up study (Botwinick, 1969), however, when the subjects were asked to choose between different levels of risk (not having the opportunity for a risk-free alternative), no differences in cautiousness were found between young and old.

Rabbitt (1977) raises the question whether old people may require more constraints before being able to make a decision because they may have less information and thus have greater difficulty in working out appropriate solutions. It is of interest to note here that even highly intelligent young people have very different conceptions of probabilistic odds from those inherent in a given decision situation (Kahneman and Tversky, 1973).

Birkhill and Schaie (1975) furthermore found that subjects aged 62 to 86 performed better under a low-risk condition only when they had the option of responding or not responding on a particular task item. And further complications are introduced by the fact that older individuals may have both long-range goals and tactical insights on how these can best be maximized (Birren, 1969). Their response in decision situations may well be affected by considerations intruding from their long life experience which must differ from those found in the young.

A number of laboratory studies of probability matching may also be relevant here. In these studies subjects are typically expected to predict the probability of the occurrence of a subsequent signal in a series with unequal presentation rates for different signals. Several of these studies report virtually no differences in accuracy between young and old adults (Griew, 1968; Sanford, Griew, and O'Donnell, 1972). However, Sanford and Maule (1973) found that even though their older subjects could estimate fault probabilities as well as their young comparison group, the older persons were less able to use this information in a situation where they were testing faults of different pieces of mechanical equipment. Sanford (1973) argues that this effect may be due to older individuals either becoming more random in their behavior, or narrowly focusing on the correct prediction of a particular outcome to the neglect of other essential elements of the situation.

Concept Formation and Classification Ability

Laboratory studies of concept formation usually require subjects to identify a classification rule which permits them to sort a variety of complex objects (whether these are pictures, common household objects, or geometric shapes) into a number of unspecified or prescribed subsets (cf. Kendler and Kendler, 1962; Wason and Johnson-Laird, 1972). As part of such a task it is necessary to remember both a variety of features of the stimuli to be sorted and the classification rule (whether arbitrary or not) once it is adopted. Consequently, if there are a great many such aspects to be remembered, performance will become increasingly inefficient. Of importance also for older people seems to be whether the task involves presentation of a positive or negative instance of the concept to be grasped (Arenberg, 1970). Since concept formation requires the learning and memorization of rules, all of the variables which interfere with learning and memory in the aged also have an effect upon concept formation (for reviews of these topics see Arenberg and Robertson-Tchabo, 1977; and Craik, 1977). Three areas of experimentation give us some clues, however, of the performance characteristics of the elderly on concept formation tasks. These include work on transfer in concept formation, categorization behavior, and the application of training strategies.

Transfer in Concept Formation. The basic design here is to train individuals to apply a particular rule in one task and then examine what happens on another task where the first rule is no longer appropriate. Since there is some evidence that elderly individuals are more rigid and show greater perseveration (Chown, 1961; Schaie, 1958), one might argue that the older person would be affected particularly when reversal shifts are required. However, Coppinger and Nehrke (1972) did not obtain such results. They do point out, however, that previous experience with the dimensions across which shifting is demanded is critical, and further alert us to the fact that older individuals may do as well as the young in informationally simple tasks, but not necessarily when the going becomes more complex (Arenberg, 1970; Nehrke 1973; Rogers, Keyes, and Fuller, 1976). There is a popular stereotype that many previously learned and perhaps now inappropriate learning strategies interfere with the concept learning of the elderly. But left-right reading habits which are known to effect paired associate learning in the young do not seem to interfere any more in old than in young persons (Monge and Hultsch, 1971).

Another interesting experiment on the ability of older people to shift is a study using Wicken's "release from proactive inhibition" task. The assumption here is that in order to learn a new concept, it is necessary to be released from a previously learned association. Mistler-Lachman (1977) compared college students, community elderly, and elderly rest home residents on this task. She found that the college students and community elderly had comparable recovery on the shift task, while the rest-home subjects did much more poorly, suggesting that it may not be age but other disabilities which produce the shifting problems in the institutionalized aged.

