Ann. Hum. Genet., Lond. (1970), **34**, 11
Printed in Great Britain

An investigation of the difference in measured intelligence between twins and single births*

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Several investigations have shown that mean scores in intelligence tests are lower (by about 5 points on the conventional scale with mean of 100) for twins than for single births (Mehrotra & Maxwell, 1949; Sandon, 1957; Drillien, 1961). The reasons for the difference are by no means clear. It has been suggested on the one hand that they may result mainly from prenatal influences (Churchill, 1965) and on the other that they are more likely to be due to postnatal verbal handicaps experienced by twins (Day, 1932; Davis, 1937; McCarthy, 1954; Lewis, 1963).

The present investigation of the difference in measured intelligence between twins and singletons is based on the population of children used previously in examination of variation in verbal reasoning scores of single births (Record, McKeown & Edwards, 1969*a*, *b*). This population comprised all Birmingham live births in the period 1 January 1950 to 1 September 1954. Numbers of children born and numbers whose V.R. scores in the eleven-plus examination were matched were as follows:

	Number of liveborn children	Number of children whose V.R. scores were matched
Single births	84,341	48,913
Twins	2,259	1,242
Triplets	30	17
	86,630	50,172

The differences are accounted for mainly by those who left the City or died before age 11, or did not take the examination because they were ineducable, in private schools, or in special schools for the handicapped, or though in ordinary schools, had been assessed as 'borderline subnormal'. As would be expected, the proportion of liveborn children who did not take the examination was somewhat higher for multiple than for single births.

The linkage of birth data to examination results was effected by a computer working to rather rigid standards of acceptability of the identity of the two records. In order to increase the number of twins for the present analysis the unmatched twins were reviewed and by manual methods a further 167 acceptable linkages were achieved, bringing the number of twins to 1409.

However, this total was considered too small for some purposes and the series was extended by inclusion of births for the subsequent 3 years (1 September 1954 to 1 September 1957). In this period there were 1474 liveborn twins and twenty-nine liveborn triplets, of whom 755 and ten respectively took the Birmingham eleven-plus examination. The analysis is therefore based on 2164 twins and (for Table 1 only) twenty-seven triplets born in a period of approximately 8 years.

Since part of the analysis relies on a comparison with single children born in the first 5 of the

* This research was assisted by a grant from the Association for the Aid of Crippled Children, New York, and by a Research Grant from the Medical Research Council to one of us (T.McK.).

8 years, it was necessary to enquire whether standards of marking had changed in the last 3 years. Mean V.R. scores of twins examined in the two periods suggest that they did not.

	Twins born 1950–54	Twins born 1954–57
Number	1409	755
Mean V.R. scores	95·52	95·92
S.D.	14·52	14·76

The difference between mean scores is 0·40 (standard error 0·66) and between standard deviations is 0·24 (standard error 0·47). These results suggest that there was no considerable change in standards of marking between the two periods and that twins born in the 8 years 1950–57 can be compared with single children born in the first 5.

Table 1. *Mean* V.R. *scores of single births, twins and triplets*

	Males	Females	Total
(*a*) Single births	99·4 (24,348)	100·9 (24,565)	100·1 (48,913)
(*b*) Twins	94·6 (1,105)	96·8 (1,059)	95·7 (2,164)
(*c*) Triplets	91·0 (27)	93·5 (6)	91·6 (33)
Difference (*a*) − (*b*)	4·8	4·1	4·4
Difference (*a*) − (*c*)	8·4	7·4	8·5

In this and other tables, numbers in brackets are the numbers of children.

Table 2. *Ratio of numbers of twins to numbers of single births at different maternal ages and birth ranks*

Previous sibs	Maternal age			
	Under 25	25–	30–	35 and over
0	1·0* (211)	1·4 (165)	1·3 (66)	1·4 (29)
1	1·4 (123)	1·9 (234)	2·1 (166)	2·5 (84)
2	1·9 (50)	2·2 (144)	3·0 (184)	2·5 (90)
3 and over	1·3 (12)	1·9 (101)	3·0 (244)	2·8 (209)

Based on 2162 twins and 41,195 single births of known maternal age and birth rank.

* The ratio number of twins/number of singletons in this cell has been taken as one; the ratios in other cells are adjusted accordingly.

Numbers of twins are given in brackets.

Mean V.R. scores according to number of births are given in Table 1. The difference between scores of singletons and twins (4·4) is of the same order as that reported by Mehrotra & Maxwell (1949); the difference between singletons and triplets (8·5) is about twice as great.

