The Generational Ebb and Flow of Mental Abilities

K. Warner Schaie
The Pennsylvania State University

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Introduction

Extensive research on adult intelligence has shown that there have been marked generational shifts in levels of performance on tests of mental abilities (Flynn, 1984; Parker, 1986; Schaie, 1983; Willis, 1985). The usual empirical findings have been that later born cohorts appear to be advantaged when compared with earlier cohorts at the same ages. This phenomenon has been explained by arguing that increased educational opportunities, improved life styles including nutrition, and the conquest of childhood disease has enabled successive generations to reach ever higher ability asymptotes (cf. Schaie, 1984), similar to the secular trends of improvement for anthropometric and other biological markers (Shock et al., 1984). Although linear trends have been found for some variables, there seems to be contrary evidence, that suggests that such trends may have been time-limited and domain- or even variable-specific.

Recent reports of the performance of high school students on college admission tests such as the S.A.T., suggests that there has been an ebb and flow on such high school measures of mental ability levels. Reexamination of our own data on adults, moreover, suggests that cohort patterns are far from uniform across abilities. That is, positive cohort gradients are not necessarily found for all abilities, and non-linear cohort patterns can not simply be dismissed as sampling aberrations, but may represent complications introduced by countervailing contextusal trends that have an impact on mental abilities.

Accurate descriptions of patterns of cohort change in mental ability are important because they provide a foundation for gaining a better understanding of the manner in which productivity and competence shift over time in our society. Such data are also needed to understand how cohort differences in performance can lead to erroneous conclusions from age-comparative cross-sectional studies (cf. Schaie, 1977; Baltes, Cornelius, & Nesselroade, 1979). Because of the changing demographic composition of the population it is of particular intrest to assess differences in performance level at comparable ages for individuals representing areas characterized by differential fertility rates (e.g. contrasts of the pre-baby boom, baby boom, and baby-bust generations. Cohort shifts at older ages, moreover, are directly relevant to policy considerations regarding the maintenance of of a competent work force that will contain increasing proportions of older workers as mandatory retirement becomes the relic of a biased past.

Our own reports of estimated cohort gradients have generally depended upon computing differences between successive cohorts at two common age levels (Schaie, 1980, 1983). Such two-point estimates may be particularly sensitive to perturbations caused by sampling variations. With the completion of data collection for the fifth wave of the Seattle Longitudinal Study (SLS), we are now in a position to estimate seven-year cohort shifts that are less sensitive to sampling variations by basing our estimates over at least four common age levels for seven successive cohorts. The major purpose of this paper is to report updated findings of differential cohort trends in mental abilities. The first issue to be adressed is the estimation of cohort trends across and within gender for seven-year birth cohorts with average birth years from 1889 to 1959, the full range of adults now alive. Secondly, we will report time-lag data over as many as 5 cohorts, seven years apart from each other, for samples with average ages (in seven-year intervals) ranging from 25 to 81 years. Finally, we will inquire into some contextual factors that may help us project where these cohort trends may go in the proximal future.

Method

Subjects. The data reported in this paper represent the initial tests for 3413 persons (males = 1621; females = 1792) who participated in the five waves of the Seattle Longitudinal Study. All were community-dwelling adults who were randomly selected from each seven-year age stratum of the membership of a metropolitan health maintenance organization. These data were collected in 1956 (ages 22 to 70; N = 500), 1963 (ages 22 to 77; N = 997), 1970 (ages 22 to 84; N = 705), 1977 (ages 22 to 84; N = 612), and 1984 (ages 22 to 84; N = 599). Numbers of participants by cohort and gender are reported in Table 1a. Similar frequencies ordered by chronological age and gender are provided in Table 1b. All participants were in good health when tested, and were representative of the upper 75 per cent of the socio-economic stratum. For the total data base educational levels averaged 13.27 years (range: 4 to 20 years), and occupational status averaged 6.25 on a ten point scale using census classifications ranging from unskilled labor to professional.

Measures. Throughout the study, subjects have been assessed with the first five primary mental abilities (Thurstone and Thurstone, 1941; Schaie, 1985), the Test of Behavioral Rigidity (Schaie & Parham, 1975), and a demographic information form. In this report we restrict our discussion to four primary abilities: Verbal Meaning, the ability to comprehend words, a measure of recognition vocabulary; Spatial Orientation, the ability to mentally rotate objects in two-dimensional space; Inductive Reasoning, the ability to infer rules from examples that contain regular progressions of information; and Number, the ability to manipulate number concepts, as measures by checking simple addition problems. All measures were standardized to T scores (M = 50, SD = 10).

