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The relation of measured intelligence to birth order and maternal age*

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One of the difficulties in interpreting the relation between fertility and measured intelligence is the possible influence of birth order. Penrose (1963), among others, has recognized that a negative correlation between sibship size and intelligence would result if birth order and intelligence were also negatively correlated.

For various reasons most observations on birth order and intelligence have been inconsistent or inconclusive. No conclusion can be drawn from comparisons (first with second, second with third born, etc.) between school-children, for since children in low birth ranks are likely to come from small families, it is unknown whether observed differences are due to the ordinal position or to the size of family identified by it. Attempts have been made to overcome this difficulty by comparing children from families of similar size, for example, first born from two child families with second born from two child families. But at the time—usually age 11—when school-children are examined, many families are incomplete, and in the example quoted the second born is more likely to come from a completed and smaller family (since 11 years have passed without the birth of a surviving sib) than the first born (who has a sib born in the 11-year period). So again it is uncertain whether an observed difference is attributable to ordinal position or family size. This difficulty was recognized in the Report on the Trend of Scottish Intelligence by the Scottish Council for Research in Education (1949).

It would seem possible to assess the significance of birth order by examination of intelligence of children within the same sibships. Some investigations of this type have been based on small numbers or selected material, or have failed to correct adequately for age differences between sibs at the time of testing. Unfortunately age correction raises problems noted by Roberts (1947), and it is undoubtedly better to avoid them by a standard test of sibs as they attain the same age. This was the method used in the 1947 Scottish survey, and from examination of 1036 sib pairs it was concluded that there was no evidence of a relationship between measured intelligence and birth order.

In most investigations of intelligence and birth order little attention has been given to the possible significance of maternal age, and results from the few reports (summarized by Locke & Goldstein, 1937) are inconsistent. Roberts (1947) concluded that age was unimportant, but a recent investigation of 11,280 children born in Aberdeen showed that test scores increase with increasing mother's age and decrease with increasing birth rank (Illsley, 1967). This result raises the familiar difficulties of interpretation in population studies where differences within families cannot be separated from differences between families.

Our own data also comprise intelligence scores for a population of children identified at birth. Numbers are large enough to provide a substantial number of fraternities with two or more

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births within the period of study (5 years). It is therefore possible to overcome some of the difficulties by examination of differences between sibs.

SOURCES OF DATA

The data are derived from two main sources: observations on Birmingham births in the 5 years 1950–54; and the two tests of verbal reasoning taken by children born in those years as part of the eleven-plus examination.

The birth data were described initially by Charles (1951) and more recently by Leck, Record, McKeown & Edwards (1968). Essentially they comprise the obstetric records of hospital and domiciliary births, with additional information recorded to age 5, mainly by health visitors. Apart from basic data such as sex and date of birth, the present paper exploits the observations on birth rank, maternal age and social class. The social classification is based on father's occupation; but since the original grouping of occupations differs somewhat from that used by the Registrar General, children are placed in one of three groups, A, B and C. These correspond approximately to classes I and II, III, and IV and V respectively in the national classification.

The eleven-plus material was described by Barker & Edwards (1967). Briefly, the verbal reasoning tests are two of the four tests taken by children at age 11 and are probably a more acceptable indication of intelligence than the other two papers (not used in this investigation) in English and mathematics. The means of the two verbal reasoning scores were adjusted for the slight variation in age so that scores for children born in different months have a mean of 100 and a standard deviation of 15. The present examination is based on an analysis of these age adjusted (V.R.) scores.

The handling of the data has been greatly facilitated by the use of a computer. This has made it practical not only to link the birth data and the V.R. scores, but also to make sib comparisons in families with two or more births within the 5-year period (1950–54). The sib comparison is an essential part of the examination and overcomes some of the ambiguities which result from the correlation between birth rank and social class.

