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On the Question of Secular Trends in the Heritability of Intelligence Test Scores: A Study of Norwegian Twins

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Recent studies indicate that the heritability of cognitive measures has changed during the last decades (Heath et al, 1985; Plomin & DeFries, 1980). The present study investigates this issue further. Intelligence test data on 757 identical (MZ) and 1093 fraternal (DZ) male twin pairs, all tested in their late teens or early twenties, were retrieved from the files of the Norwegian Armed Forces. Scores for twins born in the period 1931 through 1960 (except the 1936 through 1943 interval) were available. The search for secular trends was performed by analyzing subgroups separately. Several partitions of the total sample were analyzed. Analysis of the finest partition of the data set (each age group was analyzed separately) revealed quite conspicious nonlinear tendencies; otherwise, the results revealed no unambigous evidence for secular trends in the heritability of intelligence test scores.

INTRODUCTION

Recently, several authors have indicated that the heritability of IQ and similar measures may have changed during the last decades. Thus, Plomin and DeFries (1980) noted that the pattern of familial correlations found in older studies (performed before 1963) is consistent with a higher broad heritability than those found in more recent studies. Caruso (1983; see also Loehlin, 1980) indicated that many of these differences could be accounted for by statistical considera-

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tions (especially restriction of range). He was, however, unable to take care of all the differences by means of statistical corrections, thus leaving the possibility of secular trends in the heritability of cognitive measures open.

A more direct approach to the question of secular trends is to search for heritability changes over groups of different ages. Two such studies have been performed on Norwegian twins. In a recent study, Heath et al. (1985) found substantial trends in the broad heritability of educational attainment. They investigated a large sample of Norwegian twins and their parents with respect to length of education (information about education was ascertained by means of a questionnaire) and found that the heritability was higher for younger than for older people and that the change in heritability was more pronounced for males than for females. For those born before the Second World War (1915–1939), about 40% of the variance in educational attainment was accounted for by effects of genes, whereas 47% was due to family background (common environments). There was no appreciable sex differences. For females born in the period 1940–1949, the relative importance of genetic and common environmental contributions changed very little (accounting for 45% and 41% of the variance, respectively), whereas the heritability among males increased to .74. The contribution of common environments was correspondingly smaller (8%). In the period 1950 through 1960, the genetic contribution was relatively lower for both females and males (38% and 67%, respectively), whereas effects of common environments accounted for 50% and 20% of the variance. The variance component due to specific (nonfamilial) environments remained approximately constant over the whole period.

Sundet, Tambs, and Magnus (1981) performed a small sample study of heritability trends of Wechsler Adult Intelligence Scale (WAIS) IQ scores for twins born before and after 1940. They found a small but not significant decrease in the impact of environmental differences between families and a corresponding increase in nonfamilial environmental variance. There was no statistically reliable indication of changing heritability, however.

Thus, the evidence concerning secular trends in the heritability of cognitive measures is quite inconclusive, and there is clearly a need for accumulating more data on this important question. The aim of this article is to report results relevant to this issue.

MATERIALS AND METHODS

The Sample

Heritability estimates were obtained by comparing the relative similarity of identical (MZ) and fraternal (DZ) twins. This is the classical twin method, the gist of which is that any excess similarity between MZ twins relative to DZ twins is due to the greater genetic similarity of MZ twins.

The twin data were obtained from files belonging to the Norwegian Armed

Forces. In Norway, military service is compulsory for every able young man. During the year before young men enter the service, they are investigated both medically and psychologically. Only those strongly disabled physically or mentally are exempted from this investigation.

The data on twins were retrieved by concatenating the Army files with the Norwegian Twin Panel, where all likesex pairs born in Norway in the period 1915–1960 are registered (Magnus, Berg, & Nance, 1983). The zygosity of the pairs was ascertained by means of a mailed questionnarie, which was answered by more than 80% of the twins. Bloodtyping of a subsample (207 pairs) showed that this questionnaire classifies 97% of the pairs correctly (Magnus et al., 1983).