Procedure. All subjects were tested in small groups in sessions which for the first three waves lasted about two hours, for the fourth wave about three hours, and for the fifth wave in two sessions of 2 1/2 hours each (necessary because multiple markers of the abilities, and other additional measures were added).

Method of Analysis. The design of this study is an independent random sampling model, where each cohort at each age is assessed on a separate sample, thus controlling for possible effects of testing, reactivity and experimental mortality (Schaie, 1965, 1973, 1977). Raw cohort differences were obtained by taking the differences between means for each pair of cohorts at all common age levels (four for comparisons of the seven cohorts born between 1896 and 1938, three for those involving cohorts born 1889 and 1945; two for the 1952 cohort, and one for the 1959 cohort). Cohort difference estimates were then obtained by averaging across all estimates to avoid undue weighting in terms of differential sample sizes. Similar estimates were obtained also separately by gender. Cohort gradients were then constructed by cumulating cohort difference estimates across the cohorts available for analysis. One-way ANOVAs examined the significance of time-lags at specific ages from 25 to 81 years.

Results

Cohort Gradients. Differences between successive cohorts as expressed in *T* score points (1/10 *SD*) were cumulated from the oldest cohort born in 1889 up to the most recently measured cohort born in 1959 for the four abilities of Verbal Meaning, Spatial Orientation, Inductive Reasoning and Number and are presented in Figure 1. It will immediately be noted that the gradients differ in slope and shape. Inductive Reasoning comes closest to showing a linear positive cohort progression. Even here there are diversions from linearity, with relatively steep increments up to the 1931 cohort and far slower and decelerating increment thereafter. Nevertheless, the cumulative increment across the currently available population is well in excess of a population standard deviation. The next most substantial pattern of positive increment across successiv cohorts is shown by Verbal Meaning. After an initial modest dip this ability rises by about 2/3 SD until the 1924 birth cohort, followed by another modest dip. Thereis a further rise to an asymptote attained by the 1945 and 1952 cohorts, once again followded by another modest dip. Spatial Orientation also shows a basically positive cohort progression, but with a much flatter and variable profile. This ability reaches an initial asymptote after an 1/3 SD rise for the cohorts from 1910 to 1931. A further rise to a new peak of approximately 1/2 SD above the base cohort occurs in 1938, which is followed by a drop to the earlier asymptote in 1952, but with recovery to the higher level by the most recent cohort.

A very different pattern is shown for Number. Here a peak of about 1/3 SD above base is reached by the 1910 cohort at a level that is maintained through the 1924 cohort. Thereafter an almost linear negative slope is found that continues through the most recent cohort which is approximately 1/4 SD below the 1889 base.

Gender Differences. It might be suspected that some of the irregularities in the cohort patterns described above could be a function of differential representations of men and women in the cohort estimates (see also Table 1a), that would have an effect if cohort by gender interactions occurred over all or part of the cohort range studied. Figure 2 therefore provides cohort gradients estimated separately for men and women for the four abilities of interest.

The most regular pattern represented for the total sample by Inductive Reasoning also pertains separately for women. The implications of the 1959 cohort drop is not clear; it might be sampling fluctuation based on a single sample estimate. The cohort pattern for men is less regular, and seems to represent more of a "stairstep" profile. Nevertheless, it also maintains a clearly positive direction. It is interesting to note that there seems to be a lag effect, with magnitudes of cohort difference for men representing that of women for the previous cohort.

Gender differences in cohort profiles for Verbal Meaning include the attainment of initial asymptotes by the 1910 cohort for females but not until the 1924 cohort for males. Similarly, negative change for the most recent cohorts is observed for females by 1952 but for males only by 1959.

Several interesting gender differences characterize the cohort progression for Spatial Orientation. The early asymptote for the total group actually conceals distinct gender-specific patterns. Positive cohort change continue for men actually to an asyumptote attained for the 1924 through 1938 cohorts. For the women however an initial peak is reached for the 1910 cohort with a drop close to base for the 1917 through 1931 cohorts. This is followed by a steep rise in 1938 and 1945, after which point the male and female cohort gradients again converge.

There are also distinct patterns for Number. First of all, note the greater increment from base for the women. A linear positive is observed until a peak is reached for the 1917 cohort. From the on there is successive decrement terminating below base level, interrupted only by a temporary plateau from the 1931 to the 1945 cohort. By contrast, the men reach an asymptote already in 1910. The is followed by a "stairstep" decrement until 1945, followed by modest recovery for the two most recent cohorts.

