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The Natural History of a Longitudinal Study

In this chapter I will describe how I became intrigued with the study of psychological development from young adulthood to advanced old age, how I came to be a "gerontologist," and how my career became interwoven with a program of scientific inquiry conducted by me, my associates, and my students over the past thirty-five years that has come to be known as the Seattle Longitudinal Study (SLS).

SOME BRIEF BIOGRAPHICAL NOTES

I was born in the city of Stettin, which was then the capital of the German province of Pommerania, in 1928. My parents belonged to the Jewish middle class; my father and mother ran a small outfitters store for the then rapidly growing crowd of motor bikers. We lived in a three-room apartment in one of those dreary tenement blocks that had become common in most German towns by the turn of the century. Our apartment fronted the street and at least had a balcony that my mother kept covered with flowers during the warmer months, of which there are few on the shores of the Baltic. My native town was a sleepy, provincial city of about 150,000 inhabitants involved primarily in the garment industry, ship building, and fish processing. It also had a terminal for transferring grain and coal from the river barges to freighters that went to Scandinavia, Russia, and beyond. The big excitement was a visit to Berlin, which was an hour's train ride away. Today, Stettin is Poland's westernmost port city, and I confuse people by telling them that I was born in Poland, but have never lived there! Both statements are technically correct, since during my childhood, Poland was somewhere way off in the east and as a child I never knew anyone who spoke Polish!

Shortly after I was born the great depression hit Europe; hence I remained an only child. And not very long thereafter the unemployment lines lengthened, the Weimar Republic went on a self-destruct course, and Hitler and his Nazis took over. When I turned 6 years old, the time came to start elementary school, and I attended a private school that had hastily been formed by the local Jewish community to protect its children from the daily harassment experienced in the public schools. I attended that school through the middle of Fifth grade, learning enough basic skills so that I can still converse in German and write grammatically correct prose in that language, although studded with archaic colloquialisms that were common in the 1930s.

In the middle of Fifth grade came "Crystal Night" (November 9, 1938), the systematic destruction of Jewish synagogues and stores by Nazi hooligans, and the incarceration of most Jewish men in concentration camps. My father was able to avoid the latter by going into hiding. He desperately tried to find a way for our family to leave Germany, since the likely consequences of our remaining had become convincingly clear. By that time hardly any country was willing to accept Jewish refugees from Germany; thus the question was primarily one of how to get out, regardless of where one might wind up going. My father discovered that it was possible to book passage on an Italian cruise ship that plied a route through the Suez Canal and around India and Malaysia ending up in the Chinese port city of Shanghai. In June 1939 my parents and I took the train from Stettin to Trieste (the two anchor points in Winston Churchill's famous iron curtain speech!) and embarked not really knowing where we would go. After several futile attempts to go ashore along the way, we finally were allowed to enter Shanghai. At the time, Shanghai was still an international settlement governed by the consular representatives of seventeen nations that were signatories to the so-called "unequal treaties" that during the nineteenth century had forced foreign concessions upon Chinese soil that were not subject to Chinese law. Thus, the reason we were allowed to land was primarily because the amorphous local government had not been able to get its act together to keep us out!

To an 11-year-old, the trip to the Far East and the bustling and exotic streets of Shanghai seemed high adventure, and I gave little thought to the uncertain future facing my family. There was a large foreign population in Shanghai, with a substantial Jewish community that arrived either during the expansion of western trade in China or after the Bolshevik Revolution in Russia after World War I. Some of these people had even acquired great wealth, and they formed charitable organizations that attempted to provide shelter and food for all and education for the young. I attended a school for refugee children for about two years, acquiring English language competence, and completing an educational program that would approximate that of an American junior high school. Then

came Pearl Harbor. My English and American teachers were interned by the Japanese authorities, and I became an involuntary high school dropout at age 14!

