Phenotypic Variation in Populations

Relevance to Risk Assessment

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VARIABILITY IN COGNITIVE FUNCTION IN THE ELDERLY:

IMPLICATIONS FOR SOCIETAL PARTICIPATION

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INTRODUCTION

There is a vast literature on the course of psychometric intelligence over the adult life span that has made us familiar with the finding that most abilities tend to peak in early midlife, plateau until the late fifties or early sixties, and then show decline, initially at slow pace, but accelerating as the late seventies are reached (Botwinick, 1977; Cunningham, in press; Labouvie-Vief, 1985; Schaie, 1980a). There remains some controversy on the specific ages at which certain abilities peak and on the ages at which significant decline can first be detected (Botwinick, 1977; Willis, 1985). Data from cross-sectional studies usually draw relatively pessimistic conclusions for those variables where positive cohort trends have been observed, and unduly optimistic conclusions for those variables where cohort trends have been negative. Age-comparative work is often flawed, moreover, because of the fact that it is difficult or impossible to match samples differing widely in age with respect to other variables that might critically effect the dependent variable of interest. Longitudinal studies are consequently called for, because they control for cohort effects and, of course, allow within-subject comparisons. Nevertheless, longitudinal studies may also yield under- or over-estimates of mean age changes, depending upon whether the longitudinal panel has been exposed to favorable or unfavorable attrition (Schaie, 1983b; Schaie & Hertzog, 1982).

Most of this research literature on cognitive functioning in adulthood has been useful primarily in informing us on group trends. Such trends, however, do not necessarily represent the patterns of cognitive change found for all or most individuals. Vast individual differences have been observed in virtually all biological and behavioral processes involved in human development (Shock et al., 1984). It thus becomes necessary to give close consideration to the many variations in which individual aging may be expressed (cf. Birren & Renner, 1977; Birren & Cunningham, 1985; Schaie, in press). No one would deny the inevitability of an accumulation of deleterious changes as we age. Many different factors, however, whether genetically or environmentally programmed, will influence the rate at which age changes occur. The specific purpose of this paper, therefore, is to examine the issue of variability in cognitive function by examining data on variability in a number of mental abilities. To do so, I shall present some detailed analyses from the

Seattle Longitudinal Study (SLS) for which data are available for five panels over a period of 28 years.

I will begin by presenting traditional cross-sectional data on group means from our most recent data collection to show that there are reliable average age differences between groups of different ages at one point in time. These data will also inform us on gender differences in abilities at various ages, as well as the age levels at which negative differences occur for various abilities. I will introduce a criterion at that point that will give us a first clue as to the extent of the overlap that is to be noted between the youngest and successively older samples. Next, I will examine the cohort gradients for selected abilities to show that the steep age differences observed at advanced ages might be spurious projections obtained by contrasting groups of individuals that have started adult life at different levels of ability. I will then contrast age differences with age changes, as estimated from seven-year longitudinal data to show that reliable age changes do occur as well within many individuals as they reach advanced age. I will further consider the distribution of individual differences across the age range from the twenties to the eighties and examine the extent of the empirically observed overlap between performance distributions at successive ages. Finally, I will comment on some of implications of these data for the societal participation of the elderly.

CHARACTERISTICS OF THE DATA BASE

The Subject Population

I began my inquiry into adult cognitive functioning some 30 years ago by randomly sampling 500 subjects equally distributed by sex and age across the range from 20 to 70 years from the approximately 18,000 members of a health maintenance organization in the Pacific Northwest (Schaie, 1983a). I reassessed survivors of the original sample and added additional panels in seven-year intervals. The sampling frame represents a broad distribution of educational and occupational levels, probably well representing the upper 75 per cent of the socio-economic spectrum. The population frame from which I have been sampling repeatedly has grown to a membership of over 300,000 individuals, but the general characteristics remain very comparable. The primary data to be examined here include the 1629 community-dwelling individuals (741 males and 888 females) who were examined in the fifth SLS cycle during 1983/85. These individuals had an average educational level of 14.3 years (SD = 3.06; Range: 1 to 20 years); their family income averaged $23,200 (SD = $9,606; Range: $1,000 to $50,000+). Occupational levels were rated on a scale from 0 for unskilled to 9 for professional occupations. Those individuals gainfully employed at the time of assessment averaged an occupational level of 6.8 (SD = 1.87). Most frequent occupations represented involve skilled trades, clerical, sales, managerial and semi-professional jobs.

