Generational vs. Ontogenetic Components of Change: A Second Follow-up[1]

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Abstract

A second follow-up study covering the period from 1963 to 1970 was conducted for the cross-sequential study of changes in adult cognitive behavior originally reported for a sample aged 21 to 70 years for the time period 1956-63 (Schaie & Strother, 1968a, 1968b). This report specifically analyses data for variables representing crystallized intelligence (Space) and fluid intelligence (Word Fluency) as well as a composite IQ measure. Results favoring attribution of age differences to differences between generations for the crystallized intelligence measure were replicated. However, epochal differences found in the case of the measure of fluid intelligence now suggest that the earlier contention of marked ontogenetic changes may hold true only for the older cohorts. Cross-sectional and longitudinal data are reported for three times of measurement using both repeated measurement and independent random sampling designs for seven seven-year cohorts with mean birth years from 1889 to 1931. New projections from these data suggest that individuals now in their middle years will be at much less disadvantage when compared to their younger age peers when they reach retirement than is the case for the present elderly.

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Introduction

For the past few years my associates and I have suggested that previously accepted data on intellectual development in adulthood and old age are probably quite misleading and uninterpretable (Baltes, 1968; Baltes & Nesselroade, 1970; Baltes, Schaie & Nardi, 1971; Schaie, 1965, 1967, 1970, 1972a). Information obtained from cross-sectional studies has generally been interpreted to suggest sharp age decrements from a peak in young adulthood. As we have pointed out repeatedly, such data confound age with generation differences and in times of rapid technological and cultural change may imply no more than that successive population cohorts have been exposed to increasing amounts of information and training. Longitudinal studies, contrariwise have typically reported maintenance of intellectual function or even gain in performance at least well into midlife (e.g., Bailey & Oden, 1955; Owens, 1953, 1955). But data obtained for a single population cohort, as is customary in most of the past studies, are subject to another confound which limits interpretability. That is, age changes in a longitudinal single cohort study are confounded with the impact of environmental events which may be unique to the time period under study and which may effect individuals equally regardless of their developmental level.

It becomes apparent than that one must distinguish between age and generation differences on the one hand and between age changes and environmental impact on the other. Alternatively for those adult behaviors where age related change is not expected one would want to differentiate components of observed change into those attributable to generation differences and temporally specific environmental impact. Strategies for data collection suitable for such analysis which have been outlined elsewhere (Schaie, 1965, 1972a) require data collection for each age level at at least two measurement points and consequently for at least two different population cohorts. These strategies have been applied with respect to a cross-sectional sample over the age range from 21 to 70 years of age and over the time period from 1956 to 1963 (Schaie & Strother, 1968a, 1968b; Nesselroade, Schaie & Baltes, 1971). In these studies, it was found that previously reported age differences on tests of crystallized ability can be primarily accounted for by generation differences, while tests involving speed of response do indeed show age changes of an ontogenetic nature also. These results found for both repeated measurement and independent random sampling designs and at the level of first and second order factor scores may, however, be questioned as to their generalizability because estimates of projected longitudinal and cohort gradients were of necessity based on a single intervening time period. The purpose of this paper is to provide a response to this question by reporting relevant results from a follow-up study conducted for the time period from 1963 to 1970. Although the complete project will now permit all types of analysis deducable from the general developmental model (Schaie, 1965) this report will be restricted to two basic questions: (1) What is the stability of projected longitudinal and cohort gradient based on data collected over a single time period; i.e., do the conclusions from our previous study stand replication, and (2) what additional projections can be obtained from systematic short-term longitudinal studies involving three measurement points.

Procedure

Subjects. The population base from which the Ss were sampled consisted of the approximately 18,000 members of a prepaid medical plan in a Pacific Northwest metropolitan area, which (except for some curtailment at the lower end of the socioeconomic continuum) was fairly representative of local census figures. Detailed procedures of the sampling plan have been reported elsewhere (Schaie, 1958, 1959). In summary, quota sampling was conducted in 1956 and 1963 for each 5 year interval from 21 to 70 years of age and with approximately 60% of the 1956 sample being retested in 1963. Because of the seven year testing interval the samples were reorganized into seven year cohorts with mean birth years ranging from 1889 to 1945. In the second follow-up residual samples from the 1956 and 1963 study were retested in 1970, and new stratified random samples was drawn for all cohorts tested in 1956 and 1963 plus the next younger cohort. Repeated measurement data are consequently available for all three data points for a sample of 162 Ss now ranging in age from 21 to 84 years, for two data points (1956 to 1963) on a sample of 300 Ss ranging in age from 28 to 77 years and a second sample (1963 to 1970) of 409 Ss ranging in age from 28 to 84 years. In addition independent random sampling data are available from the 1956 series for 490 Ss (mean sub-sample ages: 25 to 67 years); from the 1963 series for 960 Ss (mean sub-sample ages: 25 to 74 years); and from the 1970 series for 701 Ss (mean sub-sample ages: 25 to 81 years). Within each cohort there are an approximately equal number of men and women. Although attrition was relatively random with respect to socioeconomic variables, subjects loss was biased with respect to intelligence, with the retested Ss scoring significantly higher at base point over the retest resisters (Baltes , Schaie & Nardi, 1971).