After a few months at a private business school where I learned some typing, shorthand, and bookkeeping skills, I spent the next three years at various jobs as a clerk and telephone receptionist. After the Japanese authorities made all the refugees relocate to a ghetto area, vocational options became even more restricted. I was lucky to find a job as an apprentice in a small print shop. When the war ended in 1945 and the local English language newspaper reopened, I managed to get in their print shop and learned how to use a linotype machine and to typeset newspaper advertisements. During my final months in Shanghai I also had the opportunity to work as an untrained social worker with the American Joint Distribution Committee helping people about to resettle in the United States. Thus, in 1947, after my father's death, I decided it was time to resettle myself and my mother to the United States. We arrived in San Francisco in December of that year.

My printing experience served me well in finding a job, but as a newspaper printer this typically meant night work, with little to occupy my days. One day, while making up a newspaper page, I noticed a story on a high school program for adults at the local community college, and on the spur of the moment decided that it might not hurt me to have a high school diploma. I enrolled at City College of San Francisco and was able to test out of most requirements and obtained my diploma. Having gotten used to and liking the college setting, I decided to go on. I built my program of studies primarily around those courses that were offered in the afternoon, since I needed to sleep in the morning following my night shift as a printer. Since most science labs were offered in the morning, this meant that I was destined to concentrate on social science topics.

The California higher-education system allowed automatic transfer to the state university system upon graduation from junior college, and in the spring of 1950 I entered Berkeley as a psychology major. The first question my adviser asked was whether I intended to go on to graduate school, since she did not want to waste her time with me otherwise. I had not given much thought to graduate school, but since I wanted to retain my adviser, I agreed on the spot that this was what I intended to do. My casual decision was reinforced by the outbreak of the Korean war. Realizing that my student status would provide draft deferral as long as I remained in school, my decision to go to graduate school became the obvious choice.

During my first semester at Berkeley I took an excellent tests and measurement course from Read Tuddenham, who became my adviser during my second semester. Once again having trouble building a full schedule confined to the afternoons, I asked to do a directed study with him. Dis-

cussing various possibilities, I idly mentioned that I had thought his class discussion of Thurstone's (1938) primary mental abilities (PMA) work was interesting, and I wondered whether there had been any research on the PMA in adults. As a good teacher, Tuddenham told me to go to the library and find out.

In the 1930s Thurstone had analyzed more than sixty measures of mental ability with large samples of children and adolescents in Chicago. Applying his new method of centroid factor analysis he discovered that individual differences on these measures could be accounted for by no more than ten factors, which he thought of as the "building blocks of the mind." Thurstone published a formal test of the five most important of these ability factors. They were verbal meaning (a measure of recognition vocabulary), space (a measure of being able to rotate abstract figures in two-dimensional space), reasoning (a measure of the ability to induce rules from common features of an activity), number (a measure of addition skill), and word fluency (a measure of word recall).

After a thorough search it turned out that there were lots of data on children and adolescents but nothing on adults. Hence, I proposed a directed study to determine whether the low correlations between different abilities reported in childhood could be replicated in adulthood.

But where does an undergraduate find adult subjects beyond college age? As serendipity would have it, I was still being treated for the consequences of malnutrition during my Shanghai years. As it turned out, my family physician, Robert M. Perlman, was interested in geriatric practice. When I mentioned my subject problem to him, he offered to provide me with testing space and allowed me to recruit subjects in his waiting room. He also introduced me to Florence Vickery, the director of the San Francisco Senior Citizens Center, one of the first to be established in the United States. She also allowed me to recruit and test subjects at her facility. My first aging study was on the way. I was able to test several dozen subjects ranging from the twenties to the seventies. I found that the PMA remained distinct in adulthood, but that age differences were not identical for all abilities. As compared to the normative data for adolescents, it turned out that young adults and those in early middle age, on average, did better than the high school students. There were significant age differences thereafter, and older adults in particular did less well on space and reasoning than they did on their verbal and numeric skills. Administering the test to a subset of study participants in an untimed condition showed that the age difference patterns were even more pronounced when the speed restriction was removed.

