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Fifteen

# Intellectual Development in Adulthood

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## I. Introduction

This chapter is designed to bring up to date the literature on adult intellectual development and to review new directions of research on this topic that have become apparent since the last edition of this *Handbook*, emphasizing material published since 1988. Other extensive reviews of topics covered in this chapter can be found in Carroll (1993), Cunningham (1987), Lindenberger (1994), and Schaie (1990a, 1995).

I open with a review of metatheoretical issues concerned with the definition and implications of theories of intelligence for the study of adult development. Next, I consider differential patterns of intellectual aging, and then I address independent variables that affect the aging of intellectual abilities. Attention is given also to reversibility of intellectual deficit by educational training, because this topic bears upon the question of whether intellectual decline is normative or simply due to disuse. The chapter closes with some "prescriptions" for research and theory building on adult intelligence.

### A. Intelligence and Cognition: Some Definitions

In this chapter I deal with the literature for what some describe as cognitive products rather than the cognitive mechanisms treated in the information-processing context (e.g., Rybash, Hoyer, & Roodin, 1986). Measurement of intelligence has traditionally been concerned with operationalizing laboratory operations that are thought to represent intelligent behaviors in the real world. Alfred Binet already argued in 1905 that "To judge well, to comprehend well, to reason well, these are the essentials of intelligence. A person may be a moron or an imbecile if he lacks judgment; but with judgment he could not be either" (Binet & Simon, 1905, p. 106). This definition remains a classic to this day.

I would argue that there is a natural hierarchy in the study of intelligence leading from information processing, through the products measured in tests of intelligence, to practical or everyday intelligence (e.g., Baltes, 1987; Sternberg & Berg, 1987; Willis & Schaie, 1993). Understanding of the mechanisms of intelligent behavior are, of course, important, and theoretical models that attempt to account for the aging of such mechanisms (e.g., Salthouse, 1988a) are highly relevant to the study of intelligence. But the literature on information processing and the development of expertise is treated elsewhere in this handbook (see Ch. 13 by Smith and Ch. 20 by Salthouse & Maurer, this volume). Likewise, I will not deal with the topic of practical intelligence or everyday competence, because this material is covered in the chapter by Willis (Ch. 16, this volume), nor with the burgeoning topic of wisdom (cf. Sternberg, 1990).

The products or intellectual skills that characterize psychometric intelligence are likely to represent the most appropriate level for the direct prediction of many socially desirable outcomes (Willis & Schaie, 1993). The entire age span from young adulthood to advanced old age must be included, because it is not enough to compare young and old adults. Instead, we need to know at what point intellectual development peaks as well as determine the rate and pattern of decline (cf. Schaie, 1994). This is particularly important when basic work on intelligence is related to capability for industrial work and maintenance of societal productivity (cf. Avolio, 1991; Rabbitt, 1991; Welford, 1992).

### B. How Do Theories of Intelligence Affect the Study of Adult Development?

At least four influential theoretical positions have informed empirical research on intelligence conceptualized as products or performance indices. The earliest theoretical influence comes from Sir Charles Spearman's work (1904) that suggested a general dimension of intelligence (*g*) to underlie all purposeful intellectual products. All other components of such products were viewed as task or item specific (*s*). This view provides the theoretical foundation for the family of assessment devices that originate from the work of Binet and Simon (1905). The concept of a single general form of intelligence may be appropriate in childhood when there exists an isomorphic and unidimensional validity criterion: scholastic performance. But it is not useful beyond adolescence, because of the lack of a unidimensional criterion in adults and because convincing empirical evidence supports the presence of multiple dimensions of intelligence displaying a different life course (cf. Horn, 1982; Schaie, 1994, 1995).

The first influential theory that was multidimensional in nature was E. L. Thorndike's view suggesting different dimensions of intelligence, which he contended would display similar levels of performance within individuals. Thorndike also suggested that all categories of intelligence possessed three attributes: power, speed, and altitude (cf. Thorndike & Woodworth, 1901). This approach is exemplified by Wechsler's work (see Matarazzo, 1972), which specified 11 distinct scales derived from clinical observation and earlier mental tests; these are combined into two broad dimensions: Verbal and Performance (nonverbal-manipulative) intelligence. These dimensions are then combined to form a total global IQ.

The Wechsler scales have had great importance for use in the clinical assessment of adults with psychopathology. Although the Wechsler verbal and performance scales are highly reliable in older persons, the difference between the two, often used as a rough estimate of age decline, is far less reliable (Snow, Tierney, Zorzitto, Fisher, & Reid, 1989). A major limitation of the test for research on intellectual aging, however, has been the fact that the factorial structure of the scales does not remain invariant across age (McArdle & Prescott, 1992; Meredith, 1993; Sands, Terry, & Meredith, 1989). As a consequence, most recent studies of intellectual aging in community-dwelling populations have utilized subsets of the primary mental abilities (cf. Cunningham, 1987; Hultsch, Hertzog, Small, McDonald-Miszlak, & Dixon, 1992).

Factorially far simpler multiple dimensions of intelligence were identified in the classical work of L. L. Thurstone (1938), which was further expanded by Guilford (1967). The primary mental abilities described by Thurstone have formed the basis for my own work, which has utilized measurement instruments developed by Thurstone and Thurstone (1949) and by the Educational Testing Service (Ekström, French, Harman, & Derman, 1976), based on the work of Thurstone and of Guilford (1967), as well as parallel forms developed in my laboratory (Schaie, 1995).

The original work on the primary mental abilities was conducted with children (Thurstone, 1938), but the factorial structure of various subsets of the primary abilities in adults has been well described in numerous investigations of adults. Second-order factor analyses of the primary abilities have identified several higher order dimensions, including those of fluid intelligence (applied to novel/eductive tasks) and crystallized intelligence (applied to acculturated information), popularized by Cattell and Horn (e.g., Carroll, 1993; Cunningham, 1987; Horn & Hofer, 1992; Schaie, Willis, Hertzog, & Schulenberg, 1987; Schaie, Willis, Jay, & Chipuer, 1989).