The possibility remains that older people can shift on familiar tasks but are particularly disabled when new problems are to be learned. This alternative was first suggested by Ruch (1934), who required older individuals to suppress previously learned rules in remembering nonsense equations. But Boyarsky and Eisdorfer (1972) failed to demonstrate greater negative transfer in the older than in the young, a difference that would be essential to account for the contention that earlier learning interferes in new learning by the elderly. Once again, most clinicians will feel uncomfortable in trying to generalize data from laboratory tasks which are so remote from everyday life experiences. Nevertheless in more life-related studies (e.g., Speakman, 1954), similar findings lead to the conclusion that, where both simple and more complex procedures are available, the old will tend to use the simpler, but not necessarily more efficient, solutions (Rabbitt, 1977).

Classification Behavior. Three dimensions of classification have been studied. The first concerns the accuracy with which an individual can use a given classification system. The second is the number of categories individuals will use when they are free to form their own classes. And the third concerns the level of complexity used in forming classes, such as abstractness, establishment of category hierarchies, etc. Denney and Lennon (1972) studied free classification in middle-aged and elderly subjects. Only 28 percent of the elderly but 97 percent of the middle-aged sorted the geometric objects used according to similiarity on an attribute such as color, size, or shape. The balance of the elderly tended to sort so as to make a design. Because many of their subjects were foreign-born, a second study was done (Denney, 1974). This time all subjects between 35 and 59 sorted according to similarity, while as many as 89 percent of the 60–to 79–year–olds and 90 percent of the 80–to 95–year–olds sorted in that manner. The authors therefore question whether the egocentric response in the first study represents preference rather than loss of sorting ability.

Kogan (1973, 1974) asked college students and older individuals ranging in age from 62 to 85 to sort line drawings of common objects into categories. The older subjects used fewer categories, and tended to prefer categories which involved functional or thematic relationships between objects over categories which shared a common physical attribute or where each object is an example of a superordinate concept. The Kogan study was replicated over a larger age-span by Cicirelli (1976). The latter found that categorical-inferential responses increased from childhood to age 65 and then declined, while relational categories decreased until 20 and then increased systematically into old age.

Application of Training Strategies

Another clue to the understanding of problem solving is an examination of the kind of training strategies that will lead to improved performance in the elderly. Age differences in performance might be reduced, for example, if older individuals can be taught more appropriate learning strategies which are readily available to the young (Goulet, 1972). When this is done successfully, however, it may be premature to suggest that it is the learning strategy which has helped per se. Rather, what may have occurred is that the more efficient organization of the material has led to greater retention (Kintsch, 1970). Rabbitt (1977) argues that all we have done is to make it unnecessary for the individual to remember as much, or, via better organization, to remember more of the essential elements. One cannot take much exception to this position other than reminding the reader that memory is, or course, an essential component of all organized behavior, but that there is one inherent circularity in the argument, since more efficient concept formation, whether spontaneous or otherwise, is going to lead to both memory improvement and improved problem solving (also see Labouvie-Vief and Gonda, 1976; Plemons *et al.* 1978).

APPLICATION OF PROBLEM-SOLVING ABILITY TO THE EVERYDAY PROBLEMS OF THE ELDERLY

What do all the above studies mean for our understanding of what is normal or pathological in the way old people handle complex problems? At this time all the cautions that were raised in the section of intellectual abilities must again be raised here, and perhaps more so, because the problem-solving literature reviewed above is virtually *in toto* based upon cross-sectional comparisons. We must at least speculate that there are substantial generational differences in experience with complex problem-solving strategies and tendencies towards cautiousness and risk taking, as well as in decision-making skills which relate to the individual's level of formal education. But these generational differences are quite real, and the clinician must take due note and avoid attributing apparent performance deficits to potential psychopathology when such apparent deficits reflect no more than differential experience and levels characteristic of a generation of individuals who are much older than the clinician evaluating them.