The Measurement Variables

The variables to be discussed here include the first five Primary Mental Abilities identified by the Thurstones (1941). They were assessed with the SRA Primary Mental Abilities test (Thurstone & Thurstone, 1949; Schaie, 1985). Verbal Meaning (V) involves the ability to recognize and comprehend words; it is a measure of a person's recognition or passive vocabulary. This ability is assessed by providing individuals with a stimulus word and asking them to match it from a multiple choice list. Verbal Meaning is thought to be a crystallized ability that is acquired and maintained by exposure to culture-determined experiences. Spatial Orientation (S) is the ability to rotate objects mentally in two-dimensional space. This ability is involved, for example, in visualizing the direction one might enter a highway after having inspected a map, or in assembling a piece of furniture by following a set of instructions. Spatial Orientation is measured by providing the subject with an abstract stimulus figure and then asking the subject to select rotated examples of that figure that would match the stimulus upon mental rotation. Inductive Reasoning (R) is the ability to identify regularities and to infer principles or rules. It is a critical component of most problem-solving tasks. This ability is measured by asking subjects to complete a letter series task. Both Spatial Orientation and Inductive Reasoning are thought to be fluid abilities that are involved in the mastering of novel experiences. Number (N) is the ability to apply numerical concepts. The ability is measured by requiring subjects to check simple addition problems. Word Fluency (W) reflects the ability to retrieve words from long-term memory by means of a lexical rule; it is a measure of a persons's recallable or active vocabulary. Subjects are given a letter and are then asked to write as many words beginning with that letter as they can think of during a short time period. All of these measures are slightly speeded paper and pencil tasks.

In addition to the first five primary mental abilities, we will also report data on a verbal memory task, requiring immediate recall of a list of twenty meaningful words studied by our subjects (Zelinski, Gilewski, & Schaie, 1979). Finally, we present data on a basic skills test (Educational Testing Service, 1975) that measures a series of real life tasks (e.g., interpreting medicine bottle labels, obtaining information from bus schedules, charts, yellow pages in the telephone book, newspaper advertisements and editorials, and interpreting maps).

The Assessment Procedure

These measures were administered to small groups of subjects as part of a broader test battery that originally required approximately two hours in a single session, but has since grown to a 5-hour battery spread over two sessions. The Primary Mental Ability measures, however, always have been given in the same position during the first part of the testing session. The tests are administered in a standard format and order by an examiner assisted by a proctor. Testing locations are at familiar sites close to the homes of our participants. Subjects first were tested in 1956 and survivors were retested in 1963, 1970, 1977 and 1983/85. The data discussed here, however, are restricted to those obtained in 1977 and in 1983/85.

FINDINGS ON AVERAGE AGE DIFFERENCES

We begin our exploration by examining the cross-sectional age differences for the 1983/85 assessment. To facilitate convenient comparisons across all the measures, all raw scores were rescaled in T-score form (M = 50, SD = 10) using the parameters obtained for the entire 1983/85 sample. Scaling in this fashion also helps us to understand the magnitude of age differences by placing them within the context of a broader population frame. For example, since 50 per cent of the population is found within the range of plus/minus 2/3 SD about the mean, an average shift of 13 T-score points would be required before the middle half of one age group would cease to overlap with the middle half of another age group.

Performance differences for the seven variables described above are listed in Tables 1 and 2, with means, standard deviations and sample sizes for each age group from mean age 25 to mean age 88 in seven-year intervals. Since one of the major individual difference variables is gender, we have

Table 1. Means and standard deviations for five Primary Mental Abilities for mean ages 25 to 88 years in T-Score units (M = 50, S.D. = 10).

Mean Age	N	Verbal Meaning		Spatial Orientation		Inductive Reasoning		Number		Word Fluency	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
25	(84)	54.38	7.87	56.25	10.45	59.11	7.59	48.87	8.61	55.06	10.86
32	(81)	54.53	7.58	55.40	7.87	58.15	7.80	51.44	9.80	55.11	9.16
39	(124)	56.17	6.54	55.21	10.39	57.84	6.83	51.39	8.78	54.93	9.01
46	(154)	55.68	7.88	55.69	9.47	56.23	7.51	51.77	9.51	53.64	8.43
53	(194)	53.90	7.43	53.46	9.30	54.17	8.01	50.98	10.55	52.58	9.44
60	(262)	52.65	8.16	51.44	8.71	51.43	7.97	52.31	10.73	50.09	10.00
67	(292)	49.31	8.90	48.27	8.68	47.44	8.18	50.67	9.64	48.06	8.82
74	(261)	44.59	8.72	44.63	7.70	43.37	7.59	48.80	9.16	46.58	9.05
81	(136)	39.14	8.77	41.53	6.48	38.74	6.59	44.15	9.20	43.53	9.04
88	(41)	34.42	8.49	37.54	5.12	36.31	6.17	41.29	8.70	40.58	7.66

Table 2. Means and standard deviations for measures of immediate recall and for performance on real life tasks for mean ages 25 to 88 years in T-Score units (M = 50, S.D. = 10).

Mean Age	N	Immediate Recall		Real Life Tasks	
		Mean	S.D.	Mean	S.D.
25	(37)	59.48	7.78	56.06	3.52
32	(74)	56.94	7.95	55.87	4.78
39	(112)	57.23	7.89	56.07	2.33
46	(144)	55.62	8.39	55.21	3.93
53	(182)	52.12	8.38	54.02	4.09
60	(246)	50.53	8.79	52.76	5.63
67	(288)	48.77	9.72	50.51	8.53
74	(254)	45.04	8.32	45.19	10.25
81	(124)	41.99	8.83	37.30	12.80
88	(39)	39.68	9.38	28.22	11.94

provided graphic representations of age differences in performance separately for men and women in Figures 1 to 7. As will become evident, there are substantial reliable age differences favoring younger adults, as well as significant gender differences. However, the age level at which significant differences from young adults can be detected, as well as the presence and direction of gender differences are quite ability-specific. These specific patterns of age differences will next be examined.