The introduction of Piagetian thought into American psychology led some investigators to consider the application of Piagetian methods to adult development. The Genevan approach, however, has contributed only sparsely to the study of adult cognition (but see Alexander & Langer, 1990; Commons, Sinnott, Richards, & Armon, 1989; Kuhn, 1992; Labouvie-Vief, 1992; Schaie, 1977–1978).

Cutting across these theoretical positions there are also discernable secular trends in relative emphases on different aspects of adult intelligence. Woodruff-Pak (1989) identified four stages: In the first, lasting until the mid-1950s, concerns were predominantly with identifying steep and apparently inevitable age-related decline. The second stage (in the late 1950s to mid-1960s) involved the discovery that there was stability as well as decline. External social and experiential effects influencing cohort differences in ability levels identified during this period led to a third stage (beginning with the mid-1970s) in which the field was dominated by attempts to alter experience and manipulate age differences. In the latest stage, the impact of successful demonstrations of the modifiability of intellectual performance has led investigators to expand definitions of intelligence and explore new methods of measurement.

### C. The Role of Longitudinal Studies

The study of adult intelligence presents us with two related but nevertheless distinct objectives. The objective of most age-comparative studies is to determine whether adults at different age levels also differ in intellectual performance at a particular moment in historical time. When such information is needed for policy-relevant determinations, cross-sectional methods will suffice. But cross-sectional data are not directly relevant to the question of how intelligence changes with age *within* individuals, nor will such data help discover the antecedents of individual differences in the course of adult development. Increased attention has therefore been given to the role of longitudinal data in understanding adult intellectual development. A respectable number of longitudinal studies have been conducted in the United States and in Europe that cover substantial age ranges (Busse, 1993; Costa & McCrae, 1993; Cunningham & Owens, 1983; Eichorn, Clausen, Haan, Honzik, & Mussen, 1981; Jarvik & Bank, 1983; Rott, 1990; Schaie, 1995; Shanan, 1993; Steen & Djurfeldt, 1993).

An important new addition is provided

by the initiation of longitudinal studies in the very old, providing hope that we will soon have better information on age changes in the 90s and beyond (e.g., Baltes, Mayer, Helmchen, & Steinhagen-Thiessen, 1993; Poon, Sweaney, Clayton, & Merriam, 1992). There have also been recent proposals for multivariate models that jointly examine cross-sectional and longitudinal data (McArdle, Hamagami, Elias, & Robbins, 1991; McArdle & Prescott, 1992). Their promise remains to be demonstrated.

### D. Observed and Latent Variables

Most research on intelligence is not so much concerned with age changes or differences in specific measures but rather with understanding the effects of intellectual aging on the underlying ability dimensions. Within the primary mental ability framework, the question has been raised whether specific abilities or second-order constructs are of greater importance. For adult development, however, assessment would seem to be optimal at the primary level, because the role of *g* becomes less central as expertise is developed in specific skills and because most age-related change in cognitive processes requires more than a single component to explain individual differences (Salthouse, 1988b, 1992).

Aging patterns differ between the various primary mental abilities (Schaie, 1995; Schaie & Willis, 1993) and the various second-order ability factors (Horn & Hofer, 1992), and measures of intellectual functioning are not necessarily factorially invariant across age and time (Schaie et al., 1989). Although the factor structure of abilities may be fairly stable across age, differences in factor covariances, particularly in the regression of the observed marker variables on the factors, have been reported (cf. Hertzog, 1987; Horn & McArdle, 1992; Schaie et al., 1989). Although most factor scores based on multiple markers provide valid comparisons across age, the same cannot be said for individual scales whose regression on a given ability factor may vary markedly from young adulthood into old age.

## II. The Course of Adult Intellectual Development

In this section, I review briefly what seem to me to be the substantive conclusions that can be reached from the current literature. I utilize information from a broad array of current studies, but caution the reader that I lean heavily on results from my own work.

### A. What Do We Know about Population Parameters for Age Changes and Age Differences in Adult Intellectual Aging?

Intellectual aging as a multidimensional process in normal community-dwelling populations has been studied most intensively in the Seattle Longitudinal Study (SLS; Schaie, 1993, 1994, 1995). The principal variables in this study, which has extended thus far over a 35-year period, were five measures of psychological competence known as *primary mental abilities* (Schaie, 1985; Thurstone & Thurstone, 1949): Verbal Meaning, Space, Reasoning, Number, and Word Fluency (the ability to recall words according to a lexical rule). During the last two test occasions, six multiply-marked abilities were assessed at the factor level: Inductive Reasoning, Spatial Orientation, Perceptual Speed, Numeric Ability, Verbal Ability, and Verbal Memory.

Various combinations of the primary mental abilities are represented in all meaningful activities of a person's daily living and work (Willis, Jay, Diehl, & Marsiske, 1992; Willis & Schaie, 1986a, 1994a). The SLS has followed large numbers of individuals over each 7-year interval over the age range from 25–88 years. On average, there is gain until the late 30s or early 40s are reached, and then there is stability until the mid-50s or early 60s are reached. Beginning with the late 60s, however, 7-year decrements are statistically significant throughout. These data suggest that average decline in psychological competence may begin for some as early as the mid-50s, but that early decrement is of small magnitude until the mid-70s are reached. Because of the modest gains from young adulthood to middle age, longitudinal comparisons from a young adult base (age 25) show significant cumulative decline from that base only by the mid-70s.

At the factor level, longitudinal decline is noted by the mid-50s for Perceptual Speed and Numeric Ability, by the late 60s for Inductive Reasoning and Spatial Orientation, and by the late 70s for Verbal Ability and Verbal Memory. Figures 1 and 2 show longitudinal gradients for the five observed mental abilities and six derived ability factors.

A number of recent short-term longitudinal studies confirm that age change in cognitive functions is a rather slow process. Thus at least two studies have found virtual stability over a 3-year period (Hultsch et al., 1992; Zelinski, Gilewski, & Schaie, 1993).

