The Seattle Longitudinal Studies of Adult Intelligence

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My pervading interest over the years has been to understand the bases for the vast individual variations in the life course of adult intellectual abilities. Most of the relevant work has been done in the context of the Seattle Longitudinal Study (SLS), the first testing of which served as my doctoral dissertation at the University of Washington in 1956 and of which the sixth cycle is currently in progress. This work has been done within the framework of Thurstone's conceptualization of psychometric intelligence. Results of our previous efforts have been widely disseminated in the psychological and gerontological literature, in a comprehensive report through Wave 4 of the study[1] and in various analyses of the data from Waves 5 and 6.[2–4] Here I provide a brief overview.

THE SEATTLE LONGITUDINAL STUDY

Our principal data base consists of over 5,000 subjects on whom cognitive and other collateral data were acquired during our six major testing cycles (1956, 1963, 1970, 1977, 1984, and 1991). In addition, there were four related studies dealing with the effects of life complexity on adult cognitive development, the effects of sampling from an expanded population frame, the "aging" of the test battery, and family similarity in intellectual performance. All of our study participants are or were members of a health maintenance organization (HMO; Group Health Cooperative of Puget Sound) in the Seattle, Washington, metropolitan area, or family members of these individuals. The HMO serves governmental subdivisions and labor unions that attract both blue- and white-collar employees as well as a large, individually recruited membership that includes independent crafts people, people in service occupations, and all levels of professionals. Our samples underrepresent the lowest socioeconomic segment of the population but are quite representative of at least the upper 75% range of the socioeconomic spectrum. Such broad population representation is rare in most studies of psychological individual difference variables.

As is true in other longitudinal studies, we have encountered nonrandom subject attrition; subjects who return for retest typically outperform those who do not return. Dropout effects increase in magnitude subsequent to the first retest occasion. They are not systematically related to age, but reasons for dropout do change across the age span. Attrition effects have been reported for each of our study cycles, and we have proposed corrections for the effects of attrition and other confounds on estimates of cognitive age changes.[5]

Throughout our study, we have assessed the primary mental abilities of verbal meaning, spatial ability, reasoning, number skill, and word fluency, identified by Thurstone as accounting for the major share of individual differences in cognitive abilities in children and adolescents. Although these measures have limitations for school-age populations, they have turned out to be rather useful for the description of normal aging in adults. We have also assessed subjects consistently with rigidity-flexibility measures and an attitude scale of social responsibility.[6] Limited demographic data were collected during the first three cycles, but since 1974 we have taken a more complete personal data inventory, the Life Complexity Inventory (LCI), which includes topics such as major work circumstances (with homemaking defined as a job), friends and social interactions, daily activities, travel experiences, physical environment, and lifelong educational pursuits. Because of our interest in exploring age changes and differences in factor structure, multiple markers for most abilities were included beginning with the fifth (1984) cycle. The primary abilities of verbal comprehension, spatial orientation, inductive reasoning, numerical computation, and perceptual speed are now measured at the latent-construct level.[6,7] Measures of verbal memory, a criterion measure of real-life tasks (the Basic Skills Test from the Educational Testing Service), and a scale for measuring participants' subjective assessment of ability changes between test cycles have also been added. Health history records have been obtained for subjects followed at least 14 years; each outpatient visit or hospital day is coded by diagnosis, and annual counts of illness incidents and illness episodes are calculated.

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BRIEF SUMMARY OF RESULTS FROM THE SLS

Throughout the history of the SLS, an effort now extending over 36 years, we have focused on five major questions, which we have attempted to ask with greater clarity and increasingly sophisticated methodologies at each successive stage of the study.[5] This summary reviews these questions and indicates what we have learned from the SLS to date to answer them.

Does Intelligence Change Uniformly Through Adulthood, or Are There Different Life-Course Ability Patterns?