Measures. The SRA Primary Mental Abilities Test (PMA), the Test of Behavioral Rigidity (TBR), a socioeconomic status questionnaire and a survey on satisfaction with the medical plan were administered in group sessions handling from 10 to 50 Ss and lasting approximately 2 hours each.

Analysis. To facilitate comparisons, all scores were transformed into T scores with means of 50 and a standard deviation of 10, using as a base the first test administration for all three series to a combined group of 2251 Ss. The analysis of variance was then used to test the significance of the age-cohort (cross-sectional) and age-time (longitudinal) differences as well as their interaction with possible sex differences (cross-sequential model) for both the repeated measurement and independent random sampling data. Cross-sectional observed longitudinal and projected longitudinal gradients were then plotted to bear upon the question of replication of two-point derived gradients as well as the construction of gradients from three point data. Finally families of cohort gradients were constructed to estimated possible changes in slope as well as level of gradients as inferred from the three point data.

Results

To respond to the questions raised earlier and because of the complexity of these data, the present report will be restricted to two of the PMA variables, Space (to represent measures of crystallized ability) and Word Fluency (as an example of a fluid ability variable). In addition data will be presented for the composite IQ measure derived from the PMA via Thurstone's 1949 formula (V + S + 2R + 2N + W).

Let us first of all examine the results for the cross-sequential ANOVA reported in Table 1. This table compares the results for two studies using repeated measurement of the same Ss conducted in 1956-63 and 1963-70. Each study utilizes data on seven cohorts with mean ages at base point ranging from 25 to 67 years of age each cohort being observed again after a seven year interval. Significant cohort differences observed for all variables during the first study are found to be replicated. The null hypothesis with respect to time of measurement differences is again supported for the measure of crystallized ability, as is the cohort by time of measurement interaction for the composite IQ measure. Not replicated, however, is the time of measurement difference (interpreted in our earlier study as evidence of ontogenetic age change) for Word Fluency, the fluid intelligence measure. Instead, a significant cohort by time of measurement interaction is found for both measures of crystallized and fluid ability. A significant sex difference on Space in favor of the males is replicated, but the second study additionally resulted in a sex difference on Word Fluency in favor of the females and a significant sex by cohort interaction.

Table 2 lists the mean differences for each age interval covered in the study. Figures 1a to 3b show both cross-sectional (solid lines) and longitudinal (dashed lines) age gradients plotted for the two studies. It will be noted that the cross-sectional gradients show a steady upward shift over time except for the oldest age groups on Space. For Word-fluency, however, there was a general decrement from 1965 to 1963 but an increment from 1963 to 1970. The figures for the IQ measure show general overall gain for both periods except for the oldest age level. On Space it is noted once again that ontogenetic age changes do not occur until age 60. On the other hand, it was not possible to replicate the age decrement found for Word Fluency for all cohorts in the 1956-63 study. In the replication, ability decrement for Word Fluency was found only in the three oldest cohorts, i.e., beyond age 60. For the global IQ measure, level performance or gain was again shown for all but the oldest cohorts beyond age 60.

In addition to the evidence on the replicability or lack thereof for two point short-term longitudinal studies, we are also able to report fourteen year data over three measurement points for a somewhat attrited sample (N = 162). In addition, since we obtained independent random samples from the same cohorts at all three measurement points we can also report an analysis of the mean differences for this larger representative set of samples. The cross-sequential ANOVA is again the proper design to differentiate generational differences and ontogenetic change. Table 3 summarizes the appropriate ANOVA for both the repeated measurement and independent random sampling designs.