Figure 1 shows the age difference patterns for Verbal Meaning, a measure of recognition vocabulary. Overall there is a slight trend for women to perform better then men ($p = .06$). However, sex differences reach statistical significance only at age 60. Note that positive age differences prevail to a peak at age 39. A significant negative age difference is first detected at age 67. However, it is not until age 81 that the middle half of that age group ceases to overlap with the youngest sample (25 year-olds). Variability within samples decreases slightly until age 39, increases until age 67 and then remains at the same level.

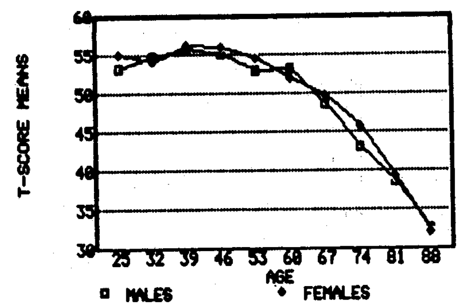

Fig. 1. Age difference patterns for Verbal Meaning

Age difference patterns for Spatial Orientation is shown in Figure 2. There is a highly significant gender difference in favor of males. This difference appears throughout the adult life span, although it is not statistically significant for the two oldest groups. Significant negative age differences for Spatial Orientation are first shown at age 53. Again, it is not until age 81 that there is no overlap for the middle half with the youngest sample. Variability on Spatial Orientation, however, peaks in young adulthood and linearly decreases thereafter.

Figure 3 shows the age difference patterns for Inductive Reasoning, the ability to draw inferences and identify rules; skills that are basic for activities requiring complex problem-solving. Overall, women perform significantly better than do men. When examined separately by age, however, this female superiority is statistically significant only during middle age and early old age (46 through 67 years). Significant negative age differences are first noted as early as age 46. Overlap of the middle half of the older sample with the younger group ceases to be found by age 74. Variability decreases slightly in young adulthood, then rises again until early old age, with decreasing variability thereafter.

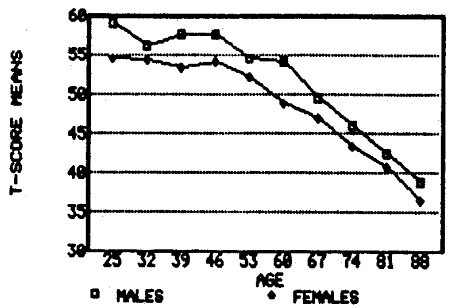

Fig. 2. Age difference patterns for Spatial Orientation

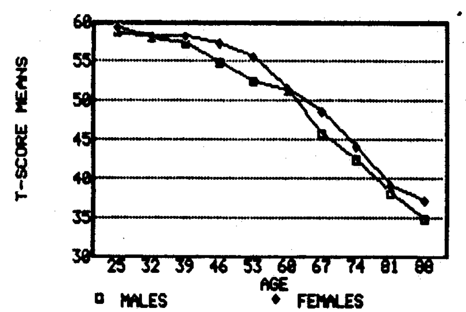

Fig. 3. Age difference patterns for Inductive Reasoning

Age difference patterns for Number, our measure of quantitative skills, are shown in Figure 4. Although there is an overall significant gender effect favoring males, we can detect reliable sex differences within age groups only at ages 32 and 60. Age differences for this variable differ markedly from those previously examined. Statistically significant positive age differences are found up until age 60, and significant negative differences do not occur until age 81. Even at age 88, the middle half of the sample still overlaps with the youngest group. Further, variability on Number increases until age 60, with subsequently decreased variability remaining at about the young adult level.

Word Fluency is our active vocabulary measure involving the recall of words; its age difference patterns are shown in Figure 5. Overall gender differences for this variable favor women. However, statistically significant within sub-sample differences are found only at age 46 and for the three oldest sub-groups. Significant negative age differences are first detected at age 60, but overlap of the older and youngest middle halfs does not cease until age 88. Word Fluency shows a modest decline in variability from young adulthood until middle age, with increased variability into early old age, and then further restriction of variability.

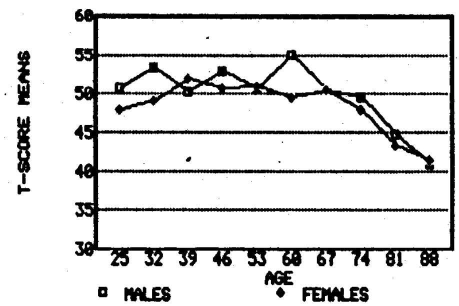

Fig. 4. Age difference patterns on Number.