There were 86,630 Birmingham livebirths in the period 1 January 1950 to 1 September 1954; V.R. scores were matched for 50,172 children. The difference between the two numbers is accounted for mainly by those who left the City or died before age 11, or who did not take the examination because they were in private schools, in special schools for the handicapped, or, though in ordinary schools, had been assessed as 'borderline subnormal'.

Since it is well known that measured intelligence is considerably lower for multiple than for single births, 1242 twins and 17 triplets have been excluded. The subsequent investigation is based on 48,913 single births.

It has been reported that at about the time of puberty, when the eleven-plus examination is taken, test scores are higher for girls than for boys (Scottish Council for Research in Education, 1949). This conclusion is confirmed by the present series, in which mean scores were 99·4 and 100·9 for males and females respectively. Apart from its intrinsic interest, this observation makes it necessary to take account of sex differences, for example in sib comparisons. The difference is not large enough, however, to require separation of the sexes when considering the relation of test scores to variables such as maternal age, birth rank and social class.

RESULTS

Figure 1 shows in three dimensions the striking association between V.R. scores and maternal age and birth order. Scores rise regularly with increasing age and fall with increasing birth order, and when the effects of the variables are combined at the extremes the differences are very great (106·1 for first born of mothers aged 40 and over; 88·6 for fifth and later born of mothers aged 25–29). The numerical data are given in Table 1. The chief difficulty in interpreting these results has already been referred to, that it is not clear to what extent they are attributable to differences within families or between families. This problem can be investigated by consideration of sibs.

Sib comparisons are restricted to single children who took the eleven-plus examination and to adjacent birth ranks, viz. first are compared with second, second with third born, etc. There were 4705 fraternities with two or more children born within the 5-year period, and they provided 5083 pairs as follows.

No. of fraternities	No. of children in the period	No. of adjacent pairs
4347	2	4347
338	3	676
20	4	60
		Total 5083

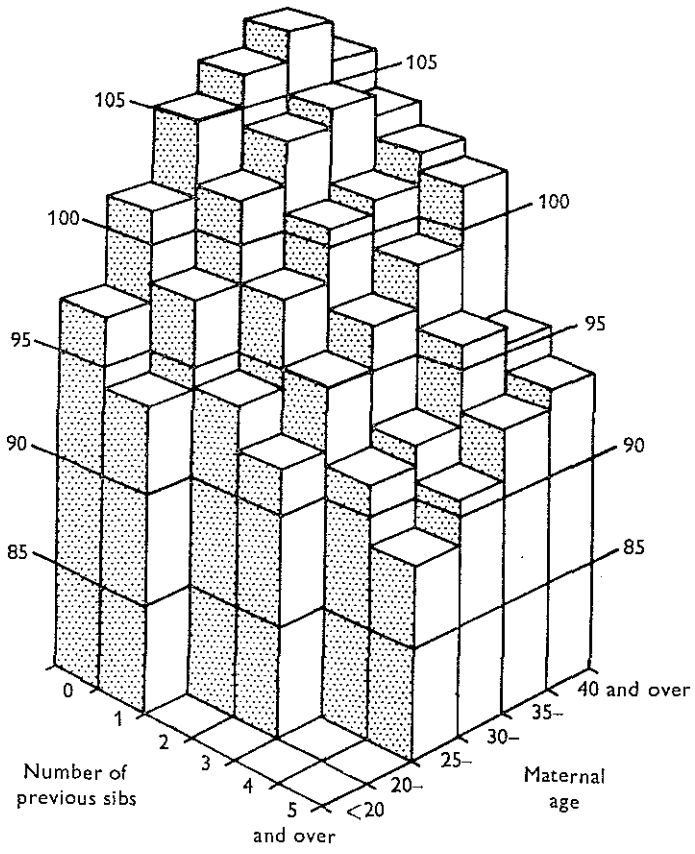

Fig. 1. Mean V.R. scores according to age of mother at birth of child and number of previous sibs.