It was possible to retrieve intelligence test data for 757 MZ pairs and 1,093 DZ pairs. The year of birth ranged from 1931 to 1960. Data for twins born in the period 1936–1943 were not obtainable. Thus, we have data on 22 age groups of male twins, all of which have been tested at approximately the same age (late teens or early twenties), thereby avoiding a confounding of age and year of birth. The sample includes about 40% to 45% of the male twin population born in the actual period. Sample attrition was due mainly to selection in the twin panel (Magnus et al., 1983) but also to missing intelligence test data on one or both members of the twin pair. Thus, the main bias is introduced because of the buildup of the twin panel. In addition, the fact that disabled youngsters are exempted from the medical and psychological investigations may also introduce some bias. Other sources of bias may be present as well. However, due to the population-based twin panel, this sample may be more representative for the general population than for most twin studies.

Test Material and Scoring Procedures

The intelligence test used by the Norwegian Army consists of three subtests—Arithmetics, Word Similarities, and Progressive Matrices (an abbreviated version of Raven's Progressive Matrices). The Arithmetics subtest consists of 30 items. This test, of course, purports to measure arithmetic ability but also logical reasoning ability. Actually, the items are quite similar to those in the Arithmetics subtest of WAIS. The Word Similarities subtest is a multiple choice test containing 54 items. A key word is given, and the task is to pick out the synonymous word among six alternatives. The Progressive Matrices subtest contains 36 items. The test–retest reliabilities of the Arithmetics, Word Similarities, and Progressive Matrices subtest are .84, .90, and .72, respectively. The intercorrelations between the subtests are .53 (Arithmetics and Progressive Matrices), .64 (Arithmetics and Word Similarities), and .59 (Progressive Matrices and Word Similarities) (Notes from The Psychological Services of the Norwegian Armed Forces, 1956).

The data reported in this paper is a general ability (GA) score obtained by a combination of subtest scores (equally weighted). The Word Similarities subtest unfortunately was not included in the battery until 1954. Thus, the GA scores for the 1931–1934 age groups are not strictly comparable to the rest. Considering the comparatively high intercorrelations between the subtests, this may not be a very serious limitation. The scale used is an ordinary Stanine ($M = 5$, $SD = 1.96$). Test norms have remained unchanged over the whole period covered by the present investigation. The test–retest reliability of GA is .87 (Notes from The Psychological Services of the Norwegian Armed Forces, 1956). We have calculated the correlation between the GA score and the WAIS IQ for a small sample ($n = 48$) and found it to be quite high ($r = .73$).

Statistical Models

The data analyses were performed by constructing models where the within- (V_W) and between-pair (V_B) variances of MZ and DZ twins were connected to genetic and environmental factors (Eaves, 1977). This may be done in different ways and with varying degrees of complexity but, for the present purposes, the following simple model is sufficient: Let V_G be the variance due to genetic differences, V_{EW} the variance due to environmental differences that cause within-pair variation, and V_{EB} the variance due to between-pairs environmental differences. Under the assumptions of random mating, no dominance, negligible genotype–environment interactions and covariances, and equality of total score variances for MZ and DZ twins (for a discussion of these assumptions, see Jinks & Fulker, 1970), the following set of equations holds true:

$$V_{WMZ} = V_{EW}$$

$$V_{BMZ} = V_G + V_{EB}$$

$$V_{WDZ} = 1/2V_G + V_{EW}$$

$$V_{BDZ} = 1/2V_G + V_{EB}$$

Within- and between-pair variances are connected to mean squares in a simple manner (Winer, 1971):

$$E(MS_W) = V_W$$

$$E(MS_B) = V_W + 2V_B$$

where E denotes expectations. By simple substitution, the within and between variances for MZ and DZ pairs may be written in terms of expected mean squares:

$$E(MS_{WMZ}) = V_{EW}$$

$$E(MS_{BMZ}) = 2V_G + V_{EW} + 2V_{EB}$$

$$E(MS_{WDZ}) = 1/2V_G + V_{EW}$$

$$E(MS_{BDZ}) = 3/2V_G + V_{EW} + 2V_{EB}$$

The best available estimates of the expected mean squares are the mean squares calculated from the data.

