Intergenerational Differences in Adult Cognitive Behavior; Results from a 21-year Independent Samples Study

Vicki Stone, K. Warner Schaie, and Judy Gonda

No topic in adult developmental psychology has received more attention than that of intellectual performance. In his recent review of research on human abilities from 1970 to 1975, Horn (1976) likens this vast and diverse literature to a 100-headed Hydra; it is a field marked by widely varying theoretical perspectives, inconsistent research findings, and considerable controversy among investigators. Thus, while scientific fields of inquiry usually progress from the descriptive to the explanatory, in the area of cognitive behavior, both types of research are conducted concurrently.

Intellectual performance is particularly difficult to explain developmentally because of the variety of influences which may be confounded with age. In 1965, Schaie outlined the General Developmental Model in which he described the three common sources of variation in developmental designs: ontogenetic change, intergenerational or cohort differences, and time-of-measurement differences. Any two of these effects may be simultaneously compared in an analysis of variance. Thus, three separate designs, termed sequential strategies, may be derived from the General Developmental Model.

Application of sequential strategies to cognitive data has sparked considerable controversy, both on substantive and methodological grounds. Horn and Donaldson (1976) have warned that application of sequential designs in which age is not an independent variable may divert attention away from genuine ontogenetic decline which merits the researcher's attention, for both explanation and modification. Others have suggested methodological refinements, (Adam, 1977; Botwinick & Arenberg, 1976) such as equalizing the time spans of the independent variables. In a recent article, Buss (1979) recommends that only the age by cohort design be applied to cognitive data, because these two sources of variance usually present the major confound in cognitive research.

However, there are at least two reasons for implementing the time by cohort or time by age designs which Buss does not acknowledge. First, time-of-measurement differences are of interest in any longitudinal sequence, in order to determine whether there are systematic variations between test occasions, such a regression effects or differences due to instrumentation. Furthermore, given the same number of sampling units, these designs permit one to examine cohort or age differences over a greater number of levels relative to the cohort by age design. This is particularly helpful in descriptive studies where the investigator wishes to examine age or cohort differences over the maximum range available.

The present study reports the results from a cross-sequential, or time by cohort analysis of cognitive data collected from independent samples over a 21-year period. That is, a new random sample of individuals spanning the cohort range of interest was tested at each measurement occasion. This sampling procedure circumvents many of the well-known problems of repeated assessments, where selective attrition positively biases the sample, jeopardizing both the internal and external validity of the study (Riegel & Riegel, 1972; Schaie, LaBouvie & Barrett, 1973). The purposes for conducting this study were twofold: 1) To determine whether there are occasion-specific differences operating over the course of the longitudinal sequence, independent of any effects introduced through the use of repeated assessments, and 2) To describe the relative levels and patterns of time-related change of various birth-cohorts.

PROCEDURE

Subjects were sampled from the membership of a health maintenance organization in the northwest. The sampling procedure has been described fully in previous reports (Schaie, 1959). In summary, an age- and sex-stratified sample of 500 individuals, ranging in age from 21 to 70 was tested in 1956. New independent random samples were subsequently drawn at 7-year intervals. For purposes of analysis, individuals are grouped according to 7-year birth-cohort intervals. Table 1 shows the occasion by cohort by sex distribution of subjects. (An older cohort was also sampled in the first 3 test occasions, but was not included in the present analysis because this cell is missing from test occasion 4.

Subjects were tested in groups ranging in size from 10 to 50 individuals. The measurement variables included the five subtests from Thurstone and Thurstone's (1949) Primary Mental Abilities Test, the Test of Behavioral Rigidity (Schaie & Parham, 1977), and a questionnaire concerning demographic variables and satisfaction with health maintenance organization.

Only the five subtests of the PMA and two derived composite scores are included in this report. The 5 PMA subtests include: 1) Verbal Meaning, a test of vocabulary; 2) Space, a 2-dimensional object rotation task; 3) Inductive reasoning, a test of identifying letter series patterns; 4) Number, a series of addition problems, and 5) Word Fluency, a test of generating words with the same initial letter. The two composite scores are Intellectual Abilities, which is derived by the formula $V + S + 2*R + 2*N + W$, and Educational Aptitude, $2*V + R$. All five subtests are timed, and are administered consecutively in the order listed.