Substantial intellectual changes within individuals occur only late in life and tend to occur for abilities that were less central to the individuals' life experiences and thus perhaps less practiced. Nevertheless, in our community-based studies we found that virtually everyone had declined modestly on at least one of five mental abilities

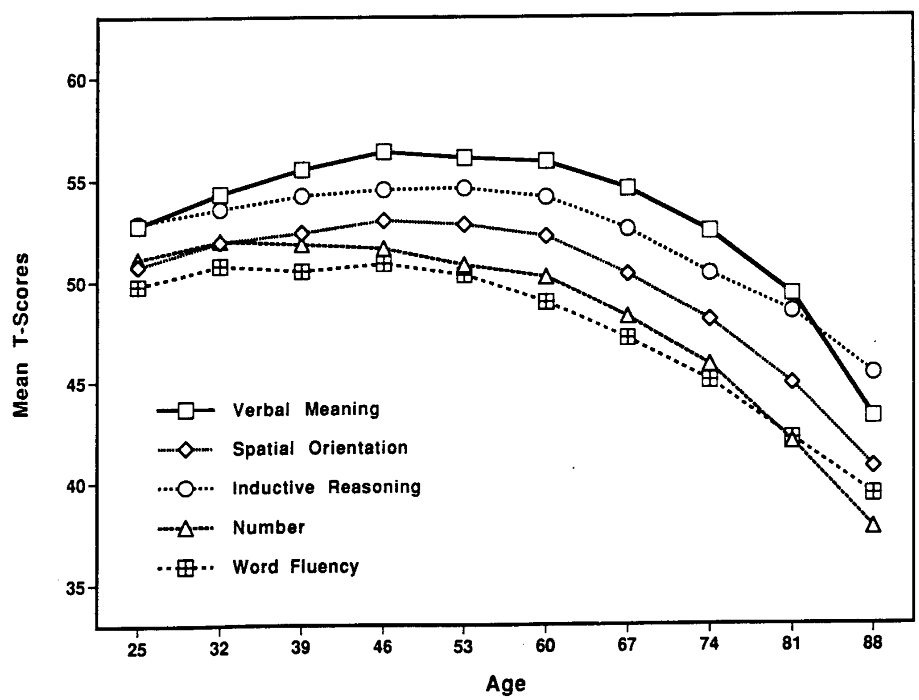


**Figure 1** Longitudinal estimates of age changes on observed measures of five primary mental abilities. (From "The Course of Adult Intellectual Development" by K. W. Schaie, 1994, *American Psychologist*, *49*, pp. 304–313. Copyright 1994 by the American Psychological Association. Reproduced by permission of the publisher.)

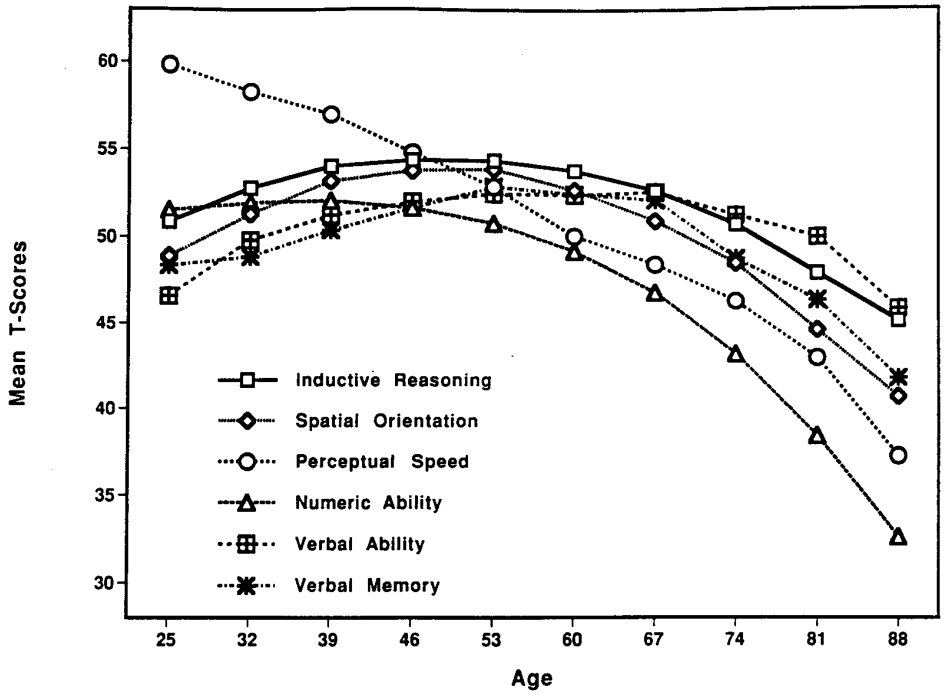


**Figure 2** Longitudinal estimates of age changes in factor scores on six primary mental abilities at the latent construct level. (From "The Course of Adult Intellectual Development" by K. W. Schaie, 1994, *American Psychologist*, *49*, pp. 304–313. Copyright 1994 by the American Psychological Association. Reproduced by permission of the publisher.)

by age 60, but that none of the study participants had declined on all five abilities even by age 88 (Schaie, 1989a).

But what about findings from age-comparative (cross-sectional) studies of intellectual performance in which young and old adults are compared at a single point in time? Due to substantial cohort differences (see Section II.B), these studies show far greater age differences than do longitudinal data. Typically, ages of peak performance occur earlier (for later-born cohorts), and modest age differences are found by the early 50s for some and by the 60s for most dimensions of intelligence. Because of the slowing in the rate of positive cohort differences, age difference profiles have begun to converge somewhat more with the age change data from longitudinal studies. Figure 3 shows age difference patterns from the SLS over the age range from 25–81 in 1970 and 1991. As can be seen, both peak performance and beginning decline seem to be shifting to later ages for most variables.