Estimation Procedures

Estimates of the parameters (V_G, V_{EW}, V_{EB}) in the model specified above were obtained by use of the LISREL IV computer program (Jøreskog & Sørbom, 1978). Given input data—in our case, mean squares—this program arrives at maximum likelihood estimates of the model parameters. In addition, LISREL supplies standard errors of the parameter estimates and a chi square goodness-of-fit test. Thus, it is possible to evaluate how well the model fits to the present data set.

RESULTS

General Considerations

To investigate whether there are secular trends in the heritability of GA, it is, of course, necessary to subdivide the total sample into several age cohorts. It is a problem here: There are no particular a priori principles to follow when deciding upon how to do such a partition. Sociological considerations may indicate a watershed around and after the Second World War. After the war, a more egalitarian policy was implemented in the Norwegian society. This change may possibly have reduced the impact of common environments (V_{EB}) and increased the relative effect of genetic factors on intelligence test scores. This line of reasoning indicates separate analyses of the test scores of those born before and after the war. For reasons of comparability with the Heath et al. (1985) results, we have also subdivided the part of the sample born after the war into two subgroups: those born from 1944 through 1949 and those born in the interval 1950 to 1960, inclusive. To get a more fine-grained picture, we have also analyzed data from seven different groups (1931–1935; 1944–1946; 1947–1949; 1950–1952; 1953–1955; 1956–1958; 1959–1960). We have also included analyses of the total sample and of each age group separately. Analyses of several other partitions did not substantially change the main conclusions reached, so they have been omitted here.

The Total Sample

The estimates of V_G, V_{EW}, and V_{EB}, together with their standard errors for the whole sample (757 MZ pairs; 1,093 DZ pairs), are given below. (LISREL estimates the square roots of the parameters and their standard errors. Both these numbers are given in brackets.) In addition, the chi square and the corresponding p-values are given. We have also supplied the intraclass correlations for MZ and DZ twins.

$$V_G = 2.17\ (1.47 \pm .05)$$

$$V_{EW} = 0.52\ (0.72 \pm .02)$$

TABLE 1
Mean Squares within and between MZ and DZ Pairs for the Total Sample

	Observed	Calculated	Observed–Calculated
MS_{WMZ}	0.517	0.519	−0.002
MS_{BMZ}	5.642	5.901	−0.259
MS_{WDZ}	1.618	1.604	0.014
MS_{BDZ}	4.935	4.816	0.119

$V_{EB} = 0.52\ (0.72 \pm .10)$

$\chi^2 = 1.12; p = .29$

$r_{MZ} = .83; r_{DZ} = .51$

All the parameter estimates are significantly different from zero, and the p-value of the chi square indicates tolerable fit of the data to the model. As may be seen from Table 1, the discrepancies between observed mean squares and mean squares calculated from parameter estimates are comparatively small. Converted to the more common indices $h^2 = V_G/V_T$, $c^2 = V_{EB}/V_T$ and $e^2 = V_{EW}/V_T$, the parameter estimates correspond to $h^2 = .68$, $c^2 = .16$ and $e^2 = .16$. It may be noted that the heritability found in the present study is somewhat higher than ordinarily found in other twin studies of intelligence test scores (Nichols, 1978, as cited in Scarr & Carter-Saltzman, 1983; Bouchard & McGee, 1981; Rowe & Plomin, 1978). This may indicate a comparatively high environmental homogeneity of the Norwegian society.