Figure 6 provides the age difference pattern for our memory measures involving Immediate Recall of a list of meaningful words. Gender differences in memory clearly favor women. However, gender differences are not significant for the two youngest, the 60 year-old, and the oldest sample. Negative age differences in memory are the earliest detected difference and occur at age 39. Overlap of middle halves ceases to prevail by age 74. There are only relatively modest age differences in variability, with a trend for greater variability with advancing age.

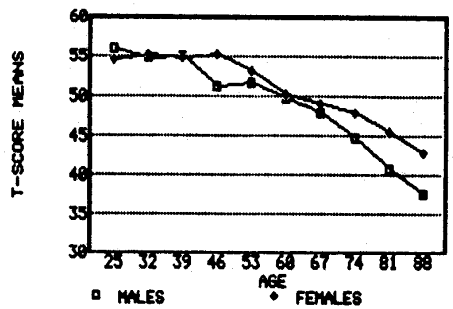

Fig. 5. Age difference patterns on Word Fluency.

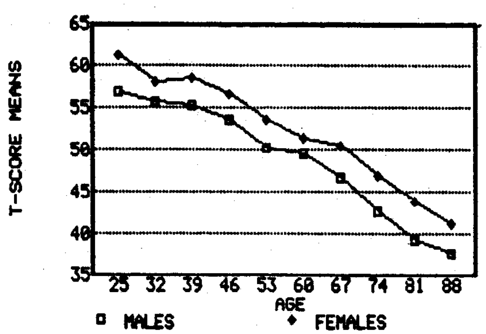

Fig. 6. Age difference patterns on Immediate Recall.

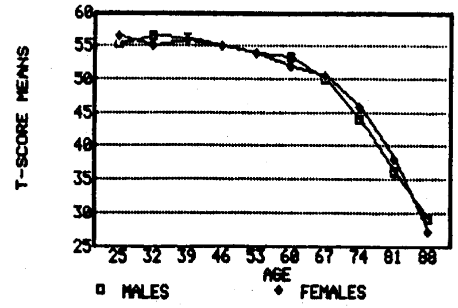

Figure 7. Age Difference Patterns on Real Life Tasks.

Our final variable is the measure of Real Life Tasks, age difference patterns for which are shown in Figure 7. No significant gender differences were found on this measure. Significant negative age differences are first detected here at age 53, but once again, overlap of middle halves for the older and youngest groups does not ceases until age 81. By contrast with the other variables, there is a marked and almost exponential increase in variability from young adulthood until old age. That is, there is much greater variability in old age on the complex measure of everyday activities than in the more specific and abstract laboratory measures of the basic mental abilities.

EFFECTS OF COHORT CHANGES IN ABILITY LEVEL

We must next consider the possible effects of socio-cultural change and consequent changes in population characteristics that might affect performance on measures of cognitive abilities (Schaie, 1986). For those abilities that have been measured in the SLS on several occasions it is possible to obtain fairly good estimates of differences in average performance for successive cohorts at the same age. In fact, we have available as many as four estimates for successive cohorts data for the Primary Mental Ability measures which were reported above, so we can obtain cumulative estimates of cohort changes. In Figure 8 we contrast the cumulative effects of cohort changes upon four of the abilities discussed earlier. Cumulative changes have been computed from the 1896 base cohort, the earliest included in our study.

There are substantially different patterns. The cohort change gradient for Inductive Reasoning displays virtually linear increment. If the youngest and oldest cohort could have been compared at the same ages we would have found no overlap between the middle halves for the two groups. The cohort changes for Verbal Meaning are almost as substantial. However, change here has slowed, with no further increment observed for the two most recent cohorts. Spatial Orientation shows modest positive cohort change until the 1938 cohort. From then on the cohort profile is mildly negative. The pattern for Number is one of positive change for the two oldest cohorts followed by a shallow negative profile up until the most recent cohorts. Given these performance level changes across cohorts, it follows that

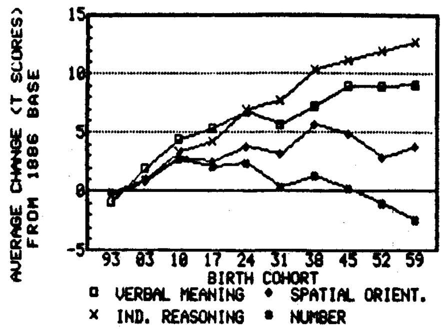

Fig. 8. Cumulative cohort changes for the Primary Mental Abilities.

cross-sectional data should yield over-estimates of negative age differences for Inductive Reasoning and Verbal Meaning, relatively realistic estimates for Spatial Orientation, and under-estimates of negative differences for Number. We can test this proposition by contrasting cross-sectional with short-term longitudinal data.