Twenty-nine pairs were excluded for various reasons (usually because one child did not complete the full eleven-plus examination) leaving 5054 for analysis.

Table 2 gives V.R. scores for consecutive children. Here it seemed essential to take account of the small but consistent differences between the sexes. The main conclusions which emerge are:

(*a*) there is a moderate correlation between scores of sibs (approximately 0·55) and this is little affected by sex;

(*b*) the mean score is 1·0 lower for later sibs (both sexes) than for earlier;

Table 1. *Mean* V.R. *score according to age of mother at birth of child and number of previous sibs*

Previous sibs	Maternal age: Under 20	20–	25–	30–	35–	40 and over	Not stated	Total
0	97·1 (1,223)	**101·3** (5,589)	**105·0** (3,853)	**106·7** (1,630)	**107·8** (512)	**106·1** (140)	— (17)	103·0 (12,964)
1	93·9 (161)	97·7 (2,661)	**102·1** (3,985)	**104·2** (2,611)	**104·9** (907)	**104·1** (189)	— (15)	101·6 (10,529)
2	— (8)	94·2 (861)	97·8 (2,154)	**100·7** (2,042)	**101·4** (932)	**102·9** (231)	— (14)	99·0 (6,242)
3	— (1)	91·8 (220)	95·1 (1,042)	96·9 (1,206)	98·9 (719)	**101·9** (238)	— (9)	96·8 (3,435)
4	—	— (56)	91·3 (405)	94·1 (704)	96·0 (443)	95·5 (186)	—	94·0 (1,794)
5 and over	—	— (14)	88·6 (256)	90·6 (717)	93·0 (845)	94·1 (515)	— (1)	92·1 (2,348)
Not stated	— (1)	— (3)	— (1)	— (2)	— (2)	—	— (3)	— (12)
Total	96·7 (1,394)	99·3 (9,404)	101·0 (11,696)	101·0 (8,912)	100·3 (4,360)	99·3 (1,499)	— (59)	100·3 (37,324)

Numbers of children are given in brackets. Of the original 48,913 children, 11,589 of unknown social class are excluded. To save space in this and following tables, standard errors of means are not given. They can be readily calculated from the fact that the distribution of V.R. scores has a standard deviation of 15 points. For example, the standard error of the mean is 1·5 points for a group of 100 children, 0·5 for 900, and 0·3 for 2,500.

Table 2. *Comparison of* V.R. *scores of consecutive sibs according to sex*

Type of sib pair	No. of pairs	Mean V.R. score of (1) Earlier sib: Male	(1) Earlier sib: Female	(2) Later sib: Male	(2) Later sib: Female	Difference (1)–(2)	Coefficient of correlation between sibs
Male:male	1231	98·4	—	96·8	—	1·6	0·55
Male:female	1307	97·9	—	—	98·6	−0·7	0·53
Female:male	1218	—	99·5	97·3	—	2·2	0·57
Female:female	1298	—	99·3	—	98·5	0·8	0·55
Differences (upper–lower)		0·5	0·2	−0·5	0·1	—	—
All males		98·2	—	97·0	—	1·2	—
All females		—	99·4	—	98·5	0·9	—
Difference (female–male)		1·2		1·5			
Both sexes (5054 pairs)		98·8		97·8		1·0	0·55

(*c*) the difference is greater if both are males (1·6) than if both are females (0·8) and the sex difference accentuates the difference for FM pairs (2·2) and reverses it for MF (−0·7);

(*d*) the sex of the sib, whether preceding or following, has no consistent influence on the V.R. score.

The relation of scores to birth order is examined in Tables 3 and 4. Table 3 gives for the total population in Table 1 the differences between the crude means, and between means standardized to correct for the influence of maternal age. Since the relationship of scores to age and birth order is inverse, the effect of standardization is to increase the differences. For example, the difference between means for first and second born children is raised by standardization from 1·8 to 2·9.