Three Subgroups

The main statistics of the data from the three different subgroups (1931–1935; 1944–1949; 1950–1960) are displayed in Table 2.

Both means and standard deviations show secular trends. The decreasing standard deviations as a function of year of birth may be of some interest in the present context. There are essentially two different kinds of interpretation of this tendency. It may be a trivial ceiling effect due to increasing means, or it may be

TABLE 2
Number of Pairs, Mean, and Standard Deviations for MZ and DZ Twins for Three Subgroups

Year of Birth	Zygosity	*N*	*M*	*SD*
1931–1935	MZ	88	5.05	1.92
	DZ	110	4.76	1.85
1944–1949	MZ	220	5.33	1.82
	DZ	327	5.38	1.90
1950–1960	MZ	449	5.65	1.67
	DZ	656	5.66	1.72

TABLE 3
Parameter Estimates, Intraclass Correlations, and Chi Squares with Corresponding *p*-Values for Subgroups

Year of Birth	Zygosity	*r*	V_G	V_{EW}	V_{EB}	h^2	$V_{EW/VT}$	$V_{EB/VT}$	X^2_1	*p*
1931–1935	MZ	.84	2.24	0.57	0.71	.64	0.16	0.20	0.18	.67
	DZ	.51	(1.50±.16)	(0.75±.06)	(0.84±.29)					
1944–1949	MZ	.83	2.64	0.57	0.30	.75	0.16	0.09	0.70	.40
	DZ	.51	(1.63±.10)	(0.75±.04)	(0.55±.27)					
1950–1960	MZ	.83	1.93	0.49	0.50	.66	0.17	0.17	0.69	.41
	DZ	.51	(1.39±.061)	(0.70±.023)	(0.71±.12)					

Note. The numbers in brackets are the square roots of the parameter estimates together with their standard errors.

caused by reduced environmental variability, especially, reduced impact of common environments due to greater homogeneity of social conditions. In the first case, the parameter estimates (V_G, V_{EW}, V_{EB}) should be affected about equally, leaving the relative contribution of each approximately constant. In the case of reduced environmental variability, a change in the relative magnitudes of the parameters might be expected, viz., reduced V_{EB} relative to V_G (provided, of course, constant V_{EW}).

The parameter estimates and associated statistics are shown in Table 3. As may be confirmed by inspection of the chi squares and their associated *p*-values, the model fit is good to very good for all three subgroups. The differences between observed and calculated mean squares also tend to be quite small; none of them exceeds 10% of the observed mean squares (cf. Table 4).

The parameter estimates reveal no clearcut secular trends; the changes are small and nonlinear. The h^2 estimates first increase from .64 to .75 and then decrease to .66. Corresponding tendencies are found in the c^2 contributions

TABLE 4
Mean Squares Obtained from Data (Observed), Mean Squares Expected from Model (Calculated), with Differences for Three Age Groups

Year of Birth		Observed	Calculated	Observed–Calculated
1931–1939	MS_{WMZ}	0.574	0.571	0.003
	MS_{BMZ}	6.805	6.473	0.332
	MS_{WDZ}	1.673	1.691	−0.018
	MS_{BDZ}	5.172	5.353	−0.181
1944–1949	MS_{WMZ}	0.564	0.567	−0.003
	MS_{BMZ}	6.025	6.445	−0.420
	MS_{WDZ}	1.911	1.887	0.024
	MS_{BDZ}	5.302	5.125	0.177
1950–1960	MS_{WMZ}	0.482	0.484	−0.002
	MS_{BMZ}	5.103	5.342	−0.239
	MS_{WDZ}	1.462	1.450	0.012
	MS_{BDZ}	4.486	4.377	0.109

TABLE 5
Number of Pairs (*N*), Means, and Standard Deviations for MZ and DZ Twins for Seven Age Groups