Soon thereafter Dr. Perlman received an announcement that the Second International Congress of Gerontology was to be held in St. Louis, Missouri. Perhaps to ensure a tax-deductible trip, he suggested that I submit my findings as a convention paper with him as a coauthor. The paper was

accepted, but in order to report respectable statistics, I now had to recruit a friend, Fred Rosenthal, who was a semester ahead of me, to run the tests that I had not yet mastered. Thus, in August of 1951, I mounted the Greyhound bus for my first long American trip: St. Louis. Gerontology was still a very small group; the congress had about 200 registrants, two-thirds of whom were Americans. Perhaps no more than thirty were psychologists. I met many of the founders of geropsychology, including James Birren, Robert Kleemeier, Irving Lorge, and Robert Havighurst. This was very heady stuff for a college junior, and I was even more excited when the editor of the *Journal of Gerontology*, John Esben Kirk, invited me to submit my paper, entitled "Differential Deterioration of Factorially 'Pure' Mental Abilities," as a journal article and promptly accepted it. My entry into the field of adult developmental psychology and gerontology was obviously determined by these events!

During my last semester at Berkeley, I did some more reading on individual differences and became interested in the concepts of behavioral rigidity and perseveration, as studied by psychologists such as Kurt Lewin, Abraham Luchins, Jacob Kounin, and Charles Spearman. They suggested that the boundaries between different domains of behavior would rigidify with age, and that there would be increasing interference in shifting away from old and no longer appropriate strategies to the adoption of new and more appropriate problem-solving strategies. If this was the case, I thought that age differences in the PMA might well be explained by progressive reduction in cognitive functions for those who were more rigid to begin with or who became less flexible as they aged.

The article in press probably helped my acceptance into the clinical psychology program at the University of Washington. What was more important, in contrast to most of my classmates, I found an intellectual niche and I had a set of research objectives at the very beginning of my graduate training. In addition to obtaining the necessary clinical training to become an academic clinical psychologist, I wanted to focus my research on the interesting puzzle of why it is that some people maintain their intellectual powers into old age while others begin to decline at an early adult stage. I didn't realize it at the time, but I was posing a challenge, the response to which would occupy my entire career.

My first year as a graduate student was spent working my way through the various background courses needed to eventually pass the comprehensive examination. Having had excellent preparation in the conventional statistical methods at Berkeley, in a combined experimental and statistics course (taught by Warner Brown, Rheem Jarret, and Donald Riley), I was able to skip the usual first-year methods sequence, and dive directly into multivariate analysis and factor analysis (Paul Horst) as well as scaling methods (Allen Edwards) courses. Thus, I was ready to begin the development of an instrument to measure the rigidity-flexibility con-

cept that I had become interested in at Berkeley. I thought this might have explanatory value for individual differences in cognitive aging. I identified a set of ten potentially appropriate measures from the literature that I adapted for use with a population ranging in age from young adulthood to old age. Subjects were recruited from presentations given on various topics on personality in adulthood to church and fraternal groups as well as to adult education classes. I was able to test about 300 subjects over several months, and was ready to conduct a multiple group factor analysis (on a Monroe calculator, a device on which an analysis now requiring a few minutes of computer time then took several weeks of full-time work), in which I identified that the different measures could be represented as three dimensions of rigidity-flexibility. These factors were a *motor-cognitive rigidity* factor, representing difficulty in shifting problem-solving strategies on motor-cognitive tasks; an *attitudinal rigidity* factor, involving questionnaire responses that represented unwillingness to shift established behavior factors in favor of new and more appropriate behaviors, and a *psychomotor speed* factor, consisting of the ability to perform psychomotor tasks rapidly. I replicated the factor solution on another sample, and eventually published this material as the *Test of Behavioral Rigidity*. This work was accepted in early 1953 as my M.S. thesis (directed by Charles Strother, Paul Horst, and Sidney Bijou).