Our studies have shown that in adulthood, there is no uniform pattern of age-related changes across all intellectual abilities. Limiting one's concern to an overall index of intellectual ability (IQ) therefore does not suffice to understand age changes and age differences in intellectual functioning for either individuals or groups. Figure 1 shows longitudinal age trends on the five primary mental abilities that have been studied throughout our investigations.[2] Our data provide support for the proposition that active or fluid abilities (those that are primarily genetically determined) tend to decline earlier than passive or crystallized abilities (those that are primarily acquired through cultural mechanisms such as schooling and experience). There are, however, important ability-by-age and ability-by-cohort interactions that complicate matters. Our more recent cross-sectional data suggest that women may decline earlier on fluid abilities than on crystallized abilities, whereas men exhibit the opposite pattern. Fluid abilities begin to decline earlier, but crystallized abilities show steeper decrement than fluid abilities once the late 70s are reached.[1,3,5] Age

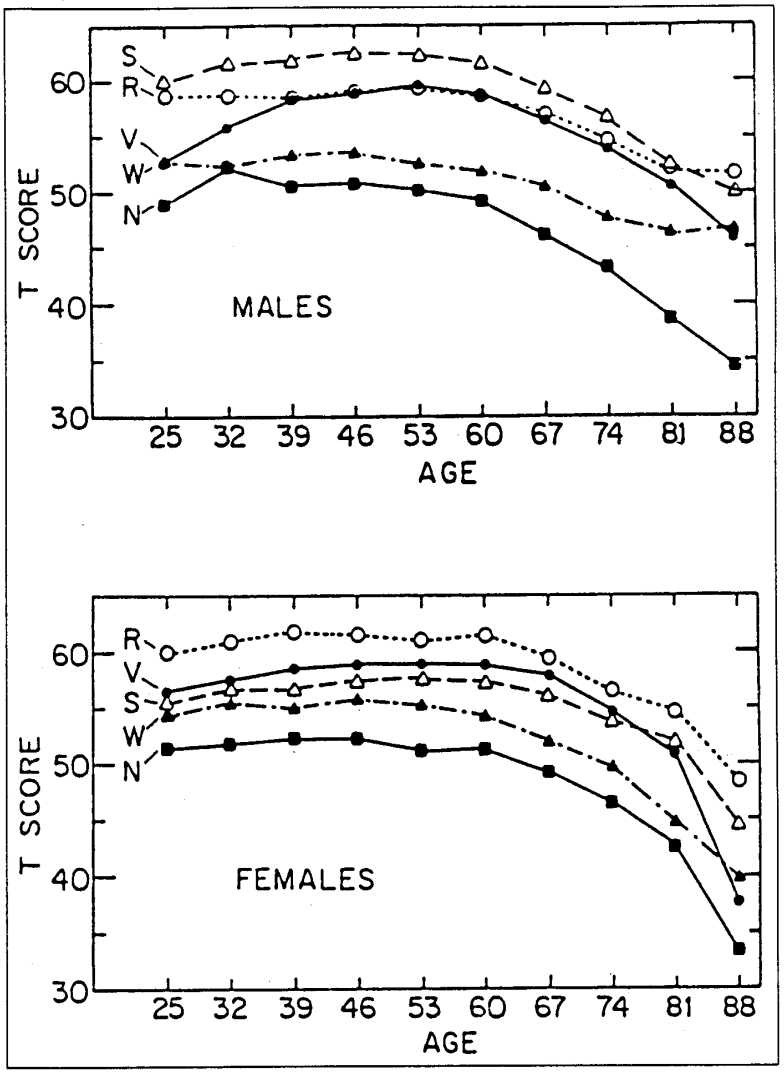

Fig. 1. Longitudinal age changes on the primary mental abilities, by gender, based on observed changes over 7-year intervals. S = spatial orientation; R = inductive reasoning; W = word fluency; V = verbal meaning; N = number skill. *T* scores are standard scores with mean of 50 and standard deviation of 10. From Schaie.[1] Reprinted by permission.