Numbers of triplets are too small for detailed examination and the remainder of the analysis is concerned with investigation of the following possible influences on the singleton/twin differences: (*a*) maternal age and birth rank; (*b*) birth weight and duration of gestation; (*c*) type of twinning; (*d*) order of birth; and (*e*) survival of co-twin.

MATERNAL AGE AND BIRTH RANK

Since V.R. scores vary according to maternal age and birth rank (Illsley, 1967; Record *et al.* 1969*a*), and since the distribution of twins is also related to these variables, it is desirable at the outset to enquire to what extent the difference between scores of twins and single births can be attributed to this association.

Table 2 shows the well-known increase in frequency of twinning with increasing age and with increasing number of previous sibs. Table 3 gives scores of twins and single births according to maternal age and number of sibs. In spite of some irregularity due to small numbers, the pattern is the same for twins as for singletons: scores increase with increasing age and decrease with increasing number of sibs. In every cell, however, mean scores are lower for twins than for single births.

By standardizing the scores of the single children to the maternal age distribution of the

Table 3. *Mean* V.R. *scores of twins and single births according to maternal age and number of previous births*

Previous sibs	Maternal age: Under 25		25–		30–		35 and over		Total	
	Twin	Single	Twin	Single	Twin	Single	Twin	Single	Twin	Single
0	95·9	100·5	100·7	104·9	99·3	106·7	104·5	107·5	98·6	102·9
1	96·3	97·5	95·8	102·0	102·4	104·1	101·2	104·8	98·5	101·6
2	89·6	94·0	93·5	97·6	98·3	100·8	97·6	101·8	95·8	98·9
3 and over	86·9	92·2	85·7	93·1	90·0	94·3	93·3	95·8	90·6	94·5
Total	94·9	99·0	95·0	100·8	96·4	100·9	96·3	100·0	95·7	100·1

Based on 2162 twins and 41,195 single births of known maternal age and birth rank.

twins the twin/singleton difference is increased and by standardizing for birth rank the difference is decreased (see Fig. 1). This result could be predicted from Tables 2 and 3. Less predictable is the effect of standardization in respect of both variables. This reduces mean scores of singletons slightly (from 100·1 to 99·6) but leaves an appreciable difference between twins and singletons (3·9) unexplained.

It is concluded that only a small part of the score difference can be attributed to the increased frequency of twinning with increasing maternal age and birth rank.

BIRTH WEIGHT AND DURATION OF GESTATION

It was reported previously for single births that scores increase with increasing birth weight and that children born early or late have lower scores than those from pregnancies of average duration (Record *et al.* 1969*b*). Table 4 shows that the same relationships exist for twins, although again there is some irregularity due to small numbers. In most cells values are higher for singletons than for twins, which suggests that the total twin/singleton difference may not be explained by the distributions according to birth weight and duration of gestation.

Results of standardization for the two variables are also consistent with this conclusion. By standardization of the singletons to the twin distribution it was noted that weight differences have more effect than gestation differences; but since it is very unlikely that twins and single births of the same weight and duration of gestation are alike in all other respects, standardization for these variables is a procedure of doubtful validity. For this reason the results have not been given in Table 4.