It is important to note here that no one on the Washington psychology faculty was particularly interested in adult development or aging. It was necessary, therefore, to create my own academic support system. I discovered that there was a latent interest in gerontology in a number of other departments, and I was able to convince the dean of the graduate school to sponsor a Committee on Gerontology. Of course, the committee needed an executive secretary; consequently, in the fall of 1953, I was finally able to give up working nights as a newspaper printer, since I was given fellowship support in return for staffing the new committee as well as pursuing my own research on aging.

As the first activity of the new committee, I proposed an intensive study of a group of well-functioning elders that would encompass not only psychological variables, but also include an examination of health status, physical activities, and environmental contexts. A small grant from the University of Washington research council to Charles Strother permitted the recruitment of twenty-five men and twenty-five women over the age of 70 years who had completed a college degree or beyond. Most participants came from the membership of the retired faculty association, supplemented by others living close to the university. Not surprisingly, this advantaged group still maintained high levels of functioning and activity on virtually all our measures. Several reports emerged from this study, the first was presented at the 1955 American Psychological Association meeting in San Francisco.

ORIGINS OF THE SEATTLE LONGITUDINAL STUDY

Having passed my comprehensive examinations, it was time to propose a dissertation project. I was now ready to put together my pilot work on rigidity-flexibility and intelligence. As serendipity would have it, Charles Strother, my adviser, had just been named chair of the board of trustees of the Group Health Cooperative of Puget Sound, one of America's first (and now, one of the largest) health maintenance organizations (HMO). The HMO was interested in doing a consumer satisfaction survey, but had neither staff nor financial resources to allocate. A deal was struck. I was allowed to collect my dissertation data on a random sample of the adult HMO members with the condition that I conduct the consumer satisfaction survey at the same time. This arrangement worked out well, because it allowed me to recruit subjects with the formula—"we wanted to learn about the characteristics and opinions of a random sample of the HMO membership"—rather than having to recruit directly for a psychological experiment.

I randomly selected about 3,000 persons, ranging in age from 22 to 70 years. I administered the PMA and my rigidity-flexibility test (the TBR—test of behavioral rigidity) until I had assessed twenty-five men and twenty-five women in each five-year interval. As it turned out, I was able to replicate my earlier findings on differential patterns of age differences in intelligence as well as show that peak ages of performance had risen (thirties or older) since the earlier work by Wechsler and others. Substantial significant correlations were also found between rigidity-flexibility and the ability measures, but I did not find the predicted causal relationship; that, as it turned out, required longitudinal data.

When I obtained my doctoral degree in 1956 there were no employment opportunities for someone specializing in gerontology. Consequently, my mentor advised me to strengthen my clinical skills through a year of post-doctoral study and then seek employment as an academic clinician. I obtained an appointment as a fellow in medical psychology at Washington University in St. Louis, gaining skills in the assessment of psychopathology and in behaviorally oriented psychotherapy under the supervision of Ivan Menseh, Laverne Johnson, and Jack Hafner. I also had the opportunity to do some research with James Weiss, a psychiatrist who directed the Washington University Psychiatric Outpatient Clinic, to develop a Q-sort instrument for assessing the attributes of the complaints that brought older patients to the clinic, reinforcing my interest in older populations.

In the summer of 1957, I was offered an appointment as assistant professor at the University of Nebraska to teach adult cognitive and personality assessment and to supervise students in the clinical program. Consequently, my interests turned to the development of an unobtrusive method

for objective personality assessment via the relation of color and personality. In this context, I studied school children as well as mentally retarded and mentally ill persons in state institutions, and almost abandoned my interests in human aging.