Significant cohort differences across the three measurement occasions were found for all variables in both analyses, except for Word Fluency in the repeated measurement study. The latter finding may well be a function of the selective attrition in favor of the more verbally fluent. A similar explanation might be attributed to the finding of significant ontogenetic changes for all variables except Space, again in the repeated measurement study. Significant cohort by time interactions were found for the measure of fluid intelligence and the composite IQ measure but not for the measure of crystallized intelligence in both the random sampling and repeated measurement studies. Sex differences were significant for both ability measures, but for the composite IQ were detected only the independent random sampling design. Table 4 reports means reflecting the ontogenetic changes within cohorts from the repeated measurement study. This table actually contains a family of seven simultaneous longitudinal studies each covering a fourteen year intervals for cohorts with mean birth years from 1889 to 1931. The study for the youngest cohort covers the age range from 25 to 39 years, the next older from 32 to 43 years and so on in seven-year increments to the oldest cohort covering the age range from 67 to 81 years. The means from the independent random sampling study are shown in Table 5. These means are presented in somewhat different form, i.e., by age level to illustrate the changes over time occurring when Ss from successive cohorts are examined at different times but equivalent age. Comparison with Table 4 is readily achieved by noting that members of the cohort who were 25 in 1956 had reached age 32 in 1963 and age 39 in 1970, etc.

Figures 4a through 6b show the three cross-sectional gradients which can be constructed for the three measurement points as well as the families of seven longitudinal three-point gradients. For Space (Figures 4a and 4b) note again the successive upward shift on the cross-sectional gradients. Positive generational upward movement is clearly apparent with no ontogenetic change of significance prior to age 60. Moreover, inspection of the time by cohort interaction strongly suggests that even the reported ontogenetic changes may be due in part to specific secular events over the 1963-70 time period.

Data for Word Fluency (Figures 5a and 5b) show even greater evidence of the influence of secular trends. Here cross-sectional gradients show a distinct drop from 1956 to 1963 but general rise from 1963 to 1970. This becomes even more obvious when the reader keeps in mind that the cross-sectional gradients obtained from repeated measurement data when plotted against age show each cohort advanced by one age level. The short-term longitudinal gradients clearly demonstrate the apparent secular nature of the changes assumed to be ontogenetic. That is, what in a study conducted over a single time period appears to be due to age-related maturational events, is shown to be determined by trends common to all age levels as a function of some experience apparently unique to a specific historic time interval.

Figures 6a and 6b (Composite IQ) seem to suggest that there are indeed highly significant generation differences and that ontogenetic changes, if any, cannot be shown to exist prior to the seventh life decade. Again interaction of ontogenetic and epoch-specific changes are suggested for the age levels beyond 60 years.

The results of our earlier studies (Schaie & Strother, 1968a, 1968b) were used to project estimated longitudinal age gradients by assuming that age changes obtained for the different cohorts at different age levels could be cumulated with the level of the gradient determined by the two points actually observed for each cohort. Figure 7 shows the comparison of gradients computed for the 65 (mean years of birth: 1917) in the manner used in the earlier studies based on data from the 1956-63 and 1963-70 repeated measurement studies. The projections for Space and IQ seem to be replicated. But the projected gradients that for Word Fluency differ markedly because of the cohort by time interaction detected in the three point study. That is, since environmental impact upon performance in Word Fluency appears to differ over different time epochs, the projections here shift radically.

We shall finally present new projections based upon the three point study, which yields more extended bases for each cohort as well as bases its time of measurement estimates on two elapsed time periods. For these gradients revised procedures (Schaie, 1970) will be used, which moreover will base the time of measurement estimate for the post-dicted portions of the gradient each cohort on the 1956-63 time period and the pre-dicted portion on the 1963-70 time period. Figures 8, 9 and 10 show the resulting families of gradients for all seven-year cohorts born from 1889 to 1931. Note that the age gradients for Space have higher levels for successive cohorts with only slight flattening out of the slopes. The gradients for Word Fluency, however, level off markedly with accompanying drop in peak level in young adulthood even though the level attained in old age appears to remain relatively constant. As expected for a composite score, shifts in IQ gradients take an intermediate position.

Discussion

The results of this study support our earlier contention that previously reported age differences in crystallized abilities were a function of generational differences rather than ontogenetic change within generations. However, we have now also found that there is an interaction between generational level and the historical period over which behavioral change is studied. For our present inquiry this means, that older cohorts not only in their youth attained a lower asymptote, but also that during certain time periods (such as the most recent seven-year period) they will be differentially affected by unique secular events. In other words, on measures of crystallized ability old people now retired will be found to function somewhat below their own peak level, while individuals now in their prime of life, most likely will maintain their level of functioning until shortly prior to their ultimate demise.

We were unable to replicate the findings of significant ontogenetic change over the adult age span for measures of fluid ability. Instead, the replication study found significant differences in performance change for the two seven-year periods under study for all cohorts. In view of the significant time by cohort interaction we must now conclude that the fluid abilities are showing successive changes not in level but in the slope of the developmental gradient. That is, while significant ontogenetic change over the adult life-span seems to have occurred for our oldest cohort, the rate of such change is decreasing to the point where it may be predicted that our youngest cohort will show little or no decrement into very old age. What seems to be happening is that successive cohorts experience successively increased enviornmental compensation for the actual ontogenetic change. Concomitantly, however, early adult asymptotic levels for the fluid abilities seem to be declining.