changes in perceptual speed begin in young adulthood, and group averages show a virtually linear decrement.[8]

Although cohort-related differences in the rate and magnitude of age changes in intelligence remained fairly linear for cohorts entering old age during the first three cycles in our study (until 1970), they have since shown substantial shifts. For example, scores are declining less rapidly now in old age. At the same time, younger groups are scoring lower on tests at the same ages, as we begin to study members of the baby-boom generation. Patterns of socialization unique to a given sex role within a specific historical period may also be major determinants for the pattern of change in abilities. When age changes are decomposed into those due to loss in accuracy and those due to loss in speed, men show greater loss in speed, while women lose more in accuracy.

Cross-sectional analyses of the stability of correlations among the primary mental abilities have recently been conducted over a wide age range. The pattern of factor loadings remains similar across adulthood; however, magnitudes of factor loading do change, indicating that some tests may not measure the same ability with equal efficiency at all stages of the life course.[7] Furthermore, the relevance of these findings to everyday behavior has been established by demonstrating substantial relationships between the psychometric abilities and real-life tasks.[9]

At What Age Is There a Reliably Detectable Age Decrement in Ability, and What Is the Magnitude of That Decrement?

Data collected during the first three SLS cycles indicated that average age decrements in psychometric abilities could not be confirmed reliably prior to age 60, but that reliable average decrement is indeed found for all abilities by age 74. More recently, however, we have found small but statistically significant average decrement for some, but not all, cohorts in their 50s. However, even at age 81, fewer than half of all observed individuals showed reliable decrements over the preceding 7 years. Average decrement before age 60 amounts to less than two tenths of a standard deviation, but by age 81, average decrement increases to approximately one standard deviation for most abilities.[1] The magnitude of decrement, however, is significantly reduced when age changes in perceptual speed are removed.[8] Data from the SLS have provided a normative base to determine at what ages declines reach practically significant levels relevant to public policy issues such as mandatory retirement and age discrimination in employment or to determine what proportion of the population can live independently in the community.

What Are the Patterns of Generational Differences, and What Is Their Magnitude?

Controversy remains with regard to the complex assumptions required for the estimation of generational effects. Nevertheless, results from the SLS have demonstrated conclusively the prevalence of substantial generational (cohort) differences in psychometric abilities.[1,3] These cohort trends differ in magnitude and direction by ability and therefore cannot be determined from composite IQ indices. On the one hand, for some abilities, later-born groups have attained successively higher scores at the same ages; that is, positive cohort gradients have been observed for inductive reasoning, verbal meaning, and spatial orientation. On the other hand, number skill peaked with the 1924 birth cohort and has progressively declined thereafter (i.e., has a negative cohort gradient). More recently born cohorts are also at a disadvantage when compared with prior cohorts on word fluency. These findings are similar to those observed for the Scholastic Aptitude Test (SAT) scores. As the baby boomers enter adulthood, their scores continue the negative cohort trends observed in adolescence. From these findings, we conclude that cross-sectional studies used to model age change overestimate age-related decline prior to the 60s for those variables that show positive cohort gradients and underestimate such declines for variables with negative cohort gradients (e.g., for perceptual speed[8]).

The work on generational differences in abilities among unrelated individuals has recently been supplemented by studying family members of our longitudinal-study participants. Most work in developmental behavior genetics has been conducted by means of twin studies and family studies of parents and offspring and nontwin siblings. In the past, family studies employed parents and their young offspring and young sibs; our study is the first effort to explore systematic family similarity through adulthood, and to test for stability of such similarity over time.[4]

Substantial family similarity of an average magnitude of about .25 was found for virtually all mental abilities and measures of flexibility. The similarities were found for parents and their offspring (adult children) and for siblings (brothers and sisters). The two exceptions to this finding were for the attitude measure of social responsibility and for a measure of perceptual speed, neither of which seems to show heritable variance. The magnitude of parent–offspring and sibling similarity differed for different abilities, and the overall similarity was somewhat greater for parent–offspring than for sibling pairs. The sizes of the correlations were also comparable to those found between young adults and their children in other studies.