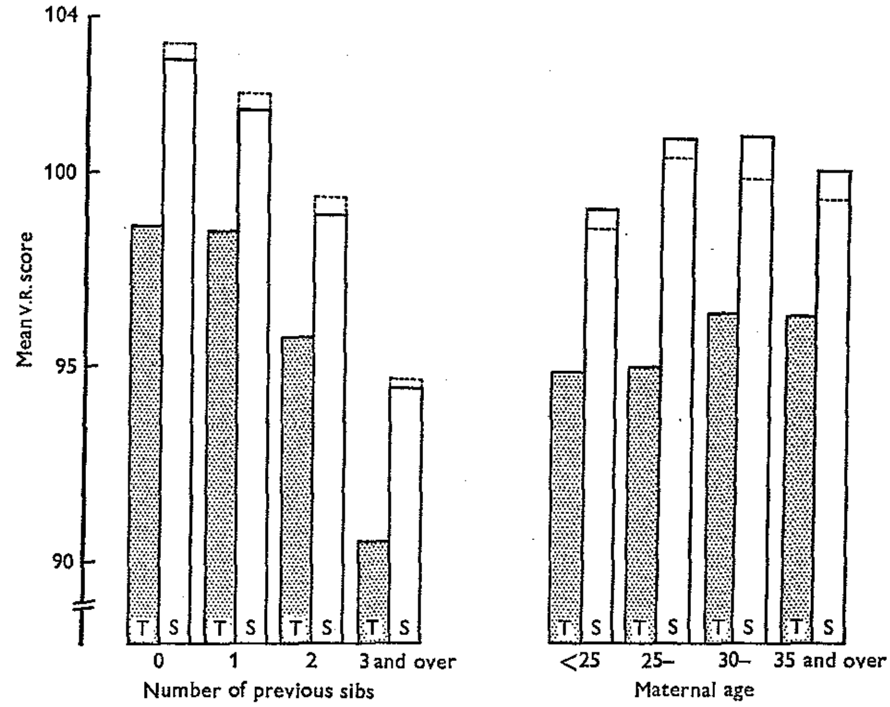

Fig. 1. Mean V.R. scores of twins (T) and single (S) children according to number of previous sibs and maternal age. Dotted lines show mean scores of single children standardized in the two cases respectively to distribution according to maternal age and number of previous sibs of twins.

A more acceptable basis for assessment of the significance of birth weight is a comparison of scores of twins from the same pairs. In Table 5 pairs with no weight difference have been excluded, along with those whose birth weights could not be related to their V.R. scores. Scores of the remaining 857 pairs are distributed according to birth weight differences between twins of the same pair. Where weight differences are small or moderate, score differences are trivial; and only when weight differences are more than two-thirds of a kilogram—a very substantial variation between twins of the same pair—is there an appreciable difference between scores.

These results suggest that twin/singleton differences in V.R. scores cannot be attributed largely to their shorter duration of gestation or retarded foetal growth, except possibly where the retardation is very marked.

TYPE OF TWINNING

It is known that prenatal hazards are greater for monozygotic than for dizygotic twins: their gestation is slightly shorter; birth weight is lower (McKeown & Record, 1952); and stillbirth and neonatal mortality is considerably higher (Record, Gibson & McKeown, 1952). It is conceivable, therefore, that the risks associated with zygosity may contribute to the low twin V.R. scores; if so there would be a difference between scores of monozygotic and dizygotic twins.

Table 4. *Mean* V.R. *scores of twins and single births according to birth weight and duration of gestation*

Duration of gestation (weeks)	Birth weight (kg.): Less than 2·0		2·0–		2·5–		3·0–		3·5 and over		Total	
	Twin	Single	Twin	Single	Twin	Single	Twin	Single	Twin	Single	Twin	Single
Less than 32	94·6 (32)	92·6 (60)	— (1)	— (27)	— (1)	— (11)	— (0)	— (15)	— (0)	— (3)	94·4 (34)	93·8 (116)
32–	96·6 (69)	92·1 (63)	92·0 (21)	96·2 (54)	— (7)	— (38)	— (2)	— (19)	— (0)	— (12)	95·8 (99)	93·6 (186)
34–	93·8 (60)	95·3 (67)	92·6 (86)	96·4 (212)	91·1 (23)	98·0 (161)	— (4)	— (125)	— (0)	— (71)	92·6 (173)	96·2 (636)
36–	90·8 (57)	94·9 (52)	93·9 (210)	97·1 (354)	94·5 (111)	97·8 (743)	98·8 (20)	98·0 (632)	— (2)	— (389)	93·9 (400)	97·4 (2,170)
38–	93·6 (32)	91·7 (49)	96·6 (197)	97·2 (541)	97·2 (254)	99·4 (2,667)	97·5 (115)	101·0 (4,310)	101·8 (18)	100·9 (2,617)	97·0 (616)	100·3 (10,184)
40–	88·8 (26)	92·0 (23)	95·1 (91)	95·4 (454)	99·1 (148)	98·6 (3,576)	97·9 (103)	100·5 (9,062)	99·2 (22)	101·9 (9,342)	97·2 (390)	100·7 (22,457)
42 and over	— (4)	— (3)	95·7 (14)	94·4 (106)	93·8 (25)	97·0 (762)	95·7 (14)	98·7 (2,119)	— (6)	— (2,795)	95·5 (63)	99·1 (5,785)
Total	93·3 (280)	93·3 (317)	94·8 (620)	96·3 (1,748)	96·8 (569)	98·6 (7,958)	97·4 (258)	100·3 (16,282)	101·2 (48)	101·2 (15,229)	95·7 (1,775)	100·1 (41,534)

Means have not been calculated for cells in which the number of twins is less than 10.