The data were arranged according to a cross-sequential design, in which birth-cohort and time-of-measurement are the independent variables. In order to equalize the time spans (21 years) of these two factors two separate analyses were conducted, one involving the earlier-born 4 cohorts, and the other involving the later-born 4 cohorts. Sex was included as a third factor. The five dependent variables were then tested in a 4(cohort) x 4 (time-of-measurement) x 2 (sex) multivariate analysis of variance. The two composite scores were tested in separate univariate analyses.

RESULTS

Summary results from the two multivariate analyses of variance are shown in Table 2. In both analyses, the multivariate F-ratios for all three main effects were significant, and equivalent in direction. Later-born cohorts performed at a higher level than earlier-born cohorts, and scores declined over the four test occasions. Women outperformed men in general, but this trend was reversed for two variables, Space and Number. In the analyses involving the earlier-born cohorts, a significant interaction between cohort and occasion emerged, with cohorts 4 and 5 showing a markedly different pattern than cohorts 2 and 3; for cohorts 2 and 3 there is a negative linear trend; cohort 4 yields a cubic trend, and cohort 5 yields a quadratic trend in some variables and a cubic trend in others.

For purposes of illustration, consider Figure 1, graphs of performance of the two composite variables, Intellectual Ability and Educational Aptitude. Data are graphed for each cohort separately over the 4 test occasions. The separate curves for the six cohorts are arranged such that age is plotted slong the horizontal axis.

First, note the cohort and time-of-measurement main effects. While cohorts 6 and 7 (the two youngest cohorts) are performing at about the same level, earlier-born cohorts are performing systematically lower. The most salient time-of-measurement difference is the consistent drop in scores at test occasion 4. The cohort by time-of-measurement interaction is seen in the varying time trends across the different cohorts. Cohorts 2 and 3 yield highly similar linear trends, although they are separated in level of performance. Cohort 4 shows an exaggerated cubic trend with performance high at time 1 and time 3, and performance low at Time 2 and Time 4. The cohort-specific trends are quite similar for Educational Aptitude.

Finally, while a direct statistical test of age differences cannot be made within the context of the cross-sequential design, the graphs provide some suggestive evidence about age changes. First, note the wide level differences between cohorts at ages 53, 60, and 67. Second, the direction of change between two age levels is not uniform until age 60.

DISCUSSION

The results of this study strongly suggest the presence of cohort or intergenerational differences in adult cognitive behavior. Particularly among individuals born prior to 1913, inter-generational differences are prominent. These differences indicate that environmental events play a major role in shaping and maintaining cognitive skills. We can speculate about the types of sociocultural events that might impact on cognitive skills among persons who are members of the birth-cohorts tested—different educational experiences, the onset on World War I, or the growth of mass media communication. Unfortunately, most of these variables do not lend themselves to experimental manipulation so explanatory research in the classic tradition cannot be conducted. Hopefully the recent availability of computer programs to test causal models based on correlative data will remedy this situation somewhat.

Birth cohorts differ both in level-of-performance and in their patterns of change across times-of-measurement with linear decline occurring only in the oldest two cohorts. Since each test occasion within cohorts is represented by different individuals, such pattern variations could arise as a consequence of sampling. Take, for example, the exaggerated cubic trend of Cohort 4. If for some reason, chance or otherwise, the more able individuals within cohort 4 were unwilling to be tested at occasions 2 and 4, the obtained trend would result. Alternatively, environmental events may exert influence over the pattern of cognitive development. For example, some particularly powerful event during a critical stage of development might increase the risk of hypertension within a given cohort. At one point in time, hypertension might lower the mean performance level for this cohort but some subsequent time-of-testing, resulting vascular disease could have taken its toll in terms of morbidity and mortality in the population, resulting in a higher mean performance level of the survivor.