Year of birth	Zygosity	*N*	*M*	*SD*
1931–1935	MZ	88	5.05	1.92
	DZ	110	4.76	1.85
1944–1946	MZ	106	5.40	1.88
	DZ	136	5.32	1.93
1947–1949	MZ	114	5.27	1.75
	DZ	191	5.49	1.88
1953–1955	MZ	123	5.51	1.80
	DZ	158	5.62	1.81
1956–1958	MZ	122	5.81	1.49
	DZ	195	5.92	1.68
1959–1960	MZ	104	5.61	1.62
	DZ	128	5.68	1.63

(.20, .09, and .17, respectively). Due to large standard errors of heritability estimates (Loehlin & Nichols, 1976), these changes are not statistically reliable. On the other hand, they are in the same direction as those found by Heath et al. (1985) with regard to educational attainment. Thus, a more fine-grained analysis in search for more complicated secular trends of intelligence test scores seems indicated.

Analysis of Data from Seven Subgroups

The number of pairs, means, and standard deviations for MZs and DZs for each of the seven subgroups are shown in Table 5.

TABLE 6
Parameter Estimates, Intraclass Correlations, and Chi Squares with Corresponding *p*-Values for Seven Age Groups

Year of Birth	Zygosity	*r*	V_G	V_{EW}	V_{EB}	h^2	V_{EW}/V_T	V_{EB}/V_T	X^2_1	*p*
1931–35	MZ	.84	2.24	0.57	0.71	.64	0.16	0.20	0.18	.67
	DZ	.51	(1.50±.16)	(0.76±.06)	(0.84±.29)					
1944–46	MZ	.81	2.14	0.66	0.85	.60	0.18	0.22	0.08	.78
	DZ	.53	(1.46±.15)	(0.81±.06)	(0.92±.25)					
1947–49	MZ	.85	2.93	0.48	0.00	.86	0.14	0.00	0.95	.33
	DZ	.43	(1.71±.12)	(0.69±.05)						
1950–52	MZ	.88	2.12	0.39	0.58	.69	0.12	0.19	0.31	.58
	DZ	.52	(1.46±.11)	(0.62±.04)	(0.76±.22)					
1953–55	MZ	.80	1.49	0.61	1.12	.46	0.19	0.35	0.11	.74
	DZ	.58	(1.22±.14)	(0.78±0.6)	(1.06±.17)					
1956–58	MZ	.79	1.70	0.49	0.45	.65	0.19	0.17	2.73	.10
	DZ	.54	(1.31±.11)	(0.70±.05)	(0.70±.21)					
1959–60	MZ	.82	2.19	0.48	0.00	.82	0.18	0.00	0.99	.32
	DZ	.34	(1.48±.14)	(0.70±.05)						

TABLE 7
Observed and Calculated Mean Squares with Differences for Seven Age Groups

Year of Birth		Observed	Calculated	Observed–Calculated
1931–1935	MS_{WMZ}	0.574	0.571	0.003
	MS_{BMZ}	6.805	6.473	0.332
	MS_{WDZ}	1.673	1.691	−0.018
	MS_{BDZ}	5.172	5.353	−0.181
1944–1946	MS_{WMZ}	0.660	0.662	−0.002
	MS_{BMZ}	6.445	6.651	0.112
	MS_{WDZ}	1.743	1.732	0.011
	MS_{BDZ}	5.693	5.881	0.112
1947–1949	MS_{WMZ}	0.474	0.481	−0.007
	MS_{BMZ}	5.674	6.353	−0.679
	MS_{WDZ}	2.031	1.949	0.082
	MS_{BDZ}	5.029	4.885	0.144
1950–1952	MS_{WMZ}	0.039	0.388	0.002
	MS_{BMZ}	6.127	5.786	0.341
	MS_{WDZ}	1.434	1.449	−0.015
	MS_{BDZ}	4.566	4.726	−0.160
1953–1955	MS_{WMZ}	0.610	0.612	−0.002
	MS_{BMZ}	5.608	5.830	−0.222
	MS_{WDZ}	1.364	1.356	0.008
	MS_{BDZ}	5.192	5.086	0.106
1956–1958	MS_{WMZ}	0.480	0.488	−0.008
	MS_{BMZ}	3.979	4.792	−0.813
	MS_{WDZ}	1.379	1.340	0.039
	MS_{BDZ}	4.282	3.940	0.342
1959–1960	MS_{WMZ}	0.471	0.484	−0.013
	MS_{BMZ}	4.764	4.867	−0.103
	MS_{WDZ}	1.744	1.580	0.164
	MS_{BDZ}	3.523	3.771	−0.248