Recent work on the Wechsler Adult Intelligence Scale (WAIS) with data sets based on normal individuals has shifted to approaches that involve latent variable models (see Horn & McArdle, 1992; McArdle & Prescott, 1992; Millsap & Meredith, 1992; Rott, 1993). Alternatively, analyses have been conducted at the item level. An example of the latter approach is a study by Sands et al. (1989) of two cohorts spanning the age range from 18–61. Consistent improvement in performance was found between the ages of 18 and 40

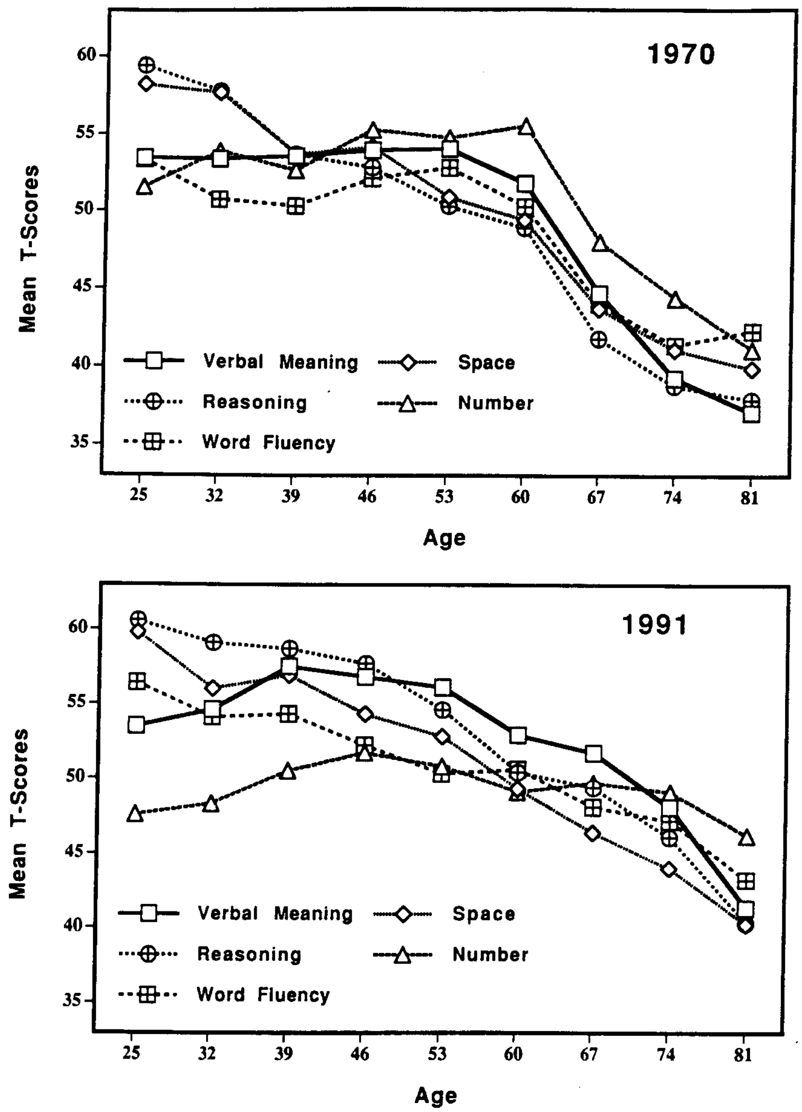


**Figure 3** Cross-sectional age differences on five primary mental abilities for samples tested in 1970 and 1991. (Adapted from Schaie, 1995.)

and between 18 and 54. Between ages 40 and 61 improvement was found for the Information, Comprehension, and Vocabulary subtests; mixed change (gain on the easy items and decline on the difficult items) on Picture Completion; and decline on Digit Symbol and Block Design (with decline only for the most difficult items of the latter test).

### B. Individual Differences in Level and Rate of Change

Is decline in psychological competence a global or a highly specific event? SLS data

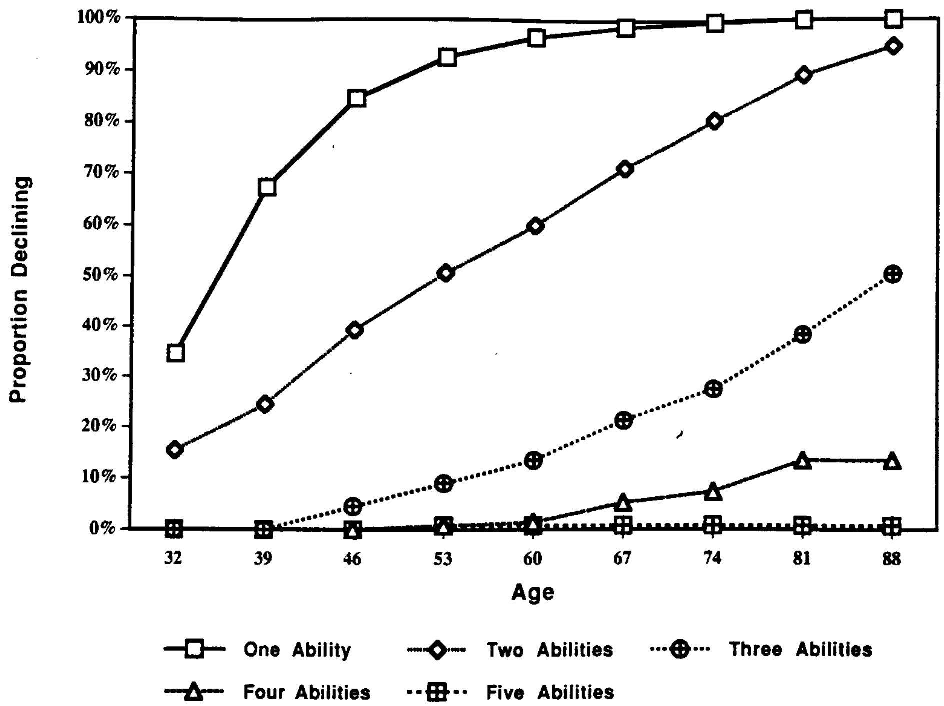


**Figure 4** Cumulative proportion by age of individuals who show significant decline on one or more primary mental abilities. (From "The Hazards of Cognitive Aging" by K. W. Schaie, 1989, *Gerontologist, 29*, pp. 484–493. Copyright the Gerontological Society of America. Reproduced with permission of the publisher).

graphed in Figure 4 show cumulative proportions by age of subjects whose level of cognitive functioning had declined on one or more abilities. Although by age 60 virtually every subject had declined on one ability, few individuals showed global decline. Virtually no one showed universal decline on all abilities monitored, even by the 80s. Optimization of cognitive functioning in old age may well involve selective maintenance of some abilities but not others (cf. Baltes & Baltes, 1990). Moreover, such optimization seems to be a highly individualized phenomenon (cf. Rabbitt, 1993; Schaie, 1989a, 1990b).