Time-lag Analyses. The data thus far discussed are based on cohort difference estimates that arise from data that for any set of two cohorts must cover age ranges that differ by at least seven years. For example, the difference between cohorts born in 1896 and 1903 is computed over the average ages 60 to 81, while the differece between cohorts born in 1903 and 1910 is computed over the avrage ages from 53 to 74. An alternate manner of studying cohort change is to consider only the data available for successive cohorts at a specific age. This is a time-lag analysis, very similar to that conducted for college aptitude tests, and is relevant to the question whether there have been significant changes have occurred, that would permit the judgment that performance levels at a given age have increased or declined as a function of shifts in population characteristics. Table 2 provides the relevant data from this analysis.

Positive cohort trends were found to be statistically significant at or beyond the 5% level of confidence for Verbal Meaning for all ages from 39 to 81 and for Inductive Reasoning for all ages from age 25 to 74. A statistically significant trend was found for Spatial Orientation only at age 25, although all observed cohort differences were in a positive direction. As expected more complex findings occurred for Number. Here statistically significant trends were observed for ages 39 through 53, but significant positive trends were found at ages 60 and 67. Magnitudes of positive time-lags over a 28 year were as great as .8 SD for Verbal Meaning, .4 SD for Spatial Orientation, and .9 SD for Inductive Reasoning. Because of the curvilinear pattern for Number, maximum negative as well as positive time-lags were small; they amounted to - .4 SD and + .3 SD, respectively.

Discussion

Cohort Differences in Abilities

The findings reported here clearly indicate that previous discussions of the impact of cohort differences upon intellectual performance in adults have been too simplistic. It is no longer possible to hold that benign changes in healthstatus, life styles, and education have a generalized positive effects that will inevitably lead each successive generation to reach an asymptote that is greater than that achieved by its predecessor. Instead, we note that cohort progressions occur at different rates for different abilities, may show gender-specific pattern, and be non-continuous. For some variables positive cohort trends may reverse, even to the point, that over a wide range of cohorts, the most recent cohorts may perform at a level that could be lower than that shown at equivalent ages observed for much older cohorts. It seems to follow that changes in socialization patterns and other environmentally programmed experiences differentially impact cohort progression as well (cf. Schaie, 1984a, 1986a). Nevertheless, it does appear that positive cohort gradients are most likely to be found for those variables that are most directly affected by a steady increase in educational exposure, whether in terms of knowledge acquisition (as would be the case for a crystallized ability such as Verbal Meaning) or in the acquisition of problem solving strategies (as would be true for the fluid variable of Inductive Reasoning). We have previously shown that increasing the familiarity of test stimuli will reduce cohort differences in the face of differential educational exposure (cf. Gonda, Quayhagen, & Schaie, 1981). Similarly, positive cohort differences observed in this study might readily be attributable to differential familiarity with similar test stimuli prior to entry into our study.

Our reanalyses of cohort progressions in ability were in part stimulated by the question whether SAT declines shown by late baby-boomers would also be seen in young adulthood. Our findings remain ambiguous with respect to that question. Referring back to Figure 1 again it may be noted that from the cohort born in 1952 to that born in 1949 there was modest increment on Inductive Reasoning and Spatial Orientation, but decline on Verbal Meaning and Number. Some would interpret this pattern to imly continuing positive cohort effects on fluid abilities, but negative effects on crystallized abilities. If this interpreation is correct, then it would be reasonable to hypothesize that the SAT fluctuations may reflect responses to changing educational practice rather than shifts in population ability levels.

It should also be noted that the increment of cohort differences has slowed markedly over the past two decades. Cumulative magnitudes of cohort differences between those now in at mid-life and those in early old age is no greater than the amount of training gains demonstrated for older adults who had not experienced age-related decline (Schaie & Willis, 1986; Willis &

Schaie, 1986). It seems reasonable than to assume, that the cohort-related aspect of the older persons intellectual disadvantage when compared with younger peers could readily be compensated for.

Some practical consequences arise from the reliably observed upward shift of performance by successive cohorts at given ages. It is instructive to note that the largest gains (see Table 2) occur for the fifties and sixties. These gains are in excess of average estimates of period effects for the past 28 years (Schaie, 1983), and thus imply that past cross-sectional norms may significantly underestimate intellectual performance of individuals at late career stages. Such findings may be particularly important in correcting for the possible misuse of older cross-sectional data in age discrimination litigation and in the development of procedures for lateral career shifts in the latter part of person's work life.

Impact of Contextual Variables

The observed differential cohort profiles now raise the question whether we can identify contextual variables that have differential impact on the abilities that we have studied and that also show differential cohort profiles. As a first step for such an examination we examined concurrent regressions of the ability variables upon several contextual variables on which data have been collected throughout the longitudinal study (Schaie, 1986b). Table 3 shows the contextual variables that have significant regressions upon the ability measures of interest in this study. Note that the relationship with current contextual variables is greatest for Inductive Reasoning and Verbal Meaning; those abilities that show both the steepest and most linear positive cohort gradients. In both instances, education, income, and multiple occupational exposure are identified as salient contextual variables. These variables alos appear for Number, but only Income accounts for a substantial proportion of variance. In addition, age at first marriage appear of contextual relevance for Verbal Meaning and Education, while age at birth of first child and physical height are relevant to Spatial Orientation.