We examined whether the degree of similarity in ability between parents and their adult children differed for younger and older parents. Because of changes in society, it has been argued that there ought to be a reduction in family similarity for younger as compared with older parent–offspring pairs. The possible reduction in shared environmental influence is thought to be due to increased outside influences in the more recent generation. However, this proposition could be supported only for reasoning and overall IQ, for which the old and middle generations showed somewhat greater similarity with their adult children than the younger generation did. For other abilities, we found stability, and for some abilities (verbal meaning and spatial orientation), an increase in family similarity for more recent generations. Correlations of

the performance of offspring or siblings with the subjects who had been in the longitudinal study remained similar over 7, 14, and 21 years, providing additional strong evidence for stability of family similarity over time and age.[4]

What Accounts for Individual Differences in Age-Related Change in Adulthood?

A unique contribution of a longitudinal study such as ours is the investigation of individual differences in antecedent variables that lead to early decrement for some persons and maintenance of high levels of functioning for others well into very advanced age. We have implicated a number of factors that account for individual differences in rate of cognitive change, and some of these factors have been shown to be amenable to experimental intervention. Although controlled experiments are required to confirm the causality of antecedent variables, an understanding of temporal priority provides important clues that then form the basis of subsequent interventions. Variables thus far implicated in reducing the risk of cognitive decline in old age include (a) absence of cardiovascular and other chronic diseases, (b) favorable environment mediated by high socioeconomic status, (c) involvement in a complex and intellectually stimulating environment, (d) flexible personality style at mid-life, (e) high cognitive status of spouse, and (f) maintenance of high levels of perceptual processing speed.

Can Intellectual Decline With Increasing Age Be Reversed by Educational Intervention?

Because longitudinal studies permit tracking individual levels over time, we were able to design interventions that remediate known intellectual decline and reduce the effects of cohort differences in individuals who have remained stable in their own performance over time but who have become disadvantaged compared with younger persons. The cognitive training studies conducted with our longitudinal subjects suggest that observed decline in many community-dwelling older people is likely to be a function of disuse and is often reversible. Indeed, approximately two thirds of our experimental subjects showed significant improvement, and about 40% of those who had declined significantly over 14 years were returned to their predecline level.[10] We have shown also that we did not simply train the test, but rather trained at the ability (latent construct) level, and that the training did not disturb the ability structure. Training gains represent primarily increased accuracy for men, but a mix of improvement in accuracy and speed for women.[10] In our recent follow-up, we have shown that trained subjects remained at a significant advantage over control subjects even after 7 years, and we have replicated the effects of initial training with a new cohort.

Some critics have expressed surprise that our cognitive interventions have been more successful than those in other studies. We believe that this success is related to more careful study design, extensive work in the development of training materials, and more careful outcome assessment than is possible in more limited intervention studies.

SUMMARY

The SLS has charted the course of selected psychometric abilities from young adulthood through old age and has investigated individual differences and differential patterns of change. We not only have been concerned with demonstrating the presence or absence of age-related changes and difference, but have provided data on the magnitude and relative importance of the life-course changes we have been studying. We have been able to identify contextual, health, and personality variables that offer explanations for differential change and that provide a basis for possible interventions. Most recently, we have begun to study age changes and differences in cognitive factor structure, have conducted analyses of the relative effect of speed and accuracy in age decline and training gain, and have investigated the relevance of cognitive training to real-life tasks. Within the context of the SLS, we have also studied cognitive similarity within parent–offspring and sibling pairs, and we have designed cognitive interventions that have been successful in remediating carefully determined declines and in improving the cognitive functions of older persons who have remained stable.

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