Table 3. *Relation of* V.R. *score to birth order*

Birth order	No.	Mean V.R. score: Crude	Mean V.R. score: Standardized	Difference between consecutive orders
1st	11,724	103·6	104·8	2·9
2nd	10,353	101·8	101·9	3·7
3rd	6,220	99·0	98·2	2·8
4th	3,425	96·8	95·4	2·6
5th	1,794	94·0	92·8	3·4
6th and later	2,347	92·1	89·4	

The crude means differ slightly from those given in Table 1 because births to mothers under 20 have been excluded in order to permit standardization to remove variation due to maternal age.

Table 4. *Comparison of* V.R. *scores of consecutive sibs according to birth order*

Birth order of sibs compared	No. of pairs	Mean V.R. scores of: (1) Earlier sib	(2) Later sib	Difference (1)–(2)
1st with 2nd	2193	101·8	100·3	1·5
2nd with 3rd	1278	98·8	97·9	0·9
3rd with 4th, 4th with 5th	1111	95·4	94·9	0·5
5th with 6th, 6th with 7th, 7th with 8th, 8th with 9th	472	91·8	91·9	−0·1

When comparison is restricted to sibs (Table 4) the differences are much smaller. Moreover, they are greatest between first and second born (1·5) and next greatest between second and third born (0·9). At birth ranks 5 and over there is no consistent difference between scores of children in adjacent birth ranks.

The conclusion which emerges from the sib comparison is that differences between mean V.R. scores of sibs are small and that the striking association with maternal age and birth order observed in a general population of births (Fig. 1) is determined mainly by differences between rather than within families. Hence the negative correlation between sibship size and intelligence cannot be attributed substantially to variation in intelligence according to birth order or maternal age within sibships. Here it should be noted that within the same fraternities it is not practical, although under experimental conditions it would be theoretically possible, to separate the influence of birth order from that of mother's age.

The problem remains of accounting for the wide differences in intelligence between children in different families reflected in the striking relationship to maternal age and birth order. Distribu-

tions according to age and birth order are effectively distributions by social class, and the results in Fig. 1 and Table 1 are just what would be expected because of the correlation between social class and measured intelligence.

Table 5. *Percentage of children in each social group (A, B and C) within each maternal age/birth order cell of Table* 1.

No. of previous sibs	Maternal age: Under 20			20–			25–			30–			35–			40 and over			Total		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
0	4	—	—	9	—	—	16	—	—	18	—	—	20	—	—	19	—	—	12	—	—
	—	77	—	—	77	—	—	72	—	—	70	—	—	66	—	—	68	—	—	74	—
	—	—	19	—	—	14	—	—	12	—	—	12	—	—	13	—	—	14	—	—	14
1	1	—	—	6	—	—	11	—	—	16	—	—	17	—	—	17	—	—	12	—	—
	—	81	—	—	78	—	—	76	—	—	73	—	—	73	—	—	69	—	—	75	—
	—	—	18	—	—	15	—	—	13	—	—	11	—	—	10	—	—	14	—	—	13
2	—	—	—	5	—	—	7	—	—	11	—	—	14	—	—	14	—	—	9	—	—
	—	—	—	—	76	—	—	78	—	—	77	—	—	75	—	—	71	—	—	76	—
	—	—	—	—	—	20	—	—	15	—	—	12	—	—	11	—	—	15	—	—	14
3	—	—	—	5	—	—	5	—	—	7	—	—	8	—	—	10	—	—	6	—	—
	—	—	—	—	74	—	—	78	—	—	78	—	—	79	—	—	80	—	—	78	—
	—	—	—	—	—	21	—	—	17	—	—	15	—	—	14	—	—	10	—	—	16
4	—	—	—	—	—	—	2	—	—	4	—	—	7	—	—	6	—	—	5	—	—
	—	—	—	—	—	—	—	80	—	—	79	—	—	69	—	—	69	—	—	78	—
	—	—	—	—	—	—	—	—	18	—	—	17	—	—	14	—	—	25	—	—	17
5 and over	—	—	—	—	—	—	2	—	—	3	—	—	5	—	—	6	—	—	4	—	—
	—	—	—	—	—	—	—	74	—	—	78	—	—	76	—	—	76	—	—	76	—
	—	—	—	—	—	—	—	—	24	—	—	18	—	—	19	—	—	19	—	—	19
Total	3	—	—	8	—	—	11	—	—	12	—	—	12	—	—	10	—	—	10	—	—
	—	78	—	—	77	—	—	75	—	—	75	—	—	75	—	—	73	—	—	76	—
	—	—	19	—	—	15	—	—	14	—	—	13	—	—	14	—	—	16	—	—	14