Figure 3 shows cohort patterns for several of the contextual variables. Those that seem most directly related to the crystallized abilities, education and income, show almost linear positive cohort gradients; albeit less steep for education than for the inflation-confounded income measure. But just as for the ability measures, there are contextual variables which have much more complex profiles. Frequency of occupational change, for example, actaully declined slightly until the 1938 cohort, but thereafter showed a steep rise; this in contrast to our other mobility measure, change in living quarters, which showed a rising cohort trend throughout. Family status variables also show complex cohort patterns. Thus age at first marriage steadily fell until the 1931 cohort, and has since been rising, while age of first child attained an initial peak for the 1910 cohort, then followed the pattern for age at first marriage, but showed a steep drop for the most recent cohorts.

Considering the interrelation of ability and contextual variables, it is my contention that many of the irregularities in the cohort progresion for our ability measures might be better understood by examining shifts in contextual variables occurring over the same time periods (see also Gribbin, Schaie, & Parham, 1980). That is, some of the "stairstep" phenomena seen in ability cohort profile may represent fluctuations in sampling and or general population characterisitcs on contextual variables that constrain the distribution of individual differences on mental abilities. Once we gain a better understanding on these relationships it may then be able to make more educated projections for cohort-related shifts in ability structure as well.

Summary

We have examined updated data on cohort differences in the four primary mental abilities of Verbal Meaning, Inductive Reasoning, Spatial Orientation, and Number for seven-year birth cohorts with average birthyears from 1889 to 1959, as well as time-lag data over as many as five perioad, seven years apart, for mean ages 25 to 81. Our data show differential cohort gradients: Steep positive and linear for Inductive Reasoning, modestly positive with occasional ainversions for Verbal Meaning and

Spatial Orientation, and curvilinear, but essentially negative for Number. We also noted that there were gender-specific aspects of cohort progressions with men often lagging behind women in magnitude and direction of change. Time-lags at specific ages were particularly significant in the fifties and sixties, and practical implications were considered. Finally, cohort progressions for contextual variables involving income, education, mobility and family formation characteristics, were also examined and suggested as possibly offering a basis for understanding irregularities in the ability cohort gradients and in enhancing projections of cohort trends in mental abilities.

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Table 1a
First Time Paticipants in the Seattle Longitudinal Study
Classified by Cohort and Gender

Cohort		Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Total
1889	M	28	39	26	-	-	103
	F	38	39	24	-	-	101
	T	76	78	50	-	-	204
1896	M	35	64	46	28	-	172
	F	37	63	42	31	-	173
	T	72	127	88	59	-	346
1903	M	35	58	42	37	24	196
	F	35	64	49	33	28	209
	T	70	122	91	70	52	405
1910	M	35	62	38	35	39	209
	F	30	81	42	38	37	228
	T	65	143	80	73	76	437
1917	M	36	79	40	35	40	230
	F	35	76	49	38	42	240
	T	71	155	89	73	82	470
1924	M	33	71	44	40	36	224
	F	37	79	43	37	43	239
	T	70	150	87	77	79	463
1931	M	38	52	34	32	33	189
	F	38	70	50	37	33	228
	T	76	122	84	69	66	417
1938	M	-	42	28	37	26	133
	F	-	58	37	36	39	170
	T	-	100	65	73	65	303
1945	M	-	-	31	29	31	91
	F	-	-	40	33	39	112
	T	-	-	71	62	70	203
1952	M	-	-	-	28	27	55
	F	-	-	-	28	28	56
	T	-	-	-	56	55	111
1959	M	-	-	-	-	18	18
	F	-	-	-	-	36	36
	T	-	-	-	-	54	54

Table 1b

First Time Paticipants in the Seattle Longitudinal Study Classified by Chronological Age and Gender

Mean Age	Males	Females	Total
25	157	200	357
32	169	205	374
39	209	239	448
46	216	225	441
53	210	235	445
60	202	224	426
67	219	230	449
74	161	151	312
81	78	83	161
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Total	1621	1792	3413