COMPARISON OF CROSS-SECTIONAL AND LONGITUDINAL ABILITY DATA

We are interested in obtaining sample parameter estimates that tell us whether age-comparative data collected at one point in time provide a distorted estimate of age changes within the same cohort. We consequently base our estimates of longitudinal change over time on the differences between average scores for each cohort obtained in 1977 and 1983/85. To obtain the largest possible cell sizes we aggregate the data across gender. The within-cohort differences then are cumulated from the youngest age level. Since the estimates come from independent random samples from each cohort they control for attrition, practice and testing effects, and are thus directly comparable to the cross-sectional data (Schaie, 1977). These cross-sectional/longitudinal comparisons are shown in Figures 9 to 12.

As predicted, the discrepancy between cross-sectional and longitudinal data is the greatest for Inductive Reasoning and Verbal Meaning, those abilities that showed the most dramatic cohort change gradients. For Inductive Reasoning, that the early decrement suggested by the cross-sectional data appear to be an artifact of the cohort changes. In the longitudinal data, the age difference profile is virtually flat until age 60, with the first statistically significant negative age difference shown by age 67 (see Figure 9). Moreover, the difference between the youngest and oldest group is now less than a standard deviation. Equally dramatic are the differences between cross-sectional and longitudinal data for Verbal Meaning. Here there are significant positive differences until age 60 is reached. Thereafter modest negative differences occur that become statistically significant by age 74. However, estimated performance in old age remains equal or better than that shown in young adulthood; e.g., there is no significant difference between the longitudinal estimates for ages 25 and 88 (Figure 10).

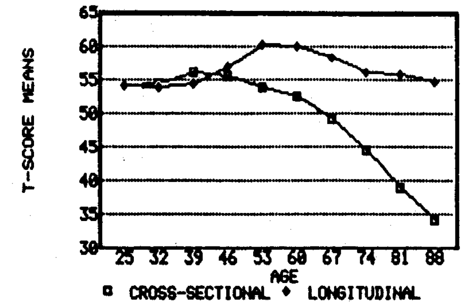

Fig. 9. Comparison of cross-sectional and longitudinal age differences for Inductive Reasoning.

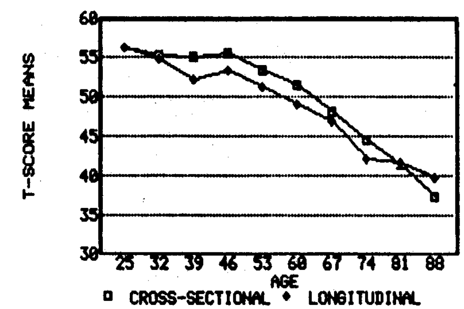

Fig. 10. Comparison of cross-sectional and longitudinal age differences for Verbal Meaning.

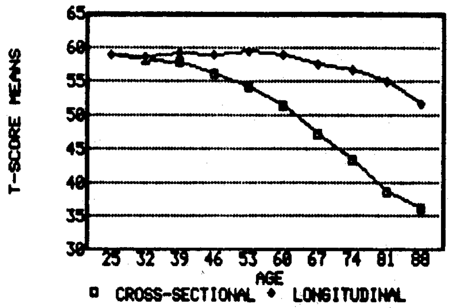

Fig. 11. Comparison of cross-sectional and longitudinal age differences for Spatial Orientation.

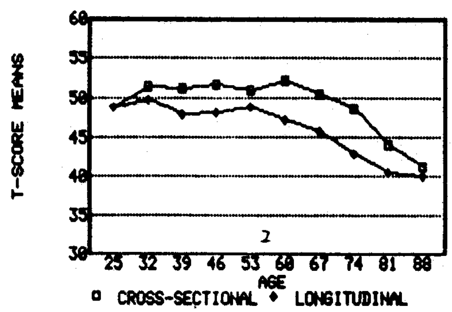

Fig. 12. Comparison of cross-sectional and longitudinal age differences for Number.

Quite different findings occur for Spatial Orientation and Number. Th longitudinal age gradient for Spatial Orientation shown in Figure 11 has a negative slope quite comparable to the cross-sectional data. The major difference is that longitudinal data suggest possibly even earlier age changes (albeit not statistically significant until age 53), but somewhat less pronounced differences in advanced old age. Likewise, the longitudinal data for Number (Figure 12) suggest a virtually level age difference pattern until age 53, with negative age differences becoming apparent by age 60 and statistically significant by age 67. Just as the positive cohort gradients for the first two abilities suggest the possibility of greater decline within individuals than shown in the longitudinal data, so do the negative cohort gradients lead to over-optimistic projections for the latter abilities. The moral, of course, is that one needs to obtain data across time to fully understand the magnitude of changes within individuals or populations.

CONCURRENT OVERLAP OF PERFORMANCE IN SAMPLES OF DIFFERENT AGE

Whether cross-sectional samples under- or over-estimate age differences that may occur within individuals as a function of cohort changes, they are, nevertheless, of considerable interest in examining concurrent levels and distributions of performance at different ages. In fact, such data are needed to give us the kind of information on the relative advantage or disadvantage of populations at different ages that are required to adjudicate a number of current policy issues. For example, these data allow us to determine what proportion of individuals have sufficient cognitive competence to live independently, or to consider what might be the consequences of modifications of retirement rules. For these purposes it does not suffice to consider merely data on group averages such as those provided in Tables 1 and 2 and displayed graphically in the first seven figures. First of all we must examine just how powerful age is as a predictor of performance, and then examine specifically the degree of empirically observed overlap of performance across age levels to determine the probability that older persons at specific ages will be at a disadvantage when compared with younger individuals, or conversely to note the proportion of older individuals that are found to function within the range provided by a younger reference population.