Table 5 gives the percentage distribution of children by social group in each maternal age/birth order cell of Table 1. For example, 19 % of first born of mothers aged 40 and over (V.R. score 106·1) were in group A (corresponding approximately to R.G. classes I and II), compared with 2 % of fifth and later born of mothers aged 25–29 (V.R. score 88·6). Mean scores for the three social groups are: A, 110·0; B, 99·7; and C, 96·4. These observations are consistent with the view that the relationships in Fig. 1 result largely from differences between the social groups.

The fact that the age/birth order pattern is apparent within each group (Fig. 2) might appear to suggest that this is not an adequate explanation. However, it must be remembered that each of the three groups is far from homogeneous in respect of occupation. The method of classification follows that used by the Registrar General, being based on the employment status (employer, self-employed, employee, etc.) and on the nature of the occupation. Group A consists of all occupations in R.G. classes I and II but also contains clerical workers. Group B consists of all occupations in class III except clerical workers, and some semi-skilled workers (class IV) are included because it was not possible to differentiate them from those in class III. Group C comprises most occupations in class IV and all in class V.

Clearly none of these groups is homogeneous and the families within each experience a wide range of economic and social circumstances. The evidence is therefore consistent with the conclusion that the relationship of V.R. scores to maternal age and birth rank (Fig. 1 and Table 1) reflects largely the association of these variables with social class.

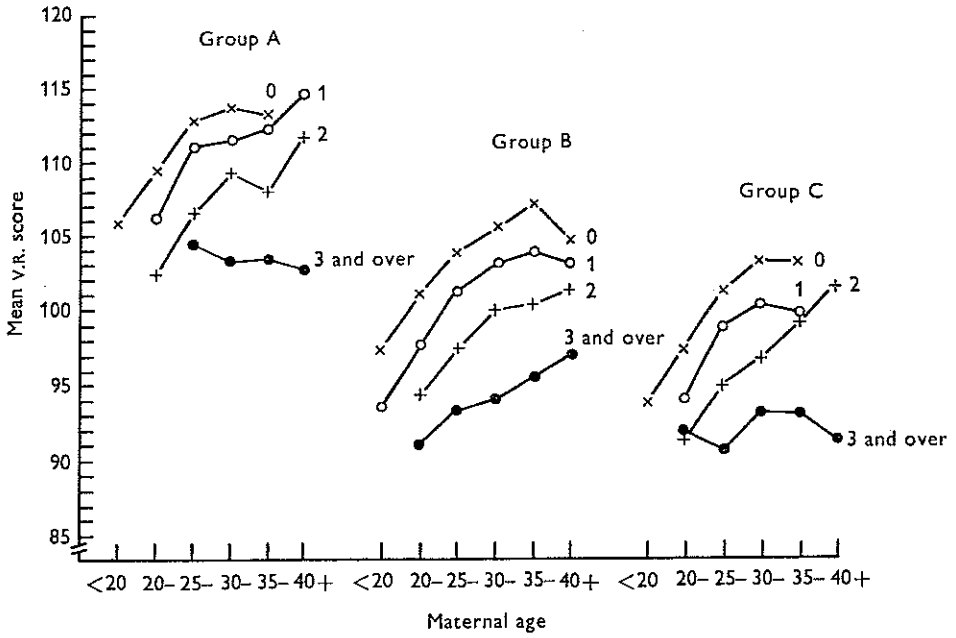

Fig. 2. Mean V.R. scores according to social group, maternal age, and number of previous sibs.