INVERTING A CROSS-SECTIONAL TO A LONGITUDINAL STUDY

In my fourth year at Nebraska, I was asked to teach the developmental section of the departmental proseminar. In preparing for that seminar, I was confronted with addressing the discrepancies between cross-sectional and longitudinal findings in the study of adult intellectual development. I soon became convinced that this issue needed to be addressed by following a structured cross-sectional sample such as the one I had collected for my dissertation. Subsequently, I designed a follow-up study that converted my original cross-sectional study of cognitive aging into a series of short-term longitudinal studies, each extending over the same seven-year period. I received funding for this study from the National Institute of Mental Health, and with the continuing cooperation of the HMO I went into the field in 1963 to conduct this follow-up. Additionally, I drew a new random sample from the HMO membership that permitted comparison of panels tested at the same age but at different times (known as "Schaie's most efficient design"). Thus the Seattle Longitudinal Study (SLS) was now in place! The first longitudinal follow-up provided some answers but it also raised sufficient methodological and substantive questions that have led to a continuing program of studies (including six major and several collateral data collections) that is still in progress. The basic design has been to retest participants every seven years, and to draw a new random sample—ranging in age from 22 to 84 years—on each test administration. Since our sample is located in Seattle, we established temporary field offices for each of the individual cycles. As more collateral studies have been added to keep us busy during the seven-year cycles, we now maintain a permanent Seattle field office. The longitudinal research program has been continuously supported by the National Institute on Aging since 1970, and has just recently been refunded to continue through 1998.

THE FURTHER BIOGRAPHICAL DATA

Throughout the course of our longitudinal study, my own professional development continued as well. I left my first academic position at the University of Nebraska in 1964 in order to organize a clinical training program at West Virginia University. Then, in 1965, I was asked to be the founding

director of a Human Resources Research Institute whose mission was to provide intellectual linkages between a new College of Human Resources and Education and the traditional social science disciplines in the College of Arts and Sciences. In the context of this institute I supervised research on the effects of the community action programs sponsored by Lyndon Johnson's "war on poverty," as well as statewide evaluations of the effects of early "headstart" programs. I was also able to conceptualize and receive funding for one of the first institutional training grants awarded by the National Institute on Child and Human Development to develop the concept of training in life span developmental psychology. Under this grant I initiated the series of conferences and monographs known as the West Virginia Lifespan Series. In 1968, I was prevailed upon to "simplify" my life by becoming chair of the Department of Psychology, a role I served in until 1973.

My old friend James Birren had founded the Andrus Gerontology Center at the University of Southern California in 1965. In 1973, I joined him as associate director for research (later director of the Gerontology Research Institute) and as professor of psychology. At USC I directed the interdisciplinary doctoral training program in aging and was instrumental in developing and overseeing a number of project-program efforts, trying to focus the skills of scientists in the biological, behavioral, and social sciences on major issues in the aging process. I also started a new longitudinal study of cognitive aging (including memory functioning) that I followed over a three-year period. It is now being continued by one of my former students, Elizabeth Zelinski.

Several years earlier I met Sherry Willis who taught at Pennsylvania State University. As our personal and professional interests began to merge, we decided that we should be at the same institution. I therefore left USC at the end of 1981 to accept an appointment as Professor of Human Development and Psychology at Penn State, and to marry Sherry. Since 1985, I have directed the Penn State Gerontology Center and in 1986 I was honored by the university with an appointment as the Evan Pugh Professor of Human Development and Psychology.

THIRTY-FIVE YEARS OF LONGITUDINAL STUDIES

The second cross-sectional study (1963) essentially replicated the findings of the base study. The short-term longitudinal study, however, disclosed substantially different information about peak levels and rate of decline. Publication of results was therefore delayed until a theoretical model could be built that accounted for the discrepancy between the longitudinal and cross-sectional data. These analyses suggested that comparisons of age group means needed to be conducted for the repeatedly measured samples as well as for successive independent samples drawn from the same cohort.