The secular trends in the means and standard deviations are quite pronounced again, especially for the two groups containing twins born in the 1956 through 1960 interval.

The parameter estimates and corresponding statistics for each of the seven groups are shown in Table 6. As may be seen from this table, the model fit is marginal for the 1956 through 1958 group. Otherwise, the fit is tolerant to excellent.

Again, there are rather small discrepancies between observed and calculated mean squares (cf. Table 7).

Inspection of the parameter estimates in Table 6 again reveals no simple secular trends of h^2 and c^2. Although there is a slight linear tendency towards increasing h^2 among younger people, this tendency is far from statistically reliable, $r = .15$, $p > .10$. The nonlinear trends seem too weak to be considered

TABLE 8
Number of Pairs of MZ and DZ Twins, Means, Standard Deviations, and Mean Squares for Separate Age Groups

Year of Birth	Zygosity	*N*	*M*	*SD*	MS_W	MS_B
1931	MZ	13	3.92	1.98	0.39	7.74
	DZ	25	4.64	2.01	2.120	6.02
1932	MZ	20	4.93	1.79	0.83	5.70
	DZ	21	4.67	1.75	2.57	3.57
1933	MZ	21	4.91	1.90	0.62	6.73
	DZ	23	4.76	1.58	1.20	3.86
1934	MZ	18	6.00	1.64	0.56	4.94
	DZ	23	4.87	1.89	1.13	6.15
1935	MZ	16	5.25	1.88	0.38	6.93
	DZ	18	4.92	2.06	1.31	7.37
1944	MZ	35	5.63	1.89	0.89	6.33
	DZ	44	5.59	1.90	1.73	5.56
1945	MZ	33	5.56	1.65	0.59	4.90
	DZ	43	5.24	1.92	1.57	5.82
1946	MZ	38	5.04	2.03	0.51	7.82
	DZ	49	5.15	1.95	1.91	5.73
1947	MZ	42	5.07	1.77	0.49	5.82
	DZ	65	5.23	2.07	2.28	6.33
1948	MZ	35	5.41	1.81	0.50	6.10
	DZ	57	5.81	1.73	1.95	4.05
1949	MZ	36	5.38	1.67	0.43	5.24
	DZ	69	5.48	1.78	1.87	4.46
1950	MZ	44	5.50	1.77	0.25	6.07
	DZ	58	5.35	1.71	1.42	4.42
1951	MZ	37	5.70	1.80	0.41	6.18
	DZ	51	5.61	1.68	1.45	4.25
1952	MZ	42	5.36	1.84	0.52	6.32
	DZ	65	5.23	1.79	1.43	4.99
1953	MZ	36	5.32	1.77	0.40	5.92
	DZ	45	5.61	1.91	1.34	5.98
1954	MZ	31	5.87	1.95	0.97	6.70
	DZ	49	5.34	1.98	1.52	6.36
1955	MZ	33	5.86	1.52	0.50	4.17
	DZ	64	5.84	1.57	1.26	3.70
1956	MZ	33	5.86	1.52	0.50	4.17
	DZ	70	5.88	1.48	0.98	3.43
1957	MZ	44	5.67	1.68	0.61	5.21
	DZ	56	5.88	1.65	1.56	3.89
1958	MZ	45	5.92	1.40	0.39	3.57
	DZ	69	6.00	1.90	1.64	5.57
1959	MZ	53	5.75	1.74	0.50	5.57
	DZ	66	5.71	1.63	1.49	3.75
1960	MZ	51	5.46	1.47	0.44	3.94
	DZ	62	5.64	1.63	2.02	3.33