For the composite IQ measure we were again able to replicate the finding that successive cohorts show increasing performance levels. But the ontogenetic changes at the older age levels must now be questioned as reflecting transient temporal events which do not stand replication.

Of interest also is the comparison between the data obtained from the repeated measurement and independent random sampling models for the cross-sequential analysis. Inspection of Figures 4a and 6b shows that the results obtained are indeed very similar. The primary difference seems to be that the repeated measurement design tends to obscure generation effects where opportunities for practice might be greater for the attrition-selected sample and obscures time of measurement effects where selective age change related to ability level might be suspected. Although one might intuitively feel that age change data ought to be obtained from repeated measurement studies, the present data further support the arguments we have made elsewhere (Schaie, 1972b) in preference of the independent random sampling design. The repeated measurement data presented here have, of course, not been controlled for effects of experimental mortality or practice effect. The latter problem has been treated elsewhere for the personality data also obtained in the course of this study (Schaie, 1971).

Projection of new age gradients within cohorts based on three point data lead to the conclusion that the retired population twenty years hence will be at much less of a disadvantage as compared to their younger peers than is true for our present elderly population. This prediction is based on the finding that generation differences on the crystallized abilities have begun to slow down and that the decrement slopes for the fluid abilities are steadily leveling off. As yet unforeseeable technological breakthroughs and educational innovations could, of course, invalidate these projections to the disadvantage of the future aged.

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Table 1

ANOVA for the Cross-sequential Analysis of Developmental Changes for the 1956-63 and 1963-70 Repeated Measurement Studies

F - Ratios

		Cohorts (C)	Time of Measurement (T)	Sex (S)	C x T	C X S	T x S	C x T X S
Space	1956-63	16.16**	1.17	22.66**	2.01	..	1.61	..
	1965-70	20.55**	..	36.17**	5.20**	1.25	1.47	..
Word	1956-63	5.41**	103.54**	2.54	1.70	1.59	1.40	1.04
Fluency	1963-70	4.92**	..	19.15**	4.14**	2.16**	..	1.28
IQ	1956-63	16.02**	12.11**	..	10.10**	..	..	1.01
	1963-70	18.64**	..	..	3.71**	1.41	..	..

Table 2

Mean Differences at Various Age Levels for the Repeated Measurement Analysis

(in T Score points)

Mean Ages	Space 1956-63	Space 1963-70	Word-Fluency 1956-63	Word-Fluency 1963-70 All Ss	Word-Fluency 1963-70 Men	Word-Fluency 1963-70 Women	IQ 1956-63	IQ 1963-70
25-32	2.10	3.77	-1.48	1.59	-1.66	2.76	2.20	2.50
32-39	-1.16	1.42	-4.02	.25	.29	.19	- .04	.96
39-46	.34	.98	-3.56	2.05	1.51	2.09	.04	.88
53-60	- .57	.08	- .34	.47	1.50	- .18	- .72	.53
60-67	- .60	-2.66	-5.26	-2.62	- .80	- .53	-2.45	-1.77
67-74	-2.68	-3.34	-5.45	-1.46	-2.50	- .65	-3.95	-3.25

Table 3

ANCVA for the Cross-sequential Analysis of Developmental Changes for Repeated and Independent Measurement Designs 1956-1963-1970

		Cohorts (C)	Time of Measurement (T)	Sex (S)	C x T	C x S	T x S	C x T x S
Space	RM	8.54**	..	8.76**	1.71	..	..	1.24
	IM	96.38**	6.59**	167.02**	1.23	..	..	..
Word	RM	1.65	41.05**	5.93*	1.87*	..	1.23	1.09
Fluency	IM	36.80**	51.38**	23.71**	4.06**	1.06	..	1.73
IQ	RM	6.61**	10.43**	..	6.81**	11	1.72	1.04
	IM	139.81**	9.63**	9.49**	3.23**	1.03	1.18	1.51