Table 2

One-way Analyses of Variance for Cohort Differences

at Specific Age Levels from 25 to 81 Years

Measured in 1956, 1963, 1970, 1977 and 1984

Age Level	Verbal Meaning			Spatial Orient.			Inductive Reasoning			Number		
	F	d1[a]	d2[b]	F	d1	d2	F	d1	d2	F	d1	d2
25	.62	2.6	1.7	2.48*	3.9	2.9	4.37**	4.7	4.5	1.76	-3.2	-.8
32	1.00	2.5	-.1	1.71	3.0	-.6	2.81*	3.8	3.8	1.75	-3.1	-1.1
39	3.46**	5.0	5.0	.95	2.9	1.4	8.12***	7.3	7.3	4.37**	-5.3	-2.3
46	5.85***	5.7	4.0	2.20	4.0	4.0	6.89***	6.1	4.6	6.82***	-2.9	-2.0
53	10.95***	6.4	5.6	2.23	3.4	2.6	10.21***	6.6	4.9	3.58**	-5.3	-3.7
60	12.19***	8.1	8.1	.86	4.2	3.7	14.69***	8.6	8.6	5.91***	7.3	1.9
67	8.57***	6.2	6.2	1.90	3.9	1.5	10.56***	6.5	4.6	2.41*	4.2	2.0
74	5.43***	4.8	4.8	.48	1.5	1.5	9.08***	4.8	4.6	1.37	2.9	2.9
81	5.60***	5.0	3.0	.61	2.2	1.2	.01	.6	.6	.67	1.1	1.1

Note - Degrees of freedom: 25 = 4,352; 32 = 4,369; 39 = 4,443; 46 = 4,435; 53 = 4,440; 60 = 4,421; 67 = 4,445; 74 = 3,309; 81 = 2,158.

*p < .05, **p < .01, ***p < .001, [a]Difference between lowest and peak level in T score points (1/10 SD); [b]Difference between base and 1984 cohort.

Table 3
Beta Weights and Multiple Correlations for Contextual Predictors of Performance Level on Mental Ability Tests[a]

	Mental Ability			
Predictor	Verbal Meaning	Spatial Orient.	Inductive Reasoning	Number
Education	.306		.249	.110
Income	.344	.304	.348	.349
Change of Occupation		.130	.140	.072
Change of Home			.138	
Age at Marriage	-.126		-.197	
Age at 1st childs Birth		-.133		
Height		.143		
Multiple Correlation	.568	.432	.611	.421

[a] Values are listed only for variables with regression coefficients that are significant at or beyond the 5% level of confidence.