Despite these encouraging data, it is clear that significant reductions in psychological competence occur in most persons as the 80s and 90s are reached. However, even at such advanced ages, competent behavior can be expected by many persons in familiar circumstances. Much of the observed loss occurs in highly challenging, complex, or stressful situations that require activation of reserve capacities (cf. Baltes, 1993; Raykov, 1989). The often voiced hope that the more able are also more resistant to intellectual decline remains generally unsupported (cf. Christensen & Henderson, 1991). But those who start out at high levels remain advantaged even after suffering some decline.

## C. Why Do Cohort Effects Matter?

There have been marked generational shifts in levels of performance on tests of mental abilities (Schaie, 1989b, 1995; Willis, 1989a). Empirical findings suggest that later-born cohorts are generally advantaged when compared with earlier cohorts at the same ages. This phenomenon has been explained by increased educational opportunities and improved lifestyles, including nutrition and the conquest of childhood disease, which have enabled successive generations to reach ever higher ability asymptotes, similar to the observed secular trends of improvement for anthropometric and other biological markers (Shock et al., 1984). Although linear trends have been found for some variables, there seems to be contrary evidence that such trends may have been time limited and domain or even variable specific (cf. Schaie, 1990c; Willis, 1989a).

Accurate descriptions of patterns of cohort change in mental ability are important because they provide the foundation for a better understanding of how intellectual productivity and competence shift over time in our society. These data also help us understand how cohort differences in performance can lead to erroneous conclusions from age-comparative cross-sectional studies (cf. Schaie, 1988). The changing demographic composition of the population makes it necessary to assess differences in performance level at comparable ages for individuals representing eras characterized by differential fertility rates (e.g., contrasts of the pre-baby boom, baby boom, and baby bust generations). Cohort shifts at older ages, moreover, are directly relevant to policy considerations regarding the maintenance of a competent workforce that will contain increasing proportions of older workers, as mandatory retirement has become a relic of a biased past, and unfavorable changes in dependency ratios will require many to work to later ages than most people now contemplate. Cohort trends over time have been reported that are likely to influence the proportion of individuals of advanced age who will remain capable of significant late-life accomplishments; these trends may reflect the ability of older individuals to take advantage of recent technological developments (Schaie, 1989a; Willis, 1989a).

Figure 5 shows cohort gradients for the same abilities for which age trends were given above. The negative shift in some abilities for more recent cohorts may make many older persons appear to be more competitive with their younger peers than has been true in the past. Because of the recent leveling off of cohort differences for some abilities and the curvilinear nature of cohort differences for other abilities, it may be expected that the large ability differences between young and old adults observed currently will be much reduced in the future. For numerical skill, in particular, we may expect a period of time when older adults will be advantaged as compared to younger persons. Conversely, the level reached by recent cohorts in educational attainment and positive lifestyles may well be close to the limits possible within our society's resources and structures. The positive shifts in potential experienced in early old age by successive cohorts (Schaie, 1990b) may therefore come to a halt by the end of this century.

Although cohort differences in intelligence have generally been studied in random population samples, we have recently supplemented this literature by investigating cohort differences in 531 adult parent–offspring pairs. Significant within-family cohort ability differences were found in favor of the offspring generation in about the same magnitude as shown in the previous studies, but generational differences became smaller for more recently born parent–offspring pairs (Schaie, Plomin, Willis, Gruber-Baldini, & Dutta, 1992).

### D. Is the Structure of Intelligence Invariant across Adulthood?

Much attention has been given to age changes and differences in level of performance,

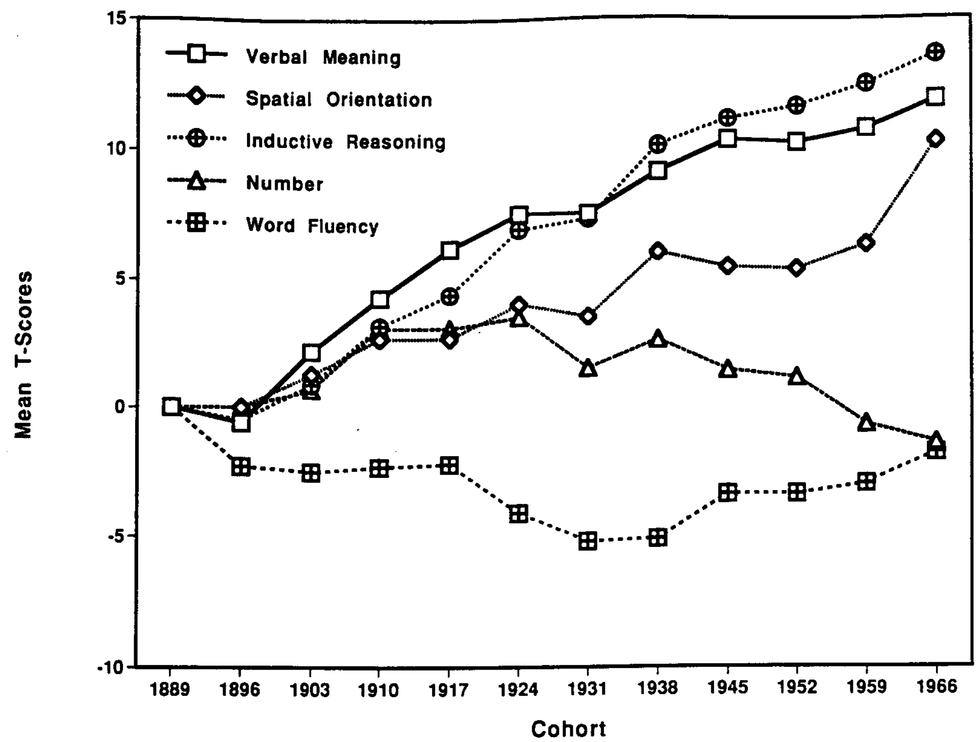


**Figure 5** Cohort gradients showing cumulative cohort differences on five primary mental abilities for cohorts born 1889 to 1966. (From "The Course of Adult Intellectual Development" by K. W. Schaie, 1994, *American Psychologist, 49*, pp. 304–313. Copyright 1994 by the American Psychological Association. Reproduced by permission of the publisher.)