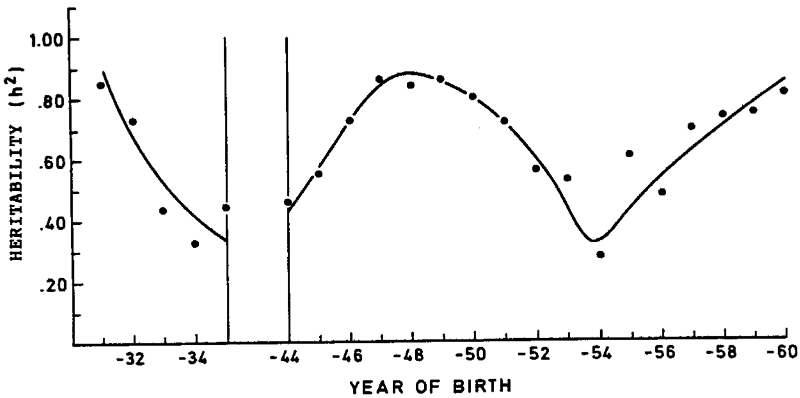

FIG. 1.

seriously. They might, of course, be the result of complicated social processes; or they might be due simply to statistical fluctuations.

Analyses of each age group separately strengthens the impression of the presence of nonlinear trends, however. The main statistics (number of pairs, means, standard deviations, and mean squares) for both MZs and DZs are shown in Table 8.

Figure 1 displays the magnitude of h^2 as a function of year of birth. There are quite conspicuous nonlinear trends, and they are statistically reliable, as shown by autocorrelation analysis (Gottman, 1981). Thus, autocorrelations of lag 1, 4, 5, and 6 are statistically significant, $p < .05$. Nevertheless, we are somewhat reluctant to accept this as conclusive evidence for systematic secular trends in the heritability of intelligence test scores. There are several reasons for this attitude: The present material may be subdivided in several different ways, none of which is, a priori, more reasonable than any other. Statistical considerations warn us that, in this kind of situation, some kind of statistically reliable tendency may show up by chance alone. Also, the sample sizes are small, reducing the statistical power of the design quite substantially. On the other hand, the tendencies shown in Figure 1 *may* mirror complicated sociological processes resulting in varying homogeneity of the environmental conditions critical for intelligence test scores.

Assuming for a moment that this is indeed the case, it is tempting to offer some very tentative speculations about possible causes. The dip in heritability in the cohorts born before the war may be due to a more uneven distribution of goods during the war (rich people remaining comparatively rich, poor people becoming even poorer). This may have affected younger cohorts more than older ones because younger children may be more susceptible to adverse environmental conditions (like poor nourishment) than older children. After the war, the standards of living improved quite substantially for poor people. This may explain the consistently increasing heritabilities for the cohorts from 1944 to about 1950. We are, however, quite at a loss in explaining the dip from about 1950 to 1954. Thus, we feel that the best strategy at present is to leave the issue of secular trends open.

DISCUSSION

In conclusion, we feel that the present results show that there are no simple secular trends in the heritability of the general ability score for the period covered in this study, at least not for males; but there may be more complicated, nonlinear trends (see Figure 1). This result may corroborate the main conclusions from an earlier study of WAIS IQ on a small sample of Norwegian twins (Sundet et al., 1981). Considering, in addition, the substantial correlation between the general ability score and the WAIS IQ (r = .73), it may be suspected that this conclusion also pertains to more standard cognitive measures. However, quite different results may be found with different subject sampling (e.g., females, children, other family constellations) and time sampling.