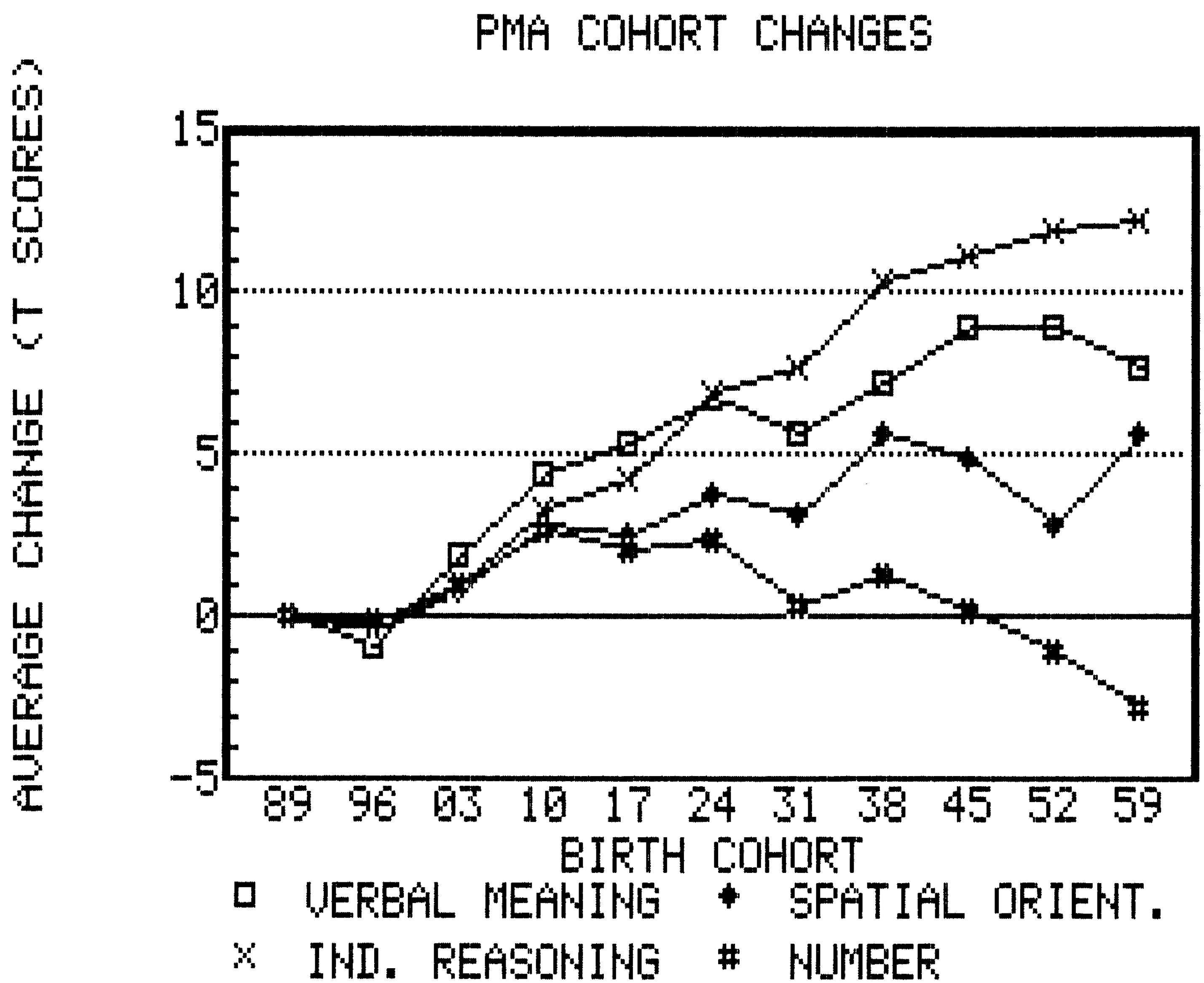
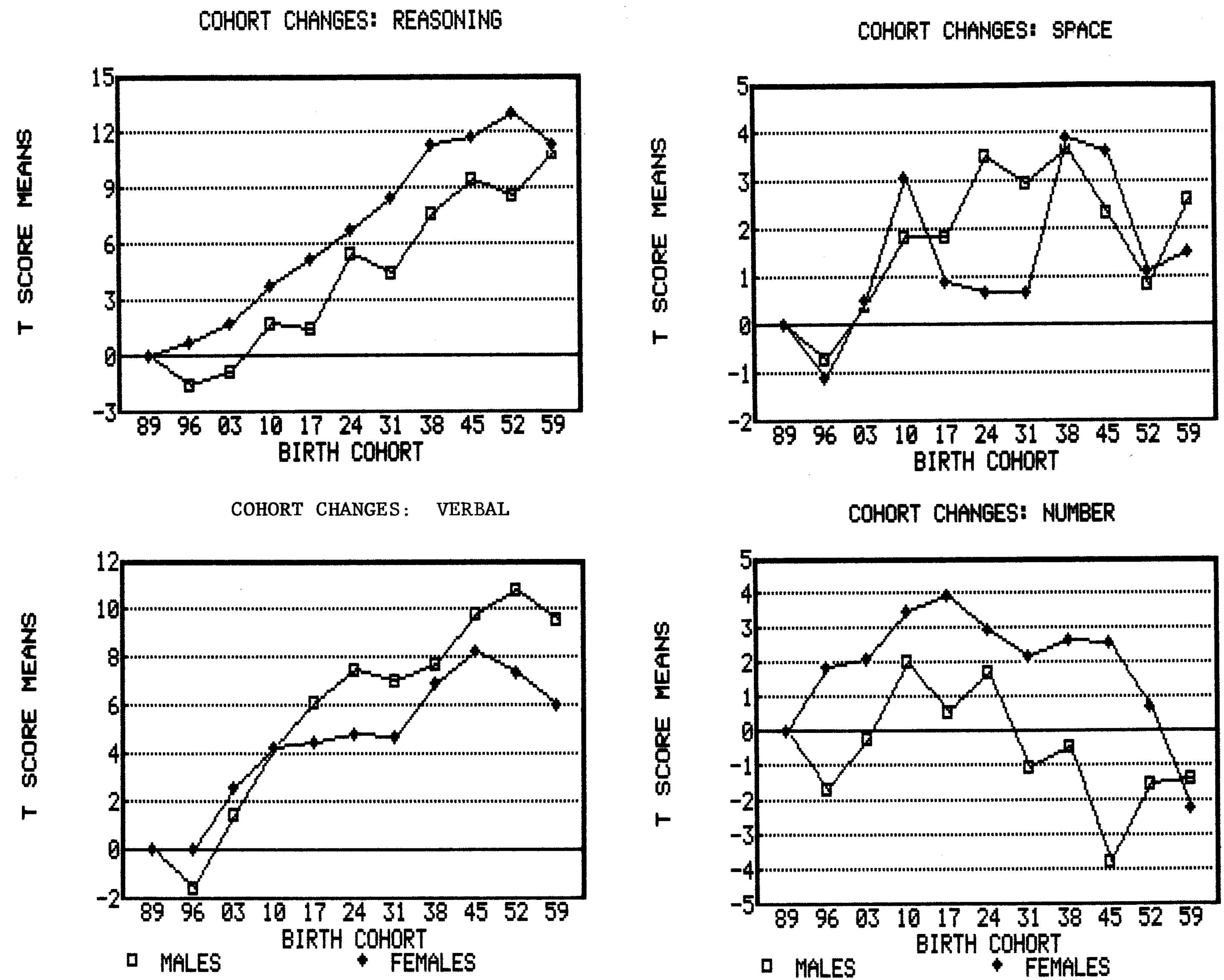