Table 4

Ontogenetic Changes Within Cohorts

	Space			Word Fluency			IQ		
	1956	1963	1970	1956	1963	1970	1956	1963	1970
C1	47.54	46.08	40.69	54.38	47.54	44.92	49.08	46.08	41.00
(1889)	(67)	(74)	(81)	(67)	(74)	(81)	(67)	(74)	(81)
C2	46.07	46.00	44.93	54.33	50.67	48.20	48.60	46.73	45.07
(1896)	(60)	(67)	(74)	(60)	(67)	(74)	(60)	(67)	(74)
C3	48.93	47.43	46.96	55.32	49.57	50.29	52.75	51.21	49.68
(1903)	(53)	(60)	(67)	(53)	(60)	(67)	(53)	(60)	(67)
C4	52.19	52.28	51.72	57.91	55.03	53.31	56.06	55.69	55.75
(1910)	(46)	(53)	(60)	(46)	(53)	(60)	(46)	(53)	(60)
C5	52.85	52.85	52.92	55.81	51.85	50.69	54.81	54.15	53.77
(1917)	(39)	(46)	(53)	(39)	(46)	(53)	(39)	(46)	(53)
C6	56.42	56.35	57.77	57.12	53.08	54.46	57.42	57.08	58.15
(1924)	(32)	(39)	(46)	(32)	(39)	(46)	(32)	(39)	(46)
C7	55.29	57.71	57.14	51.62	50.86	51.00	52.62	55.43	54.43
(1931)	(25)	(32)	(39)	(25)	(32)	(39)	(25)	(32)	(39)

Table 5

Means Observed at Various Age Level for the Independent Samples

	Space			Word Fluency			IQ		
Mean Age	1956	1963	1970	1956	1963	1970	1956	1963	1970
25	54.49	-	-	53.68	-	-	53.44	-	-
32	55.46	54.46	-	56.65	52.11	-	55.81	55.10	-
39	52.37	53.08	53.59	54.14	51.70	50.14	52.63	54.48	53.72
46	50.64	51.80	53.94	56.31	50.76	52.20	53.97	52.29	54.82
53	47.61	48.98	50.99	55.67	47.80	52.75	51.35	48.40	53.72
60	45.16	47.48	49.58	49.83	48.84	50.29	44.99	46.53	52.20
67	43.82	43.61	49.58	47.86	44.49	44.03	43.26	41.85	43.69
74	-	41.22	41.44	-	44.09	41.38	-	39.95	39.27
81	-	-	40.45	-	-	42.59	-	-	37.51

Figure 1 a. Cross-Sectional and Longitudinal Gradients for Space, based on Repeated Measurement Comparisons between 1956 and 1963.

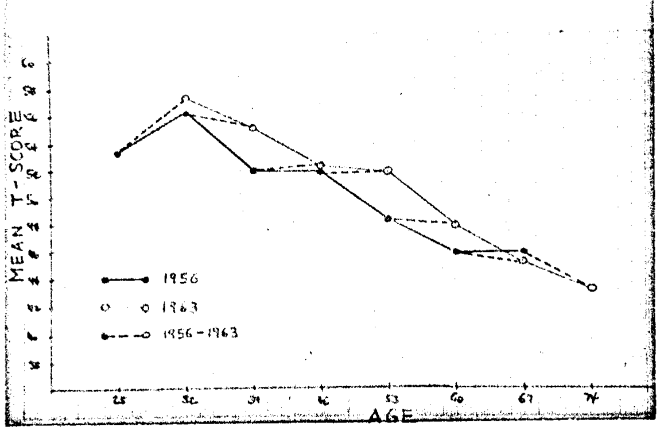

Figure 1 b. Cross-Sectional and Longitudinal Gradients for Space, based on Repeated Measurement Comparisons between 1963 and 1970.

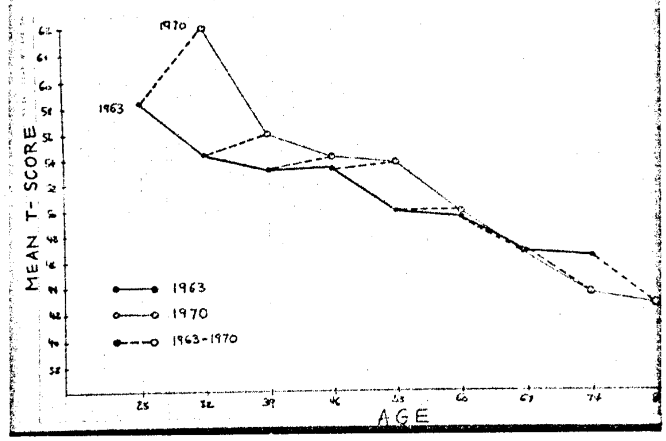

Figure 2 a. Cross-Sectional and Longitudinal Gradients for Word Fluency, based on Repeated Measurement Comparisons between 1956 and 1963.