Results were reported that called attention to substantial cohort differences; that is, differences in level of functioning between groups tested at the same age but at successive points in time (e.g., 25-year-olds in 1984 and 1991). These findings questioned the universality and significance of intellectual decrement with advancing age in community-dwelling persons. To be specific, we found that because of increases in educational attainment and other favorable environmental and lifestyle changes over the past half century, successive cohorts will perform on many variables at a higher level than did their earlier predecessors at the same age. On the other hand, if some widely practiced skill is given less attention, there may be reductions in level of performance over successive cohorts. When cohort changes are positive, older persons look like they have declined, when, in actuality, they may have remained stable but at a lower level of attainment than their younger peers. On the other hand, when cohort changes are negative (that is, earlier-born cohorts attained a higher level than later-born cohorts), older persons may look like they have remained stable even though they have declined, because they compare favorably to younger peers who attained a lower peak performance in their youth. The first phenomenon was observed for reasoning, space, and verbal meaning, while the latter phenomenon occurred for number skills and word fluency.

While the cross-sectional data implied peaks in early adulthood with decline beginning in middle age and becoming severe in the sixties, the longitudinal data, by contrast, suggested little age-related decline prior to the sixties, and only modest decline during the decade of the seventies.

It soon became evident that conclusions based on data covering a single seven-year interval required further replication, if only because two occasions of measurement permit the examination of cross-sectional, but not of longitudinal sequences; the latter requires a minimum of three measurement occasions. Only longitudinal sequences allow designs that permit contrasting age and cohort effects. Hence, plans were made for a third data collection, which was conducted in 1970. In that cycle, as many persons as possible examined on the first two test occasions were retested, and a third random sample was drawn from the residual members of the base population.

The results from the third data collection seemed rather definitive in replicating the short-term longitudinal findings, but a number of questions remained. Discrepancies between findings in the repeated-measurement and independent-sampling studies suggested the need for a replication of the fourteen-year longitudinal sequences, and it also seemed useful to follow the original sample over twenty-one years. A fourth data collection was therefore conducted in 1977, again retesting the previous samples and adding a new random sample, this time from an expanded population frame. Continuous funding also made it possible

to address a number of bothersome questions. These included analyses of the consequences of shifting from a sampling without replacement model to a sampling with replacement paradigm, an analysis of the effects of monetary incentives upon participant characteristics, an examination of the aging of the tests, as well as causal analyses of health and environmental factors upon change or maintenance of adult intellectual performance.

From the beginning of the study we followed what was then the conventional wisdom of assessing each primary ability with that observable marker variable which was thought to be the most reliable and valid measure of a particular ability. With the widespread introduction of modern methods of factor analysis, it became obvious that we needed to extend our concern with changes in level of intellectual functioning in adulthood to the assessment of structural relationships within the ability domain. In a factor analysis one begins with a larger number of measures and seeks to obtain a solution which allows one to organize these multiple measures in the smallest possible set of distinct basic dimensions. This concern argued for collecting further data with a much expanded battery.

The fifth (1984) SLS cycle was the beginning of a major role for Sherry Willis, who brought her skills in designing and implementing cognitive training paradigms. A major part of the fifth cycle was therefore devoted to the implementation of a cognitive training study with our long-term participants aged 64 years or older. This study was designed to determine whether cognitive training in the elderly remediates cognitive decline or whether it increases the level of skill beyond those attained at earlier ages. The cognitive training programs involve teaching participants more effective strategies and providing immediate feedback. In this study we found that almost two-thirds of all subjects benefited significantly from a five-hour cognitive training program, and that 40 percent of those who had reliably declined could be brought back to the performance level they had shown fourteen years earlier. The cognitive training program was also shown to remove the "reliably demonstrated" gender difference on the spatial orientation measure.