Another consideration is of importance here, and that is to ask whether the problem-solving capability of the average older person does not suffice to deal with the needs of his current life-stage. I have argued that the life-stage during which individuals respond to the demands of the environment which require complex problem solving is largely that of midlife, and that problem-solving activities in old age become increasingly oriented towards much more egocentric goals (Schaie, 1977/78). There is considerable literature to support this point of view, stemming from the analysis of creative productivity in outstanding individuals, a literature which, strictly speaking, is not longitudinal, but could be described as archival-archeological reconstruction. But this literature (notably the work of Lehman, 1953, 1962, 1965; and of Dennis, 1966), also tells us that while the most intensive productivity occurs in midlife, there are vast differences between fields. Those fields that require little experience seem to peak in both quantity and quality in early middle age, while other fields (notably history, literature, and philosophy) tend to peak towards the end of the midlife period.

What is most amazing to the careful observer is not that old people asked to perform by criteria raised for their juniors perform somewhat less well, but rather that most older people are capable of quite impressive problem solving and decision making. Again, attention should be called to studies such as those by Birren (1969) and by Schaie and Strother (1968) which ask questions about the performance of highly intelligent older people who seem to cope so well, and who, in spite of obvious physiological changes, manage to adapt to the demands of their daily existence in a resourceful and satisfactory manner.

When all is said and done, we conclude this section in a rather similar vein to what we have proposed in our discussion of the intellectal abilities. There seems to be little change until midlife, except for the need to take somewhat more time to achieve equal levels of accuracy. Slowing sensory and perceptual processes may make it likely that older people, particularly those beyond the early seventies, will tend to make mistakes by simplifying their conceptual frameworks even when this is maladaptive and by failing to spend as much time as their central nervous system requires to obtain adequate solutions because of real or perceived external pressures "to get on with it." For today's generation of elderly, there is the further disadvantage of obsolescence with respect to problem-solving strategies appropriate to an increasingly complex environment and the perpetuation of perhaps depression-engendered attitudes about risk taking, even when it is the older problem solver who needs to take increasing risks to survive and to survive well.

SOME CONCLUDING THOUGHTS

It was not the purpose of this chapter to assess the adequacy of measures of intelligence and problem solving for purposes of clinical assessment (see Schaie and Schaie, 1977a, 1977b, and Chapter 23, this volume, for full discussions of that issue). Nevertheless, the literature reviewed here must provide the baseline data for the work of the clinician in distinguishing between normal aging and psychopathology. I will therefore close by summarizing the conclusions which I feel represent a fair assessment of the current state of the art.

First, intellectual decrement and decline in problem-solving abilities within individuals, when occurring before the late fifties, is pathological rather than normal. Second, from the early sixties to the mid-seventies there is normal decline on some but not all abilities, for some but not all individuals, but beyond eighty decrement is the rule for most individuals. Third, for most individuals there is decrement beginning in the fifties for those abilities which implicate speed of response, and abilities which are sensitive to relatively modest impairment of the peripheral nervous system. Fourth, decrement is also frequently 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 or early sixties. Fifth, because of the enormous pace of sociocultural change, most persons now in their late fifties and beyond are to some extent suffering from obsolescence effects, and therefore compare poorly with their younger peers, even though they may currently function as well as they ever have. Sixth, it is essential for clinicians to distinguish between individual decline and personal disadvantage due to obsolescence, since the former may require therapeutic intervention while the latter calls for remedial education. And seventh, data on complex problem solving are not yet very clear because our knowledge is based mostly on cross-sectional studies, but there is little reason to suspect that matters will differ much from what has been said about intellectual ability.

Finally, I would like to caution clinicians once again that most of what we know about intelligence and problem solving in the elderly has been learned using instruments and techniques developed for children and young adults. We are only at the beginning of charting adult functioning with techniques which are truly indigenous to the elderly. It is quite possible, therefore, that what appears as disadvantage when compared with the young, may simply represent a regrouping and reexpression of function which might be quite appropriate and adaptive for the old. Research now in progress in a number of laboratories will hopefully shed light on this major issue in time for a future revision of this Handbook.

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