The second major research question of this study concerned the possibility of systematic occasion effects. In a previous repeated measures cross-sequential study conducted over the same longitudinal sequence, a consistent drop at time 4 was observed. This time, 3-to-time 4 decline was replicated in the present study. Time-of-measurement effects across independent samples occur either as a function of changes in instrumentation, or because of sociocultural changes which influence performance on cognitive tests. In terms of instrumentation, the only change that took place between time 3 and time 4 was a change in experimenters, but the age and training of experimenters were uniform, and instructions are read from a standard manual. In terms of sociocultural changes, it is difficult from our present perspective to identify specific events which could lead to lower mean levels of cognitive performance. However, it is possible that public concern over the use of standardized tests in areas such as employment or professional school admissions may have led to lowered motivation to perform well on such tests. The presence of this time-of-measurement effect provides further descriptive evidence of the impact of environmental events in the developmental life-span studies of cognitive development. It should also be noted that this time-of-measurement effect may inflate any apparent age-decrement in cohort by age analyses of this data set.

In conclusion, the results of the study indicate that both cohort and time-of-measurement effects influence the outcome of longitudinal studies of intelligence. Moreover, these descriptive findings suggest hypotheses for future explanatory studies. One example of explanatory research in this area is the application of path analytic models to correlative data sets which contain information about environmental variables. A second type of explanatory research involves intervention strategies aimed at modifying intellectual performance by altering environmental conditions. We are currently conducting both types of research, in an attempt to strengthen theory development in the area of adult intelligence.

TABLE 1

DISTRIBUTION OF SUBJECTS BY
COHORT, SEX, AND TIME-OF-MEASUREMENT

	TIME-OF-MEASUREMENT 1	2	3	4
COHORT 2	35 MEN 37 WOMEN	64 MEN 63 WOMEN	46 MEN 42 WOMEN	26 MEN 31 WOMEN
3	35 MEN 35 WOMEN	58 MEN 64 WOMEN	42 MEN 49 WOMEN	36 MEN 33 WOMEN
4	35 MEN 30 WOMEN	62 MEN 81 WOMEN	38 MEN 42 WOMEN	35 MEN 38 WOMEN
5	36 MEN 35 WOMEN	79 MEN 76 WOMEN	40 MEN 49 WOMEN	35 MEN 37 WOMEN
6	33 MEN 37 WOMEN	71 MEN 79 WOMEN	44 MEN 43 WOMEN	40 MEN 37 WOMEN
7	38 MEN 38 WOMEN	52 MEN 70 WOMEN	34 MEN 50 WOMEN	32 MEN 37 WOMEN