but another fundamental question is whether the structure of intelligence remains constant across adulthood. Heinz Werner (1948) was an early proponent of a differentiation–dedifferentiation hypothesis, which suggested differentiation of dimensions of human behavior during the growth stage, and eventual dedifferentiation or reintegration as individuals aged. This hypothesis was explicitly extended to intellectual development by Reinert (1970).

The introduction of confirmatory factor analysis permitted testing of the above hypothesis by designing studies that formally assess factorial invariance across age (cf. Alwin, 1988; Horn & McArdle, 1992; Millsap & Meredith, 1992). The same number of dimensions generally suffice to describe the abilities domain across adulthood, but the relative importance of observed measures as estimates of the underlying latent constructs changes across age. In my own work, my colleagues and I have found configural invariance across adulthood into the 80s in cross-sectional data, but could not accept complete metric invariance (Schaie et al., 1989). This means that in age-comparative studies one should not compare means for observed variables, but should instead compare estimated factor scores on the latent constructs. Most recently I have conducted longitudinal within-cohort factor analyses and found that metric invariance can be demonstrated over 7 years, except for subjects now in their 80s (Schaie, 1994, 1995).

## III. Antecedents of Differential Age Changes in Adult Intellectual Development

Why is it that some maintain high levels of intellectual functioning into advanced old age whereas others tend to decline early? In this context we must distinguish between the effects of normal and pathological aging, consider the impact of behavioral slowing, and explore the effects of social context and personality differences.

### A. How to Distinguish Normal versus Pathological Aging

In order to identify declines in intellectual functioning caused by acute or chronic disease (cf. Anstey, Stankov, & Lord, 1993), many investigators have attempted to control for or measure the impact of such disease. Simple questionnaires on subjective health status often suffice to adduce fairly strong relationships with levels of cognitive functioning (cf. Field, Schaie, & Leino, 1988; Hultsch, Hammer, & Small, 1993; Perlmutter & Nyquist, 1990). More ambitious efforts have involved intensive studies of health history data or the inclusion of partial or complete medical workups in some studies of intellectual development.

#### *1. Impact of Cardiovascular Disease*

One might suspect that the presence or absence of cardiovascular disease ought to be related to the rate of intellectual aging. Such analyses have been undertaken in the Duke Longitudinal Study (Manton, Siegler, & Woodbury, 1986; Palmore, Busse, Maddox, Nowlin, & Siegler, 1985) and in the SLS. In the latter, it was found that individuals who were at risk from cardiovascular disease tended to decline earlier on average on all mental abilities studied than did individuals not so affected (cf. Gruber-Baldini, 1991). Those who declined had significantly greater numbers of illness diagnoses, as well as clinic visits for cardiovascular disease.

It should be noted, however, that the effects of hypertension have been far more complicated than those of other cardiovascular conditions. When distinctions are made between moderate or medically controlled and severe hypertension, it is often found that mild hypertension may actually have positive effects on intellectual functioning (e.g., Elias, Elias, & Elias, 1990; Sands & Meredith, 1992; Schultz, Elias, Robbins, & Streeten, 1989).

#### *2. Impact of Other Chronic Diseases*

Other chronic diseases that affect maintenance of intellectual functioning include arthritis, neoplasms (tumors), osteoporosis, and sensory deficits. In one study of the very old, visual and hearing deficits accounted for almost half of the total individual-differences variance, and for more than 90% of the age-related portion of those differences (Lindenberger & Baltes, 1994).

Data from the SLS suggest that arthritics have lower functioning and greater decline on Verbal Meaning, Spatial Orientation, and Inductive Reasoning. When malignant and benign neoplasms are distinguished, persons with benign neoplasms (other than skin tumors) were found to have earlier onset of intellectual decline, but less overall decline. Persons with malignant neoplasms and benign skin neoplasms had indirect negative influences on performance (through reduced activity). Results of the influence of neoplasms on cognition might be specific to type of tumor (malignant versus nonmalignant) as well as location (skin, bone, etc.). Osteoporosis and hip fractures were predictive of earlier decline on Word Fluency. Hearing impairment was associated with an increased risk of experiencing Verbal Meaning decline, but was associated with better performance and later decline on Space. Vision difficulties predicted later age at onset of decline for Verbal Meaning and Space (Gruber-Baldini, 1991).

Some caution is urged, however, not to overinterpret the relationship between disease and intellectual functioning. This relationship may be exaggerated by the fact that the more able are more likely to engage in appropriate health maintenance behavior and seek competent help earlier, and hence are more likely to postpone the onset of serious disease.

### B. The Impact of Behavioral Slowing on Intellectual Aging

It is quite evident that decline in reaction time with age adversely affects performance on tests of intellectual abilities. Many questions remain, however, as to whether the behavioral slowing involves a single mechanism or multiple ones (cf. Salthouse, 1988a, 1993c, 1994). Slowing of performance seems to have differential effects depending not only on the cognitive processes or abilities involved but also on the format involved in the presentation of test materials (Hertzog, 1989). Although group data on age changes in reaction time or perceptual speed take quite linear form, analyses of individual differences tend to support patterns of change that are more likely to follow a stair-step pattern (Schaie, 1989b). Birren has argued for a long time that loss in speed is a species-specific characteristic of normal aging, and has concluded that if one cannot think quickly, one cannot think well (Birren & Botwinick, 1951; Birren & Fisher, 1992). Stankov (1988), moreover, showed that speed of search is related to processing information. When statistical adjustments were made for the effects of individual differences in attention, age differences in fluid abilities were markedly reduced, whereas crystallized abilities tended to show increases into later life.