PMA COHORT CHANGES
AVERAGE CHANGE (T SCORES)
15
10
5
0
-5
89
96
03
10
17
24
31
38
45
52
59
BIRTH COHORT
VERBAL MEANING
SPATIAL ORIENT.
IND. REASONING
NUMBER

Fig. 1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COHORT CHANGES: SPACE
COHORT CHANGES: VERBAL
COHORT CHANGES: NUMBER
T SCORE MEANS
BIRTH COHORT
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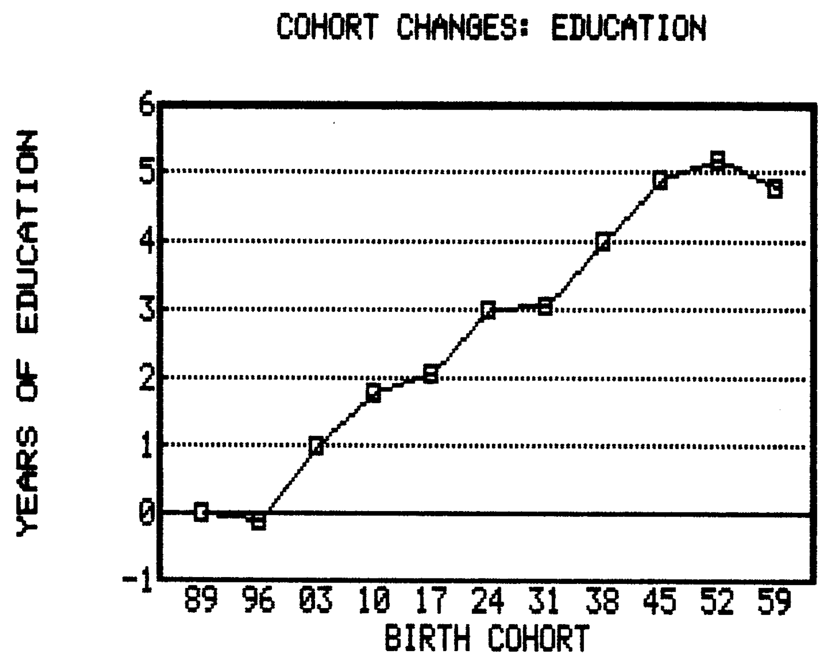
MALES
FEMALES


COHORT CHANGES: EDUCATION
YEARS OF EDUCATION
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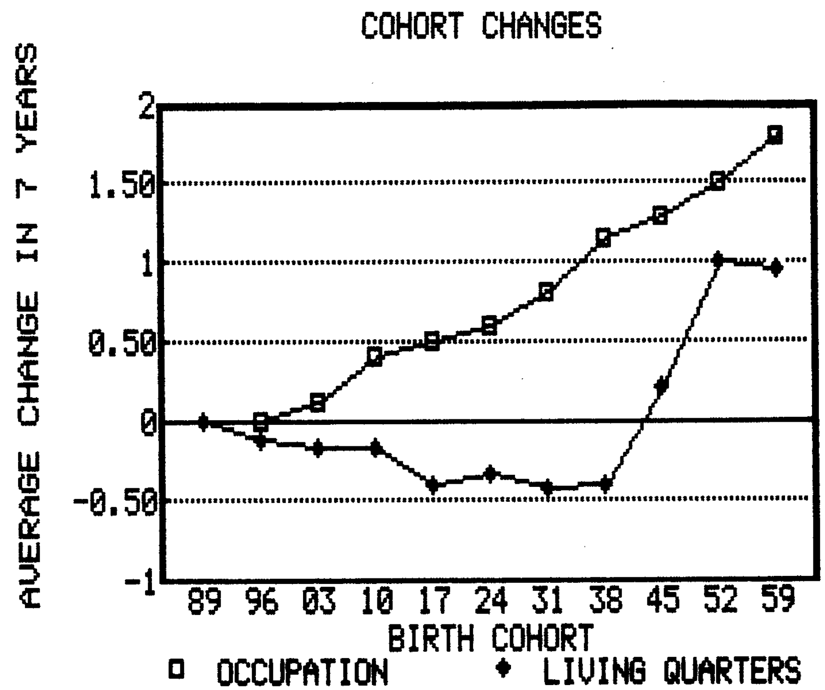
5
4
3
2
1
0
-1
89 96 03 10 17 24 31 38 45 52 59
BIRTH COHORT