Although zygosity of twins was not examined, if it were related to intelligence this would be expected to emerge in differences between scores of like-sex and unlike-sex pairs. Mean scores of paired twins, where both members survived and took the examination, were slightly higher for like-sex than for unlike-sex pairs (by 0·3 for males and by 1·2 for females: Table 6). Differences in birth weight were trivial.

This evidence suggests that increased risks associated with monozygosity have little influence on V.R. scores and are therefore unlikely to contribute to the differences in measured intelligence between twins and single births.

Table 5. *Mean* V.R. *scores of paired twins according to the difference between their birth weights*

		Birth weight difference (kg.)					
Sex		Less than 0·2	0·2–	0·45–	0·7–	0·9 and over	Total
Male	Heavier	95·4	93·4	92·9	93·4	98·2	94·4
Male	Lighter	94·1	95·0	91·7	91·8	92·2	93·7
		(111)	(82)	(47)	(20)	(12)	(272)
Female	Heavier	97·6	97·0	99·7	102·3	97·1	98·1
Female	Lighter	96·9	97·1	97·7	97·9	95·2	97·1
		(93)	(70)	(50)	(14)	(13)	(240)
Male	Heavier	91·6	92·6	92·2	97·6	98·4	93·3
Female	Lighter	94·9	91·7	95·7	96·7	98·0	94·5
		(62)	(67)	(38)	(27)	(14)	(208)
Female	Heavier	98·8	96·7	99·7	102·4	103·8	98·8
Male	Lighter	95·8	94·7	97·4	96·7	98·4	95·9
		(62)	(39)	(21)	(10)	(5)	(137)
Total (giving	Heavier	95·9	94·9	96·1	98·9	99·4	96·1
equal weighting	Lighter	95·4	94·6	95·6	95·8	96·0	95·3
to each group)	Difference	0·5	0·3	0·5	3·1	3·4	0·8
		(328)	(258)	(156)	(71)	(44)	(857)

Thirty-three pairs with no weight difference have been excluded.
Seventy-three pairs could not be used for this analysis because their birth weights could not be related to their V.R. scores.

Table 6. *Mean* V.R. *scores and mean birth weight of paired twins*

		Like-sex pairs (*a*)	Unlike-sex pairs (*b*)	Difference (*a*)–(*b*)
Males	V.R. score	94·5	94·2	0·3
	Birth weight (kg.)	2·56	2·58	−0·02
		(618)	(358)	—
Females	V.R. score	97·3	96·1	1·2
	Birth weight (kg.)	2·41	2·45	−0·04
		(590)	(358)	—

Two female twins whose birth weights were not recorded have been excluded.

ORDER OF BIRTH

Since perinatal mortality is considerably higher for the second twin delivered than for the first (Camilleri, 1963), it seems probable that surviving second-born twins also experience risks which might impair their subsequent development. If so, V.R. scores might be lower for the second than for the first twin delivered.

However, Table 7 provides no support for this conclusion. Among pairs from which both twins survived, mean scores for first born are slightly higher than for second born in unlike-sex pairs and slightly lower in like-sex pairs; when both types are considered together there is no difference. Differences in birth weight between first- and second-born twins are also very small. On this evidence, the considerable risks to which the second twin is exposed during birth do not contribute to the low V.R. scores of twins.

Although they have no direct bearing on the twin/singleton scores differences, the correlation between scores of first- and second-born twins is of interest and the coefficients are given in Table 8. As would be expected, values are higher for like-sex than for unlike-sex pairs. The estimates are very similar to those reported previously by Mehrotra & Maxwell (1949): MM, 0·69; FF, 0·75; MF, 0·63.

Table 7. *Mean* V.R. *scores and mean birth weight of paired twins according to order of birth*

		V.R. score			Birth weight (kg.)		
		First twin (*a*)	Second twin (*b*)	Difference (*a*) − (*b*)	First twin (*a*)	Second twin (*b*)	Difference (*a*) − (*b*)
Like-sex pairs	Males	94·1 (270)	94·4 (270)	−0·3	2·60 (270)	2·54 (270)	0·06
	Females	97·3 (239)	97·9 (239)	−0·6	2·43 (239)	2·39 (239)	0·04
Unlike-sex pairs	Males	94·5 (160)	94·1 (182)	0·4	2·69 (160)	2·59 (182)	0·10
	Females	96·4 (182)	95·9 (160)	0·5	2·50 (182)	2·52 (160)	−0·02
Total (giving equal weighting to each group)		95·6 (851)	95·6 (851)	0·0	2·55 (851)	2·51 (851)	0·04

224 twins whose birth order was not recorded have been excluded.