Rather than computing correlations between age and abilities directly we used our ten seven-year cohort classifications as our independent variable. Positive correlations, consequently, imply that the later born cohorts perform at a higher level than the cohorts born earlier. As suggested by the mean age difference data presented earlier, the highest age/ability correlation is shown by Inductive Reasoning ($\underline{r}$ = .621); with age thus accounting for roughly 38 per cent of the individual difference variance in the dependent variable. Considerably less variance is explained by age for the other four ability measures. Age accounts for approximately 25 per cent of the variance for Verbal Meaning ($\underline{r}$ = .496); 22 per cent for Spatial Orientation ($\underline{r}$ = .470); 13 per cent for Word Fluency ($\underline{r}$ = .365); and only 2 per cent of the variance for Number ($\underline{r}$ = .147). Age is a more important predictor with respect to our memory measure of Immediate Recall, accounting for about 24 per cent of the variance ($\underline{r}$ = .488); and even more so for the measure of Real Life Tasks ($\underline{r}$ = .545), where age accounts for approximately 30 per cent of the variance.

These figures show that age is an important characteristic that may indicate an individual's relative cognitive performance with respect to the population distribution at a particular point in time. They also suggest, however, that in all instances variables other than together are more important than age in assigning an individual's position on the ability

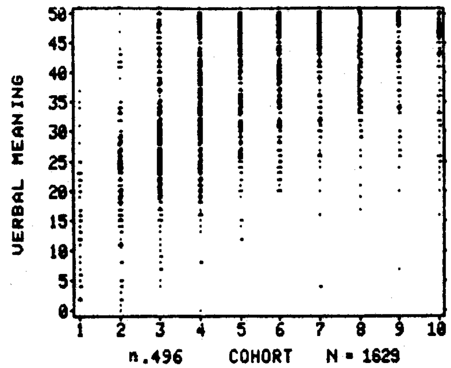

Fig. 13. Scattergram for the age distribution for Verbal Meaning.

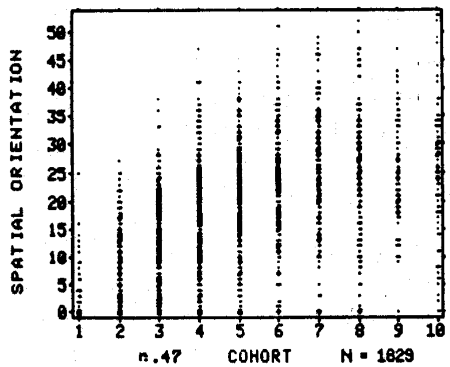

Fig. 14. Scattergram for the age distribution for Spatial Orientation.

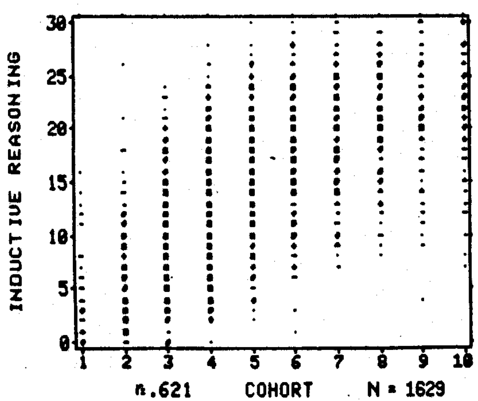

Fig. 15. Scattergram for the age distribution for Inductive Reasoning.

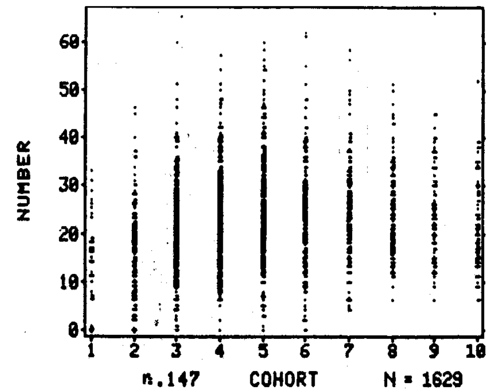

Fig. 16. Scattergram for the age distribution for Number.

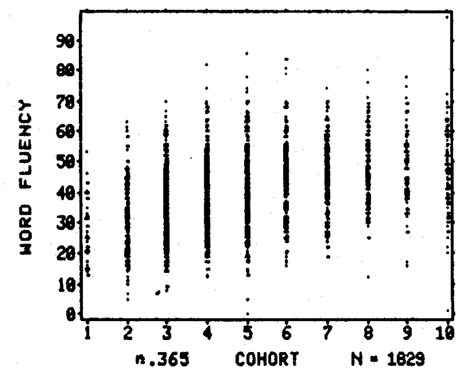

Fig. 17. Scattergram for the age distribution for Word Fluency.