It may be of some interest to compare the present results with the Plomin and DeFries (1980) analysis of U.S. data. Although these authors stress that methodological considerations render any definite conclusions quite uncertain, they suggest a possible *decrease* in heritability in more recent familial data. If this is substantiated, it may indicate different social developments in different western societies.

The differences between the present results and those obtained by Heath et al. (1985) on educational attainment also need a few comments. The fact that the samples in both studies have been ascertained from the same population-based twin registry seems to secure reasonable comparability of parameter estimates. More serious, perhaps, is the issue of time sampling. Heath et al. (1985) found the most pronounced changes of heritability (in males) between those born before 1940 and those born later than 1940. The present data set suffers from a relative scarcity of data for twins born before 1940. Bearing this in mind, it might be noted that the general ability scores show the same tendencies as educational attainment with regard to heritability changes but considerably weaker (Table 3). This is probably due at least partly to the fact that the Norwegian government in the postwar period has offered loans to young people seeking education, thus enabling youngsters with poor parents to attend higher education. Such factors, together with a more positive attitude towards education among poor people, would tend to decrease the effect of familial environments and maximize genetic potential. Environmental factors of this kind influence more "pure" cognitive measures only to the extent that cognitive ability is improved by education.

REFERENCES

Bouchard, T., & McGee, M. (1981). Familial studies of intelligence. A review. *Science*, *212*, 1055–1059.

Caruso, D.R. (1983). Sample differences in genetics and intelligence data: Sibling and parent–offspring studies. *Behavior Genetics, 13,* 453–458.

Eaves, L.J. (1977). Inferring causes of human variation. *Journal of the Royal Statistical Society, Ser. A, 140,* 324–355.

Gottman, J.M. (1981). *Time-series analysis. A comprehensive introduction for social scientists.* London: Cambridge University Press.

Heath, A.C., Berg, K., Eaves, L.J., Solaas, M.H., Corey, L.A., Sundet, J., Mągnus, P., & Nance, W.E. (1985). Educational policy and the heritability of educational attainment. *Nature, 314,* 734–736.

Jinks, L.J., & Fulker, D.W. (1970). Comparison of the biometrical genetical, MAVA, and classical approaches to the analysis of human behavior. *Psychological Bulletin, 73,* 311–349.

Jøreskog, K.G., & Sørbom, D. (1978). *LISREL: Analysis of linear structural relationships by the method of maximum likelihood. Version IV.* Chicago: International Educational Services.

Loehlin, J.C. (1980). Recent adoption studies of IQ. *Human Genetics, 55,* 297–302.

Loehlin, J.C., & Nichols, R. (1976). *Heredity, environment, and personality. A study of 850 sets of twins.* Austin: University of Texas Press.

Magnus, P., Berg, K., & Nance, W.E. (1983). Predicting zygosity in twins born 1915–1960. *Clinical Genetics, 24,* 103–112.

Notes from the Psychological Services of the Norwegian Armed Forces. (1956). *Memorandum 12B* (in Norwegian). Oslo, Norway: Author.

Plomin, R., & DeFries, J.C. (1980). Genetics and intelligence: Recent data. *Intelligence, 4,* 15–24.

Rowe, D.C., & Plomin, R. (1978). The Burt controversy: A comparison of Burt's data on IQ with data from other studies. *Behavior Genetics, 8,* 81–84.

Scarr, S., & Carter-Saltzman, L. (1983). Genetics and intelligence. In J.L. Fuller & E.C. Simmel (Eds.), *Behavior genetics: Principles and applications.* Hillsdale, NJ/London: Erlbaum.

Sundet, J.M., Tambs, K., & Magnus, P. (1981). Heritability analysis as a means of analyzing the effects of social changes on psychological variables. An empirical study of IQ scores. *Psychiatry and Social Science, 1,* 241–248.

Winer, B. (1971). *Statistical principles in experimental design.* New York: McGraw-Hill.