COHORT CHANGES
AVERAGE CHANGE IN 7 YEARS
2
1.50
1
0.50
0
-0.50
-1
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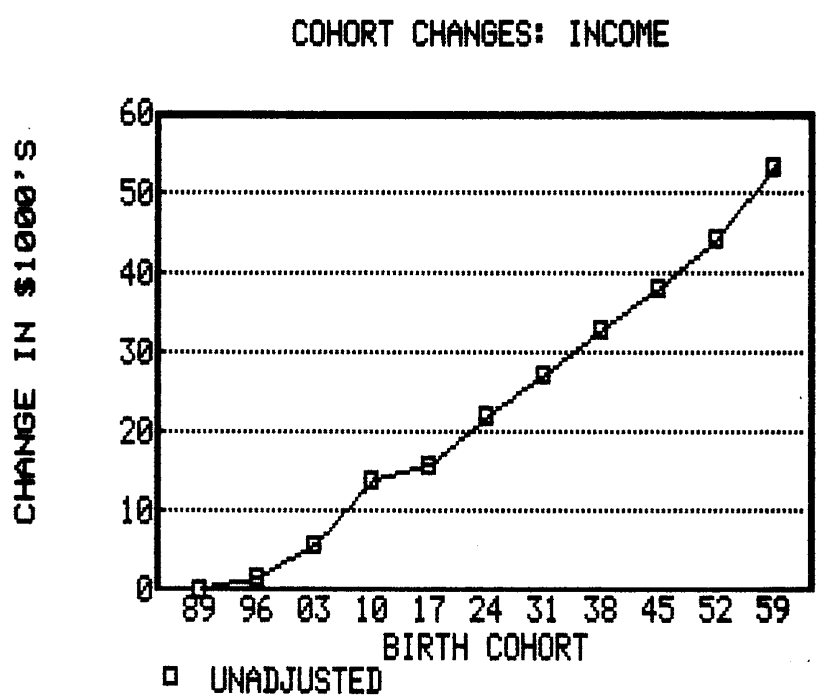
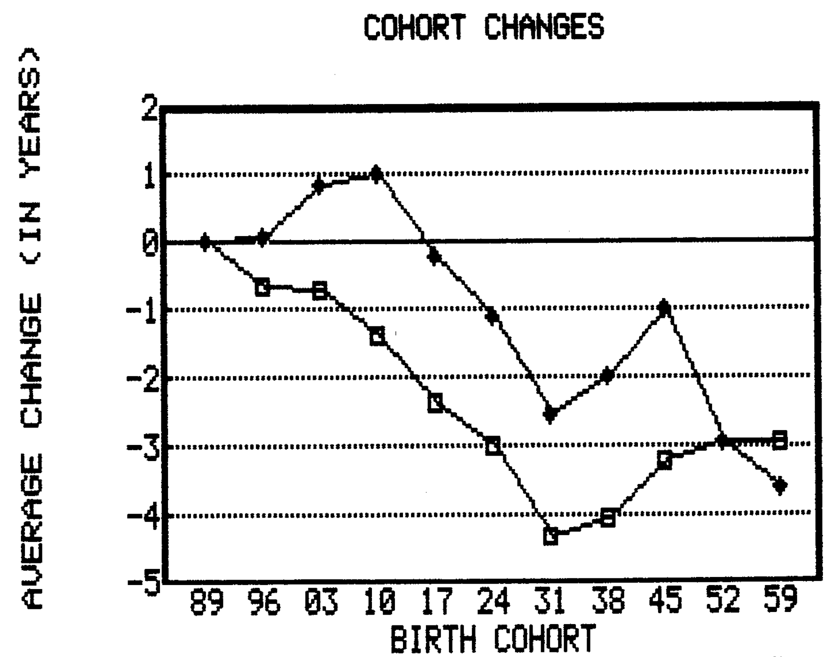
BIRTH COHORT
OCCUPATION
LIVING QUARTERS


COHORT CHANGES: INCOME
CHANGE IN $1000'S
60
50
40
30
20
10
0
89 96 03 10 17 24 31 38 45 52 59
BIRTH COHORT
UNADJUSTED


COHORT CHANGES
AVERAGE CHANGE (IN YEARS)
2
1
0
-1
-2
-3
-4
-5
89 96 03 10 17 24 31 38 45 52 59
BIRTH COHORT