The question remains as to the origin of the class differences in measured intelligence. Illsley (1967) noted that the distribution of test scores by maternal age and pregnancy number corresponds to that of post-neonatal death rates, determined essentially by socio-economic influences, rather than to that of stillbirth rates which reflect 'physiological or obstetric' influences.

There are certainly no grounds for thinking that the age/birth order distribution of V.R. scores is attributable significantly to prenatal environmental influences. The pattern exhibited in Fig. 1 is quite inconsistent with that of stillbirth rates, which are high for first born. The sib comparison also provides no evidence of the variation in scores according to maternal age and birth order which would be expected if the prenatal environment were important.

However, the correspondence between age/birth order pattern of scores and of post-neonatal death rates does not of itself justify the conclusion that differences between families are determined mainly by postnatal influences, however reasonable this deduction may seem on other grounds. Given the substantial differences between test scores of children according to their social class, the distribution shown in Fig. 1 and Table 1 would result whatever the origin of the differences. On this evidence only, they might be wholly genetic, wholly environmental, or any combination of the two.

On other grounds there is no reason to doubt the importance of post-natal experience. Within the same sibship, where genetical variation is not an issue, birth order has some bearing on test performance. The mean difference between scores of consecutive sibs is 1·0 (Table 2). The difference is greater at low than at high birth ranks (Table 4), and is not exhibited by fifth and later

born children for whom the environment is presumably so unfavourable to measured intelligence that later born children experience no additional disadvantage. The relation to social class is also instructive. In well-to-do families (group A) the difference between consecutive sibs (0·7) is

Table 6. *Comparison of* V.R. *score of consecutive sibs according to social group*

Social Group	No. of pairs	Mean V.R. score of (1) Earlier sib	Mean V.R. score of (2) Later sib	Difference (1)–(2)
A	222	109·0	108·3	0·7
B	2209	98·0	97·1	0·9
C	473	95·5	93·5	2·0
Not stated	2150	99·2	98·4	0·8
Total	5054	98·8	97·8	1·0

small, but in poorer families the difference (2·0) is considerable (Table 6). In this case it seems reasonable to believe that in group A the environment is in general so favourable that there is little disadvantage to the later born child.

SUMMARY

Verbal reasoning scores recorded in the eleven-plus examination are available for 48,913 Birmingham children born in the years 1950–54. This paper examines the relation of scores to birth order and maternal age and it is shown that they are correlated negatively with the one and positively with the other.

There were 4705 fraternities with two or more children born within the 5 years and the data are used to assess the extent to which the association of scores with maternal age and birth order are due to differences within families. Mean scores are 1·0 point lower for the later than for the earlier sibs. It is concluded that the striking association of measured intelligence with maternal age and birth order in a general population of children is determined mainly by differences between rather than within families. Hence the negative correlation between sibship size and intelligence cannot be attributed substantially to variation in intelligence according to birth order or maternal age within sibships.

The population was divided according to occupation of fathers into three social groups for which mean scores were: A, 110·0; B, 99·7; and C, 96·4. Since distribution of children by mother's age and birth order is effectively a distribution according to social class, the relation of scores to the two variables in a population of births is largely a reflection of the social class differences. On this evidence only no conclusion can be reached about the origin of the class variation. But the fact that there are small differences related to birth order between children in the same families, whose environment is relatively uniform and for whom no question of genetic variation arises, suggests that the much larger differences which exist between families also reflect in part experience in the postnatal environment.

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