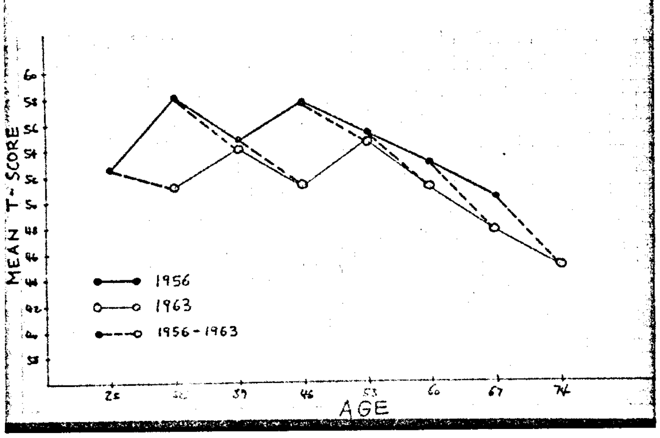

Figure 2 b. Cross-Sectional and Longitudinal Gradients for Word Fluency, based on Repeated Measurement Comparisons between 1963 and 1970.

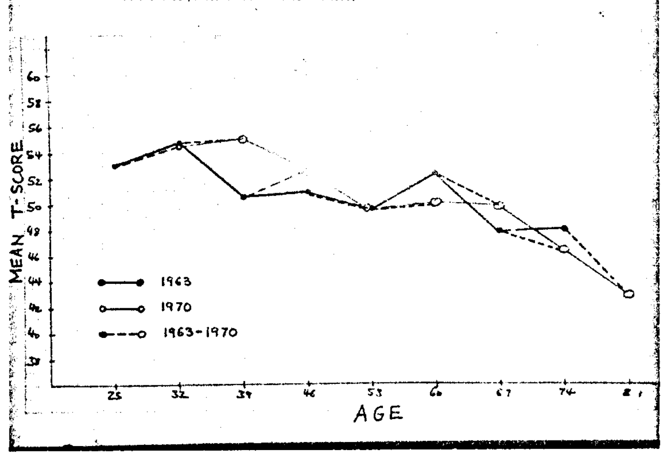

Figure 3 a. Cross-Sectional and Longitudinal Gradients for IQ, based on Repeated Measurement Comparisons between 1956 and 1963.

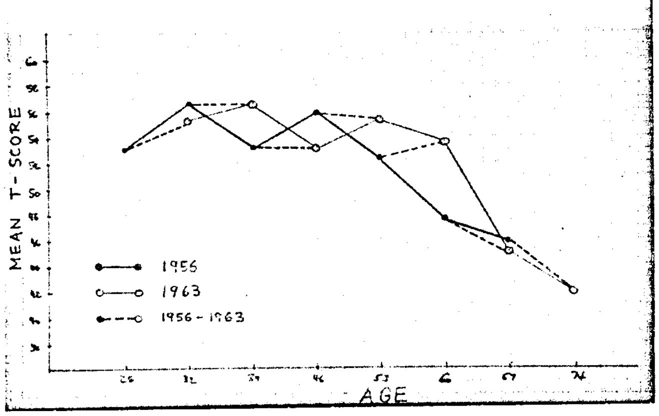

Figure 3 b. Cross-Sectional and Longitudinal Gradients for IQ, based on Repeated Measurement Comparisons between 1963 and 1970.

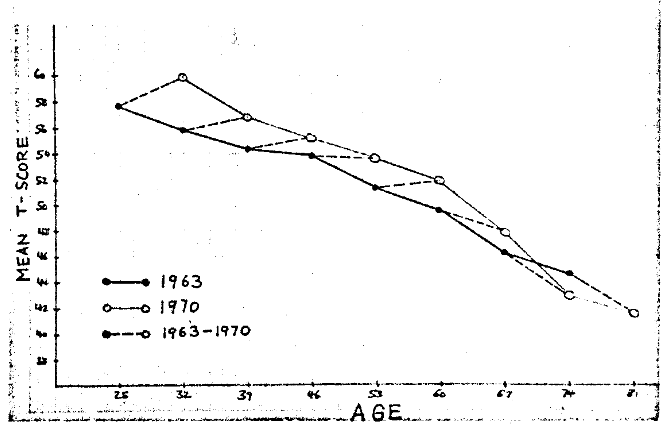

Figure 4 a. Cross-Sectional and Longitudinal Gradients for Space, based on Repeated Measurement Comparisons between 1956, 1963, and 1970.

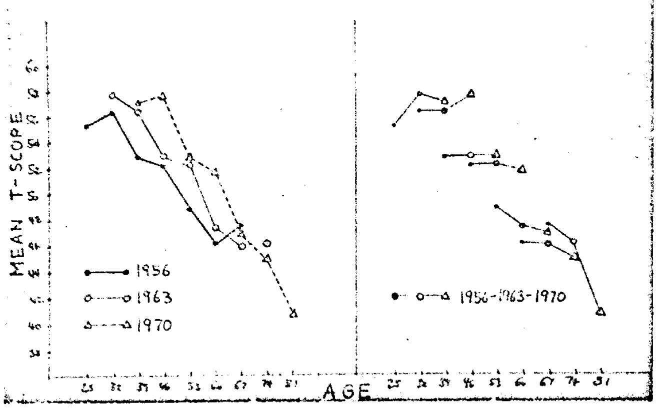

Figure 4 b. Cross-Sectional and Longitudinal Gradients for Space, based on Independent Measurement Comparisons between 1956, 1963, and 1970.