<u>BIRTH COHORTS</u>

COHORT 2	1893-1899
3	1900-1906
4	1907-1913
5	1914-1921
6	1922-1928
7	1929-1935

<u>MEASUREMENT VARIABLES</u>

<u>V</u>ERBAL

<u>S</u>PACE

<u>R</u>EASONING

<u>N</u>UMBER

<u>W</u>ORD FLUENCY

INTELLECTUAL ABILITY=
V + S + 2R + 2N + W

EDUCATIONAL APTITUDE= 2V + R

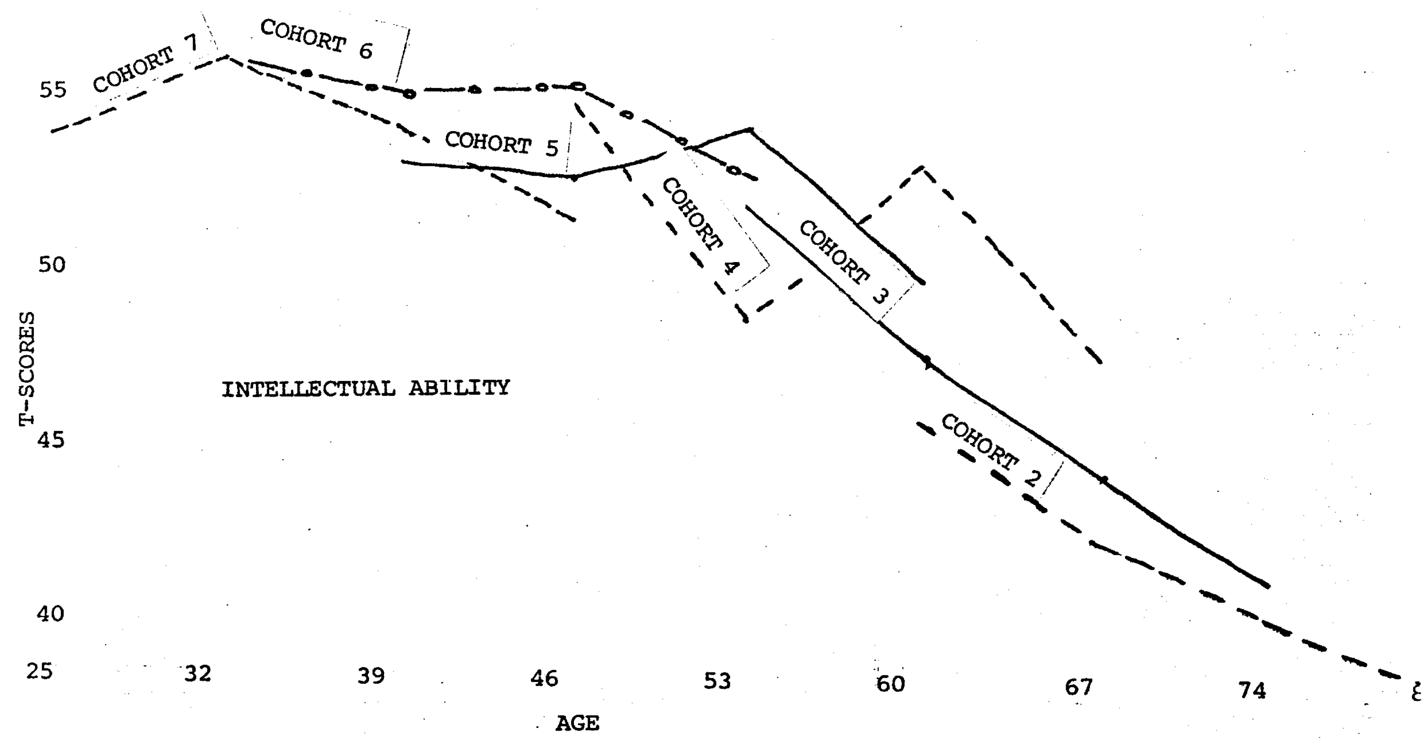
TABLE 2

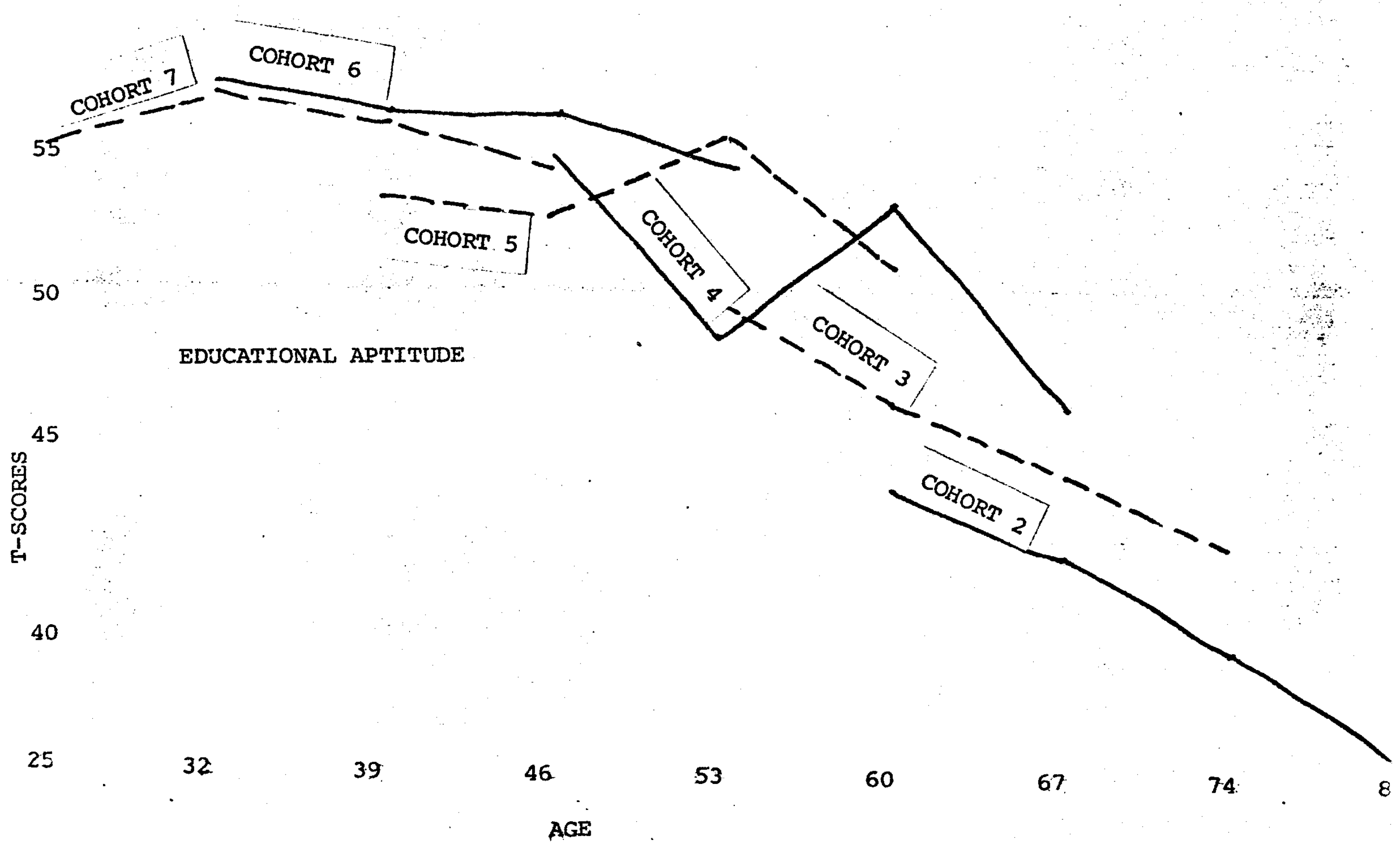
MULTIVARIATE ANALYSIS OF VARIANCE

	Multivariate F	27.19	15.35
COHORT	Verbal	107.18	18.27
	Space	74.79	25.38
	Reasoning	109.11	53.11
	Number	40.77	
	Word Fluency	41.49	6.02
	Intel. Abilities		
	Educ. Aptitude	77.87	
TIME-OF-MEASUREMENT	Multivariate F	13.96	9.57
	Verbal	24.17	8.34
	Space	18.05	8.06
	Reasoning	19.70	10.74
	Number	11.17	10.95
	Word Fluency	47.80	22.84
	Intel. Abilities	4.28*	
	Educ. Aptitude	49.26	28.66
SEX	Multivariate F	47.07	40.27
	Verbal	11.40	
	Space	99.03	109.09
	Reasoning	6.77*	
	Number	7.24*	14.79
	Word Fluency	28.20	13.36
	Intel. Abilities		
	Educ. Aptitude		53.90
COHORT x TIME-OF-MEAS	Multivariate F	2.17	
	Verbal	4.21	
	Space		
	Reasoning	2.78*	
	Njmber	3.39	
	Word Fluency	5.16	
	Inte. Abilities		
	Educ. Aptitude	4.43	

FIGURE 1