The database available through the fifth cycle also made it possible to update the normative data on age changes and cohort differences. In addition, these data made it possible to control for the effects of subject dropout and practice from repeated test administrations. Finally, this cycle displayed the introduction of new measures, such as practical intelligence, analyses of marital assortativity using data on married couples over as long as twenty-one years, and development of actuarial tables that allow the prediction of risk of cognitive decline and of the age at which decline is to be expected for a particular individual.

The most recent (1991) study cycle included a set of four related studies. First, in collaboration with Robert Plomin, we took advantage of the

longitudinal data to begin a study of cognitive family resemblance in adulthood. Although family similarity in cognition has been previously documented in young children and their parents, we have not known whether this similarity also remains throughout adulthood. We did this by recruiting a large number of adult offspring and siblings of our longitudinal panel members. Interestingly enough, family similarity in cognitive functions remains about as strong throughout adulthood as previously demonstrated for young parents and their children. Second, we abstracted health histories on our panel members and conducted more detailed investigations of the relationship between health and maintenance of intellectual functioning. These studies show both the influence of chronic disease on maintenance of intellectual functioning, as well as the importance of intellectual competence in postponing the onset of chronic disease. Third, we conducted a seven-year follow-up on the cognitive training study, showing continuing effects of the training intervention, and have replicated the initial findings with a more recent cohort of older persons. Fourth, with the first longitudinal replication of our expanded test battery, we were able to conduct longitudinal analyses of cognitive ability structures, demonstrating the greater stability of longitudinal data, and further update our normative data.

CONTRIBUTIONS OF THE SEATTLE LONGITUDINAL STUDY

The SLS has charted the course of selected psychometric abilities from young adulthood through old age. It has investigated individual differences and differential patterns of change, and has described the differential magnitude and relative importance of the observed age differences and age changes. These efforts have corrected previously held popular stereotypes about the universality of cognitive declines with advancing age. An important feature of the study has been the detection of substantial generational differences in intellectual performance. We have identified a number of contextual health and personality variables that offer explanations for differential change and that provide a basis for possible interventions. Cognitive interventions were designed that have been successful in mediating carefully documented declines and that have improved the cognitive functions of those older persons who have remained stable. We have also studied changes in cognitive ability structures across age and different cohorts, conducted analyses of the relative effects of age decline and training gain on speed and accuracy, investigated the relevance of cognitive training to real-life tasks, and studied parent/offspring and sibling similarity in adult cognitive performance.

Throughout the history of the SLS, now covering more than thirty-five years, I have focused on five major questions which I have attempted to ask with greater clarity and increasingly more sophisticated methodology at each successive stage of the study. These questions are the following:

1. *What is the differential life course of intellectual abilities?* Our studies have shown that there is no uniform pattern of age-related changes across all intellectual abilities. Hence, studies using an overall index of intellectual ability (IQ) are of only limited use for an understanding of age changes and age differences in intellectual functioning whether in individuals or in groups. Our data do lend limited support to the notion advanced by John Horn and Raymond Cattell that active or fluid abilities tend to decline earlier than passive or crystallized abilities. However, gender difference trends suggest that women decline earlier on the active abilities, while men do so on the passive abilities. Although fluid abilities begin to decline earlier, crystallized abilities show steeper decrements once the late seventies are reached.

Cohort-related differences in the rate and magnitude of age changes in intelligence remained quite linear for cohorts that entered old age during the first three cycles of our study. However, in the more recent cycles, it was found that rates of decremental age change have abated, while at the same time, negative cohort trends are observed as we begin to study members of the baby-boom generation. It is becoming apparent that patterns of socialization that are unique to a given sex role within a specific historical period may be major determinants for the pattern of change in abilities.

2. *At what age can we observe a reliable decline in intellectual abilities and how large is the decline?* Our general finding has been that reliable average decline in mental abilities does not occur before age 60 for any ability, but that reliable average decline may be found for all abilities by age 74. However, detailed analyses of individual differences in intellectual change demonstrate that even at age 81 less than half of all observed individuals experienced reliable decline over the preceding seven years. Up to age 60, individual changes, when found, are almost trivially small. But, by age 81, average decrement rises to approximately one population standard deviation (a rather substantial change) for most abilities.