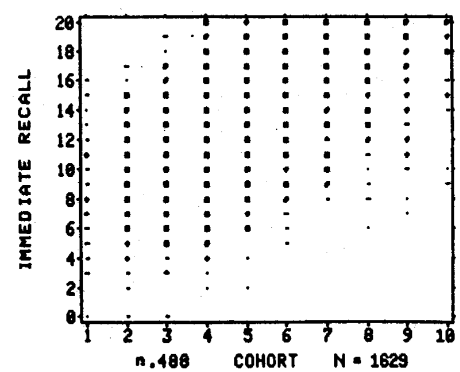

Fig. 18. Scattergram for the age distribution for Immediate Recall.

spectrum. To illustrate the resultant overlap of sample distributions over the adult life span, we provide scattergrams linking cohort membership and performance level in Figures 13 to 19. These scattergrams show the oldest to the youngest cohorts (age range from 25 to 88 years) from left to right. Although, with the exception of numerical skills, there are clear age trends, we also find that there is substantial overlap of distributions well into old age.

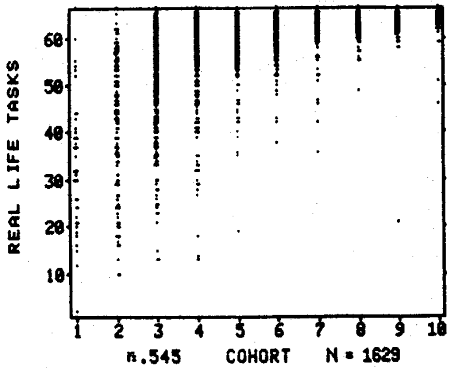

Figure 19. Scattergram for the age distribution for Real Life Tasks.

To examine the degree of overlap in a somewhat more formal fashion, I have computed proportions of overlap of successive age groups with the youngest sample (average age 25), from the variance estimates provided in Tables 1 and 2. If one assumes that the underlying populations are normally distributed,tables of the normal curve can be used to estimate the proportion of the joint distribution of two samples shared by members of both samples. Table 3 provides the results of these calculations for the seven variables shown in the scattergrams. The data immediately show that for all groups until age 60 there is greater than 90 per cent overlap for all variables with the youngest age group. Even at age 67 that degree of overlap prevails for all variables except Inductive Reasoning. At age 74 there is still better than 90 per cent overlap for Verbal Meaning, Spatial Orientation, Number, and Word Fluency, all variables other than Inductive Reasoning. That degree of overlap prevails at age 81 for the latter two variables, and even at 88 for number skills. Indeed, it is only for Inductive Reasoning that there is complete lack of overlap at any age.

SOME IMPLICATIONS FOR SOCIETAL PARTICIPATION

The major portion of this paper has been concerned with presenting current data on variation with age in cognitive abilities across the major portion of the adult life span, to characterize the distortions introduced by differential cohort flow, and then to demonstrate the tremendous degree of overlap in performance across the adult age range. It now remains to comment briefly on some of the implication of these findings for the societal participation of older individuals.

Table 3. Proportion of overlap at successive ages with score distribution at age 25.

Mean Age	Verbal Meaning	Spatial Orient.	Inductive Reasoning	Number	Word Fluency	Immediate Recall	Life Tasks
			Per Cent Overlap				
32	99.74	99.63	99.59	99.90	99.74	99.25	99.69
39	99.86	99.62	99.52	99.90	99.72	99.32	99.72
46	99.87	99.68	99.12	99.91	99.66	98.93	99.34
53	99.68	99.32	98.19	99.86	99.40	96.18	97.76
60	99.66	98.74	95.91	99.91	98.81	94.39	97.23
67	97.34	96.87	86.97	99.85	98.04	91.87	91.28
74	93.01	90.25	70.08	99.72	94.71	76.91	42.07
81	75.16	70.83	12.55	98.72	93.20	51.72	43.70
88	53.39	38.69	0.00	96.64	81.90	49.05	24.86

To begin with, it might be suggested that limitations imposed upon the full participation of our society's older members may generally be related to three major influences: increasing physical frailty, reduced cognitive competence, and societal constraints imposed by erroneous stereotypes. With the increased availability of environmental support reducing the physical demands of most occupations or everyday pursuits, physical frailty, except for those suffering from an acute disease, has ceased to be a major limitation for most older persons prior to the late eighties and above (Schaie & Willis, 1986a). As a consequence cognitive limitations have assumed increased importance in determining whether older individuals can continue to remain employed, participate in societal decision-making, or even continue to enjoy independent living and exert control over the economic resources they have acquired over a life time.