A number of studies have investigated the specific impact of level of performance on measures of perceptual speed. The usual method has been to partial out perceptual speed from the correlations between age and intellectual performance. Most studies report that age differences are markedly reduced or completely eliminated after such adjustment (Hertzog, 1989; Lindenberger, Mayr, & Kliegl, 1993; Salthouse, 1993c; Schaie, 1989b). Other possible adjustments of speed-mediated age differences in intelligence have involved measures of psychomotor speed (cf. Hertzog, 1989; Schaie & Willis, 1991).

If cognitive decrement with age is seen as a diminution of resources of which speed of behavior is a prime component (Salthouse 1988b), then other cognitive mechanisms may also be implicated. For example, reduction in the efficiency of verbal memory occurring with increasing age would reduce the preservation of information during processing of any complex cognitive task (Salthouse, 1993a). On the other hand, superior resources, such as crystallized knowledge, might reduce age differences on verbal tasks even when older subjects display slower processing speed (Salthouse, 1993b).

### C. The Social Context of Intellectual Aging

Needless to say, intellectual aging occurs within a social context. Hence, a number of demographic dimensions have been identified that tend to affect the rate of cognitive decline (cf. Schaie, 1994; Willis, 1989a).

Because of different socialization patterns, gender roles result in differential performance levels on certain mental abilities. On the primary mental abilities women consistently excel over men on reasoning and verbal skills, whereas men do better on spatial skills (Schaie, 1995). On the WAIS, adult gender differences have been found to favor men on Arithmetic, Information, and Block Design, with women excelling on Digit Symbol (Kaufman, Kaufman, McLean, & Reynolds, 1991). Because of women's greater life expectancy, men are always closer to death. At comparable advanced ages, therefore, women tend to do better (also see Berg, Ch. 18, this volume). Gender differences in rates of decline, moreover, are greater for those skills where each gender excels in young adulthood (Feingold, 1993; Schaie, 1995).

Not only are high levels of education implicated in slower rates of intellectual decline (Schaie, 1989a), but a lengthy marriage to a well-educated and intelligent spouse has also been identified as a positive risk factor (Gruber & Schaie, 1986). High occupational status and its more subtle aspects (such as high workplace complexity) are positive predictors of maintenance of intellectual functioning into old age (Dutta, 1992; Miller, Slomczynski, & Kohn, 1987; Schooler, 1987). Moreover, retirement seems to have favorable cognitive sequelae for those retiring from routinized jobs but to accelerate decrement for those retiring from highly complex jobs. Other contextual variables that have favorable impact on cognitive aging include an intact marriage, exposure to stimulating environments, and the utilization of cultural and educational resources throughout adulthood (Schaie, 1984). Lifestyle variables such as those mentioned above were also identified as positive risk factors in the Boston Normative Aging study (Jones, Albert, Duffy, & Hyde, 1991), and in studies of memory functioning in older Canadian men (Arbuckle, Gold, Andres, & Schwartzman, 1992).

### D. Personality, Cognitive Styles, and Motivation

Certain personality traits and cognitive style variables have also been found to affect maintenance of intellectual functioning. There seems to be a modest positive relationship between self-efficacy and intellectual functioning, although it remains to be resolved whether this relationship is unidirectional or reciprocal (Dittman-Kohli, Lachman, Kliegl, & Baltes, 1991; Grover & Hertzog, 1991; Lachman & Leff, 1989).

Intellectual performance might also be affected by the subjects' self-appraisal of changes with age. This question has been studied empirically by assessing perceived change in performance with objectively measured change (Schaie, Willis, & O'Hanlon, 1994). Study participants were categorized, based on their actual performance, into those who had maintained earlier performance level, significantly increased their performance, or declined in performance. A typology linking actual and perceived change in performance was created: *Realists* (those who accurately estimated change in their performance); *Optimists* (those who overestimated positive change); and *Pessimists* (those who overestimated negative change). The majority of subjects made realistic appraisals of changes in intellectual functioning. However, women were more likely to be pessimists on Spatial Orientation than men, and older individuals were more likely to be pessimists on Verbal Meaning and Inductive Reasoning Abilities and to be realists on Number ability compared to younger participants. By contrast, Rabbitt and Abson (1991) found that their subjects failed to predict objective performance on simple memory tasks, although their predictions were related to the Beck Depression Inventory. They suggested that their subjects rated their memory relative to reduced memory requirements in their current environment.

More securely established is the antecedent status of the personality characteristic of rigidity or flexibility. There are two aspects of this trait: motor-cognitive flexibility and attitudinal flexibility.

Longitudinal studies suggest that one's lifelong standing on flexible *behaviors* is maintained for most persons into the 70s, whereas, on average, people develop more rigid *attitudes* by the early 60s (cf. Schaie, 1995). It has also been shown that those with flexible attitudes in midlife tend to experience less decline in psychological competence with advancing age than those who were observed to be fairly rigid at that life stage (Schaie, 1984, 1995). These studies also concluded that high levels of motor-cognitive flexibility at the young-old stage are highly predictive of one's standing on numerical and verbal skills as well as psychological energy when reaching the old-old stage (also see O'Hanlon, 1993; Schaie, Dutta, & Willis, 1991).

## IV. Interventions in Adult Intellectual Development

### A. Is Adult Intellectual Decline Irreversible or Remediable?

Findings on individual differences in intellectual change and the identification of antecedents for differential intellectual aging cast at least some doubt on the inevitability of general intellectual decline for all individuals. More substantive evidence for such doubt is provided by cognitive intervention research that has successfully remediated some intellectual decline in the elderly. Longitudinal studies make it possible to distinguish effects of training that remediate age deficits from improvement in the performance of individuals above earlier levels. The former outcome, however, is of particular theoretical interest because it suggests that much of the intellectual aging seen in community-dwelling elderly may be experiential in nature. Training studies conducted in a longitudinal context also permit the identification of antecedent conditions that predict the likelihood of training success or failure (Willis, 1989b, 1990).