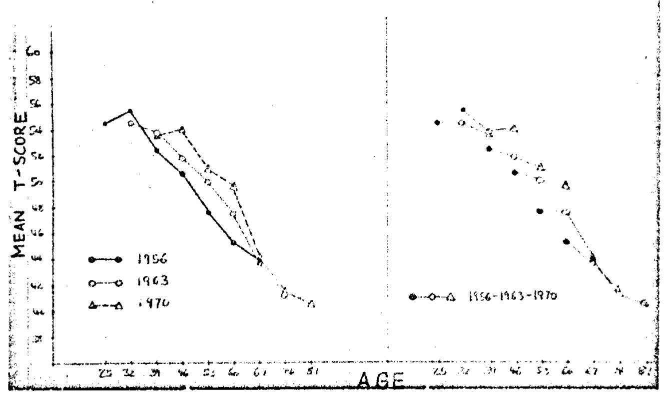

Figure 5 a. Cross-Sectional and Longitudinal Gradients for Word Fluency, based on Repeated Measurement Comparisons between 1956, 1963, and 1970.

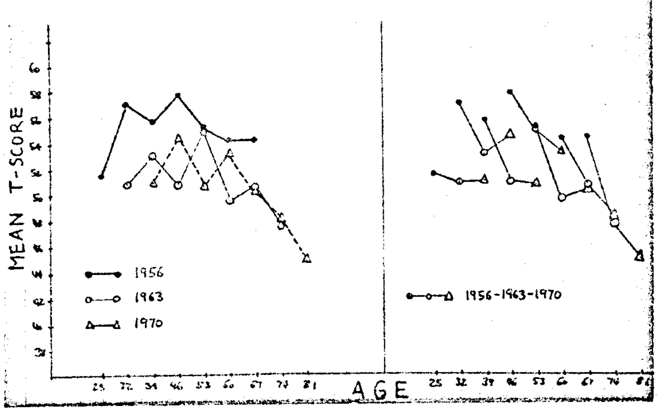

Figure 5 b. Cross-Sectional and Longitudinal Gradients for Word Fluency, based on Independent Measurement Comparisons between 1956, 1963, and 1970.

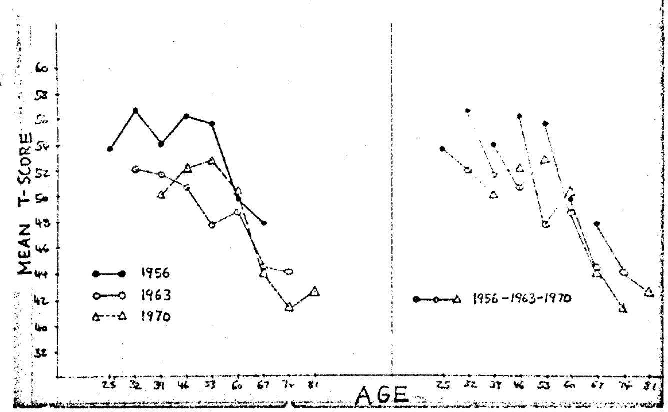

Figure 6 a. Cross-Sectional and Longitudinal Gradients for IQ, based on Repeated Measurement Comparisons between 1956, 1963, and 1970.

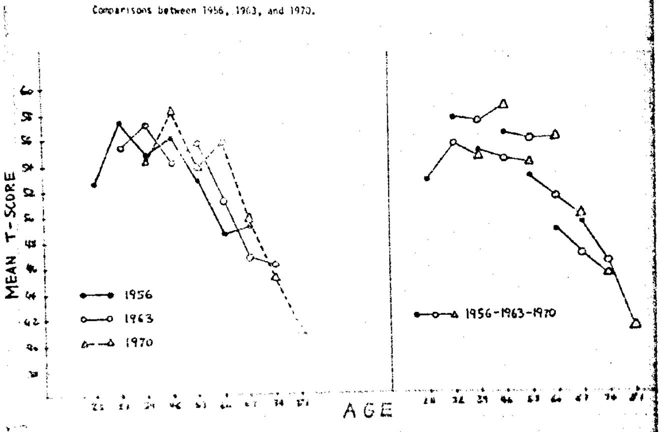

Figure 6 b. Cross-Sectional and Longitudinal Gradients for IQ, based on Independent Measurement Comparisons between 1956, 1963, and 1970.