TIME-OF-MEASUREMENT WITHIN COHORT





Paper presented at the National Gerontological Society

Washington, D.C. 1979

References

Adam, J. Statistical bias in cross-sequential studies of aging. Experimental Aging Research, 1977, 3, 325-333.

Botwinick, J., & Arenberg, D. Disparate time spand in sequential studies of aging. Experimental Aging Research, 1976, 2, 55-61.

Horn, J.L. Human abilities: A review of research and theory in the early 1970's. Annual Review of Psychology, 1976, 27, 437-486.

Riegel, K.F., & Riegel, R.M. Development drop, and death. Developmental Psychology, 1972, 6, 309-319.

Schaie, K.W. A general model for the study of developmental problems. Psychological Bulletin, 1965, 64, 92-107.

Schaie, K.W., Labouvie, G.V., & Barrett, T.J. Selective attrition effects in a fourteen-year study of adult intelligence. Journal of Gerontology, 1973, 28, 328-334.

Schaie, K.W., & Parham, I.A. Manual for the Test of Behavioral Rigidity, 2nd Edition, Palo Alto, Ca.: Consulting Psychologists Press, 1973.

Thurstone, L.L., & Thurstone, T.G. Examiner Manual for the SRA Primary Mental Abilities Test. Chicago: Science Research Associates, 1949.