The findings from the SLS provide a normative base that can help determine at what ages declines reach practical significant levels of importance for public policy; related to such issues as mandatory retirement, age discrimination in employment, or the determination of the population that can live independently in the

community. These bases will shift over time, as we have demonstrated in the SLS: Both level of performance and rate of decline show significant shifts across successive generations.

3. *How do successive generations differ in intellectual performance?* The SLS has conclusively demonstrated the prevalence of substantial generational (cohort) differences in psychometric abilities. These cohort trends differ in magnitude and direction by ability and, therefore, cannot be determined from composite IQ measures. One conclusion of these findings is that when cross-sectional data are used as a first estimate of age changes within individuals, they will overestimate age changes before the sixties for those abilities that show negative cohort gradients, and underestimate age changes for those abilities with positive cohort gradients.
Our past studies of generational shifts in abilities have been conducted with random samples from arbitrarily defined birth cohorts. A supplemental and even more powerful demonstration of generational shifts was provided by our recent family studies which compare performance levels for individuals and their adult children.
4. *What are the causes of individual differences in age-related ability change in adulthood?* The most unique contribution of a longitudinal study of adult development stems from the fact that only longitudinal data allow us to investigate individual differences in antecedent variables that lead to early decline for some persons and maintenance of high levels of functioning for others well into very advanced age. In our study we have been able to implicate several factors that account for these individual differences, some of which are amenable to experimental intervention. The variables that we have identified as being important in reducing the risk of cognitive decline include: (a) the absence of cardiovascular and other chronic diseases; (b) a favorable environment that is often a consequence of high socioeconomic status; (c) involvement in a complex and intellectually stimulating environment; (d) flexible personality style at midlife; (e) marrying an intelligent spouse; and (f) maintaining high levels of perceptual processing speed.
5. *Can age-related intellectual decline be reversed through educational intervention?* Findings from the cognitive training studies conducted with our longitudinal subjects (under the primary direction of Sherry Willis) suggest that intellectual decline observed in many community-dwelling older people is likely to be a function of disuse and is therefore reversible for many persons. In our study, approximately two-thirds of the experimental subjects showed significant improvement, and about 40 percent of those who had

declined significantly over fourteen years were returned to their predecline level of functioning on the ability on which they were trained.

The dialectic process between data collection and model building that has been characteristic of the SLS, in addition to the increase in our knowledge base, has a number of methodological advances to the design and analysis of studies of human development and aging. In addition, the study has provided baselines for clinical assessment, and has made contributions relevant to education, basic instruction in geropsychology, and a variety of public policy issues.

WHAT LIES AHEAD?

Life as a professional gerontologist encourages one to believe that scientific productivity can be maintained well into advanced old age. Consequently, since mandatory retirement for academics finally ended this year, my future plans do not include formal professional retirement. Work in my laboratory has just started examining the role of health behaviors in the maintenance of physical health and high levels of cognitive functioning. We are busy with the secondary data analyses following our last study cycle, and we are branching out into studies of qualitative changes in word fluency over age. We expect to continue exploring the relation between psychometric intelligence and competency in the instrumental tasks of daily living, and we are committed to studying rate of intellectual aging in families and conducting a seventh study cycle beginning with a further follow-up on the effects of cognitive training in 1997. Finally, we hope to work on the relationship between our screening measures of cognitive behavior and neuropsychological assessment methods to explore the possibility of earlier identification of risks for dementia. If our subjects will allow us to conduct a postmortem, we might even be able to study anatomical and cellular features of the normal aging brain and their relations to cognitive behavior. Longitudinal studies have a life of their own; they involve multiple generations of students and investigators. For me it has been, and continues to be, an intellectually exciting and professionally rewarding odyssey.

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