The data on age differences presented here demonstrate that the average older person, whether because of age-related decline or having started out at a lower level than today's young adults, may well be at disadvantage on many cognitive skills when compared with young adults. It is important to note, however, that statistically significant age differences may represent quite limited absolute orders of magnitude. For example, although average reaction times tends to increase by a factor of 1.5 to 2 from the twenties to the seventies, the actual increment in time required for the successful performance of a task of reasonable complexity will typically not exceed one or two seconds (Salthouse, 1985). Likewise, data from the SLS suggest that more complex cognitive processes show changes that are large in terms of absolute performance do not occur until the late seventies or early eighties (Schaie, 1980b, 1983a). Again, it is quite rare, that age differences reported in the literature prior to the late seventies attain a magnitude that on average would interfere with successful job performance.

To give a specific example, let me share with you my own observations, in the course of developing testimony in age discrimination litigation, of the performance of operators weighing trucks on a highway scale. I found that it took a truck on average something like 30 seconds to pass a scale operator's station, while only 6 seconds were required to perform the measurements. Slowing of reaction time leading to an increase of a second or two in time needed for the job operation consequently would be irrelevant to the operator's ability to do the job.

Much of the literature on adult cognitive development deals with very specific aspects of cognition and employs laboratory paradigms that are not necessarily representative of the complex processes involved in everyday tasks or occupational pursuits. For example, it is not at all clear whether the age distributions shown for performance on laboratory tasks would also be found for occupational pursuits. The literature on expertise shows that although many individuals experience some behavioral decrement by the time the late sixties are reached, such decrement does not seem to occur for highly practiced tasks at which the individual is an "expert." Maintenance of "expert" functions typically involves experience in carrying out a complex task. In other words, experience usually suffices to compensate for behavioral slowing on well-practiced tasks that are part of a person's job skill requirements (Charness, 1981; Glaser, 1987; Salthouse, 1987; Salthouse & Somberg, 1982).

It would seem to me, that the evidence suggests strongly that many factors other than age are more salient in determining cognitive performance than does chronological age until late mid-life. As old age approaches an increasing proportion of individuals, for a variety of physiological and experiential reasons, do suffer some decline in cognitive performance, albeit those aspects of decline that are primarily experiential are reversible (Schaie & Willis, 1986b). What is most important to keep in mind, however, is that the range of individual differences is so great, that until the late eighties are reached, many older persons can still be found who function at least within the average range of young adults. Consequently, it seems necessary to conclude that chronological age is not a proper indicator for the development of public policies that would exclude any person from full societal participation. The United States Congress in its recent revision of the Age Discrimination Employment Act seems to agree with this position.

The above considerations raise some exciting possibilities for behavioral and social scientists to engage in primary prevention of cognitive dysfunction in later adulthood at a number of different levels. There are three major areas that seem to be particularly amenable to behavioral intervention. The first is concerned with educating the media and the public services sector. Many of the assumed cognitive disabilities of early old age, as shown by our data, are for most persons not fact, but the presumption of such disabilities is directly related to stereotypes about aging that become self-fulfilling prophecies. It is of considerable importance therefore to provide guidance to the media that will lead journalists to concentrate upon the 95% of the elderly who are not institutionalized and to report on and show successful older individuals who display full cognitive competence. The public service sector, moreover, must be educated to be more understanding of the moderate cognitive changes occurring with age in some individuals and to consider the possibility of intervention in many such instances regardless of their client's age. Obviously this involves adoption of attitudes that lead to value their older clients as being of equal importance as those at other life stages and deserving of equally high quality service and attention.

Applied developmental scientists need also become active in the area of health education. Although an increasingly successful effort is being made to convince the public that dietary, smoking and drinking behaviors must be controlled by mid-life at the latest to assure physical fitness in old age, similar efforts still remain to be implemented in other behavioral areas. For example, educational efforts are needed to convince individuals to seek adequate compensation for sensory changes by attending to suitable modifications of their working and living environments. The data presented here suggest that many older persons function at cognitive levels that are well within the range of much younger populations groups. Those who do have the personality characteristics that let them structure their environment in appropriate ways can contribute serendipitously to maintain active stimulation of their cognitive processes (Schaie, 1984). But it is also possible to program formal obsolescence-reducing educational mechanisms and cognitive training programs that will improve the functional level of those older persons who show significant but experientially induced cognitive decline (Schaie & Willis, 1986b).

A third area in which behavioral and social scientists can provide interventions that would maintain the societal participation of a greater proportion of the elderly relates to the transition from the world of work to that of (not infrequently enforced) leisure. In the United States, recent changes in mandatory retirement legislation have led retirement to become an increasingly complex decision. The arbitrary guideposts of chronological age now provide constraining time frames rather than specific end points. With the end of legally permissible mandatory retirement for most employees, many employers are beginning to offer more flexible retirement options, with the intent of better utilization of older workers, but also providing more realistic plans for change and continuity in industrial organizations. These developments open new options and opportunities for individuals moving into old age but also add much uncertainty. Applied developmental scientists consequently need to become increasingly active in preretirement counseling programs, including formal assessment programs that help workers and their employers to appraise needs and abilities as they relate to reassignment or retirement decisions. Such processes will lean heavily on our understanding of the variability of individual performance at all ages.

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