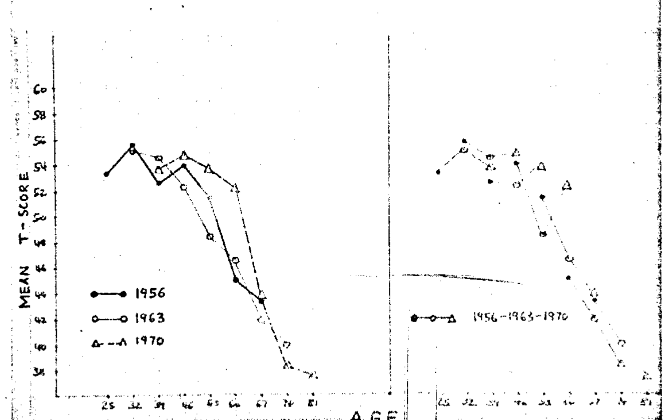

Figure 7. Projected Longitudinal Gradients for Cohort 5 (Mean Year of Birth: 1917), based on Repeated Measurement Comparisons between 1956-1963 and 1963-1970.

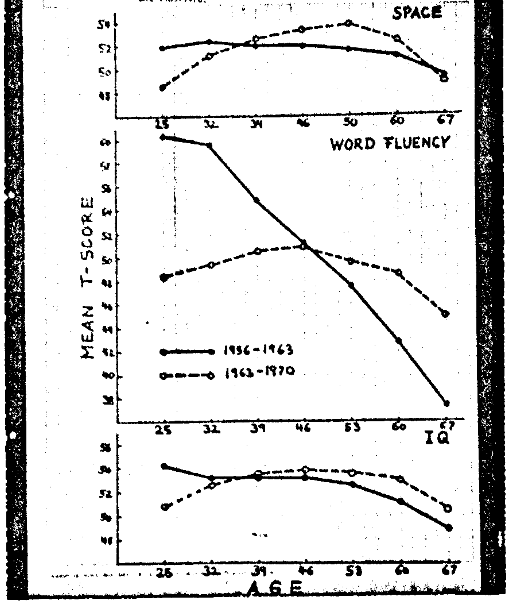

Figure 8. Estimated Cohort Gradients for Space, based in Independent Measurement Comparisons.

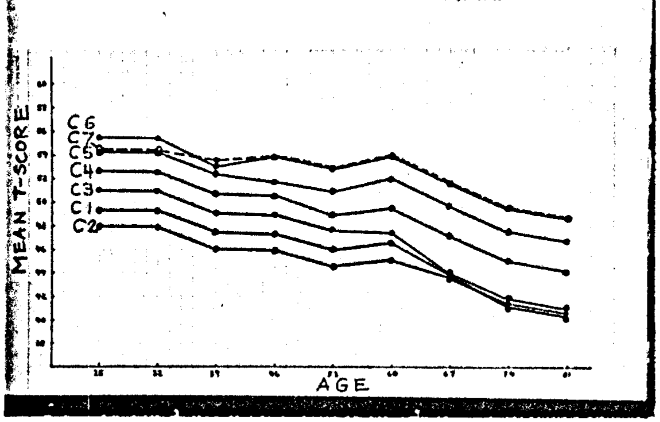

Figure 9. Estimated Cohort Gradients for Word Fluency, based on Independent Measurement Comparisons.

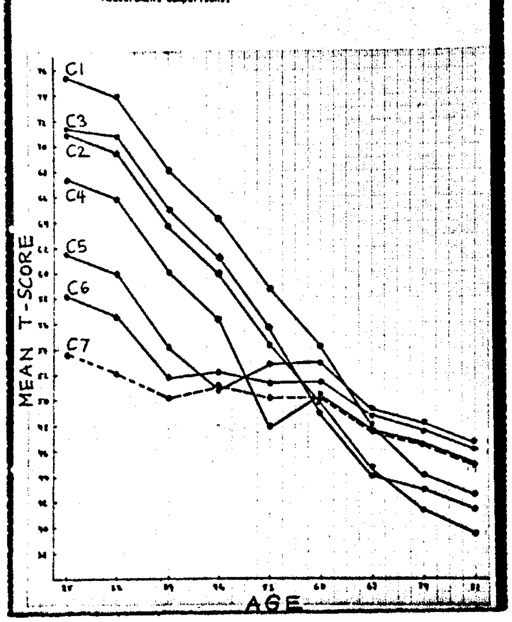

Figure 10. Estimated Cohort Gradients for IQ, based in Independent Measurement Comparisons.