### B. Remediation of Deficit versus Reduction of Cohort Effects

Much of the work on cognitive training was conducted in the context of the Adult Development and Enrichment Project (ADEPT, Baltes & Willis, 1982) and the SLS (Schaie & Willis, 1986; Willis & Schaie, 1986b). Both of these studies involved pre-posttest designs, with 5 hr of instruction in strategies at the ability level, given in small groups in the ADEPT study and individually in the SLS. In the former study, significant training gains were demonstrated for subjects over age 60 for the primaries of figural relations and induction, whereas in the latter study, significant training gains occurred for inductive reasoning and spatial orientation. In the SLS, moreover, significant gain occurred for subjects who had declined as well as for those who had remained stable. Women experienced greater training effects on spatial orientation, and training benefited both speed and accuracy in women but primarily accuracy in men (Willis & Schaie, 1988). In both studies, near transfer was shown to occur for alternate markers within each ability, but there was no far transfer to other primary abilities.

Variations of the ADEPT study, introducing multiple training conditions, or conditions involving self-programmed training conditions, have for the most part replicated the original findings in a German sample (Baltes & Lindenberger, 1988; Baltes, Sowarka, & Kliegl, 1989), and in American studies by Blackburn, Papalia-Finley, Foye, and Serlin (1988) and Hayslip (1989). A study of figural relations training by Denney and Heidrich (1990) showed equal magnitudes of improvement for young, middle-aged, and old subjects.

Does cognitive training change the structural characteristics of the primary abilities (i.e., convert a pretraining fluid ability to a crystallized ability—cf. Donaldson, 1981)? In the SLS, invariance of factor structure across training was confirmed in the training groups. Minor shifts occurred in the factor loadings of the individual markers of the abilities trained, but training did not result in any of the markers loading on factors other than those hypothesized (Schaie et al., 1987).

### C. Long-Term Effects of Cognitive Interventions on Adult Intellectual Development

Cognitive training will clearly yield significant improvement in the performance of older persons on the targeted abilities, but skepticism has remained whether such training produces any lasting effects. Long-term follow-up over a 7-year period has been conducted for both the ADEPT and SLS training studies. Significantly lower decline over 7 years was shown in the ADEPT study for those individuals trained on figural relations as compared to the control group (Willis & Nesselroade, 1990). In the SLS, similar findings occurred for both Inductive Reasoning and Spatial Orientation abilities (Willis & Schaie, 1994b). In the latter study, those who had declined prior to the initial training were at the greatest comparative advantage upon follow-up. Both studies also examined effects of booster training. As would be expected, as subjects entered advanced old age, booster training, although yielding significant effects, resulted in somewhat lower magnitudes of training effects. It seems then that periodic reactivation of specific mental skills is likely to reduce the magnitude of intellectual decline in community-dwelling persons.

## V. Conclusions: Future Directions for Research on Intellectual Aging

In my 1990 review I concluded that there had been a turning away from studies that simply defined the extent and ability specificity of age differences and age changes in intelligence, toward a greater preoccupation with individual patterns of change and with the identification of antecedent variables that might account for the vast array of individual differences. I also identified much progress in the study of practical intelligence, a field that has expanded so much in the most recent period that an entire chapter is devoted to it in this volume (see Willis, Ch. 16).

Progress has continued also in identifying the social structural, health, and personality variables that account for such differences. No longer are contextual variables treated as methodological confounds; rather, increasing efforts are being made to identify the precise influences that will eventually predict individual hazards of intellectual decline and maintenance. Important theoretical efforts therefore have been directed toward replacing index variables, such as age or cohort, with more direct explanations of individual differences (also see Salthouse and Maurer, Ch. 20, this volume, and Anstey et al., 1993).

Findings presented in this chapter lead to the prediction that intellectual age differences in adulthood will become more compressed over the next decade because of the apparent plateauing of positive cohort differences for some abilities, and the occurrence of negative effects for others. The baby-boom cohort is now in midlife, and given the enormous demographic pressures affecting this group, monitoring of its cognitive functioning as it ages attains greater importance (cf. Willis & Schaie, in press).

More work is needed on the role of lifelong experience in the maintenance of intellectual functions and productive performance in societal roles. Information gathered with retrospective questionnaires indicates that the role of experience may be less than common sense would suggest (e.g., Salthouse & Mitchell, 1990). But the sparse relations found between age and job performance (Avolio & Waldman, 1990; Salthouse & Maurer, this volume) suggest to me that experience cannot yet be written off as an important source of compensation for loss of speed and cognitive efficiency.

I have previously called attention to the lack of comparative work on intellectual aging within minority groups in the United States; also lacking are informative cross-cultural comparisons with intellectual aging in other societies (but see Dai, Xie, & Zheng, 1993). Life course sociologists have taken advantage of substantial environmental interventions (e.g., the Great Depression, farm crises, cultural revolution, and so on) that may have differential effects upon human development (e.g., Elder, Rudkin, & Conger, 1994). Adult cognitive psychologists have yet to emulate this useful approach in their work.

Further progress has been made in work on cognitive intervention to show that intellectual decline in old age is not necessarily irreversible and that formal intervention strategies are available that might allow longer maintenance of high levels of intellectual function in community-dwelling older persons. The data on successful cognitive interventions have now been supplemented by evidence of positive long-term effects of these interventions. It is still necessary, however, to remove these techniques from the laboratory to a broader social context. This would require the implementation of "clinical trials" as well as the investigation of modes of intervention that are indigenous to the daily experience of older persons (such as games and other activities that may be cognitively challenging; see, e.g., Tosti-Vasey, Person, Maier, & Willis, 1992). Also needed are efforts to relate the effect of cognitive training to specific activities of daily living.

The field of adult intelligence has matured from a descriptive science toward one that increasingly calls for the identification of precise mechanisms and the identification of antecedents of individual differences. It has also progressed to the stage of interventions informed by basic science in the interest of improving intellectual competence in old age.

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