Table 8. *Correlation between* V.R. *scores of twins and co-twins*

	No. of pairs	Coefficient of correlation
Like-sex twins: both male	309	0·67
both female	296	0·80
total	605	0·74
Unlike-sex twins	358	0·62
All twins	963	0·70

SURVIVAL OF CO-TWIN

Willerman & Churchill (1967), among others, have recognized that one of the most critical pieces of evidence concerning the contribution of prenatal and postnatal influences to measured intelligence would be a comparison between twins brought up together and twins separated from birth. Evidence of this type was explored by McDonald (1964) in a small series from which results were somewhat inconclusive.

In the present investigation it has been assumed that twins were brought up together if both took the eleven-plus examination and that they were brought up like single births if their co-twins were stillborn or died within a month of birth. In this comparison standardization for maternal age and number of previous sibs has been necessary, since both variables have an influence on early mortality.

Twins brought up alone scored appreciably higher than those whose co-twins survived, although their birth weights were substantially lower (Table 9). The mean score of single surviving twins (98·8) was only 1·3 points below that of singletons (100·1). This difference is further reduced (to 0·7) when the mean score of singletons is adjusted by standardization (to 99·5) to the maternal age and birth rank distribution of twins. On this evidence, any increased difficulties associated with the prenatal development or birth of surviving twins have little or no influence on their verbal reasoning at age 11.

Table 9. *Mean* V.R. *scores and mean birth weight of twins according to fate of co-twin*

		Fate of co-twin		
		Stillborn or died in first 4 weeks (*a*)	Survived and sat examination (*b*)	Difference (*a*) − (*b*)
Males	V.R. score	98·2	94·4 (crude)	3·8
			93·9 (standardized*)	4·3
	Birth weight (kg.)	2·34	2·58	−0·24
		(85)	(976)	
Females	V.R. score	99·3	96·9 (crude)	2·4
			96·5 (standardized*)	2·8
	Birth weight (kg.)	2·22	2·45	−0·23
		(63)	(948)	
Total (giving equal weight to each sex)	V.R. score	98·8	95·6 (crude)	3·2
			95·2 (standardized*)	3·6
	Birth weight (kg.)	2·28	2·52	−0·24
		(148)	(1924)	

* Standardized to the maternal age/birth rank distribution of group (*a*). The mean score of single births standardized to this distribution was 99·5.

DISCUSSION

The intelligence of twins, as measured by V.R. scores in the eleven-plus examination, has a dual interest. It is of interest in its own right, as an indication of the degree of handicapping experienced by twins in consequence of the coexistence of two individuals before and after birth. But the twin data also throw light on some problems of single pregnancy, particularly interpretation of the variation in scores associated with birth weight and duration of gestation. This variation will be considered first.

The sib evidence previously examined (Record *et al.* 1969) showed little difference in V.R. scores in relation to birth weight; the twin data support this conclusion. Score differences between twins from the same pairs are trivial unless the weight differences are large (more than two-thirds of a kilogram) when there must be doubt about the comparability of the pair in respects other than weight.

But even the reservation concerning considerable weight differences seems to be overcome by the observations on twins whose co-twin died before or soon after birth. Such twins, raised singly, have a mean score which is only slightly lower than that of single births. This indicates that the large differences in weight and duration of gestation between single and multiple births do not result in appreciable score differences. It therefore seems justified to conclude that the smaller variations in weight and gestation length in single pregnancy also have little effect, and that the substantial score differences associated with these variables in a general population of births are a reflexion of other influences.

Since twins and their co-twins have a common pregnancy, their comparison can throw no light on the relation of intelligence to maternal age and birth order. But the data previously examined, particularly the sib evidence, suggested that the wide variation in association with these variables is largely a reflexion of other influences such as social class (Record *et al.* 1969*a*).

However, the present communication has been concerned mainly with investigation of the difference in verbal reasoning scores between twins and single births. The lower twin scores cannot be explained by differences from single births in maternal age and birth order or in birth weight and duration of gestation. They are not accounted for by the risks associated with monozygosity. These risks are reflected in lower birth weights, shorter gestations and higher stillbirth and neonatal death rates for like-sex than for unlike-sex twins (McKeown & Record, 1952; Record, Gibson & McKeown, 1952); yet V.R. scores are approximately the same for both. Scores are also unrelated to the order of delivery of twins in the same pair, although the second born is at greater risk than the first (Camilleri, 1963). Taken together these observations suggest that considerable variation in experience before and during birth has little influence on measured intelligence, and that the explanation of the substantial difference between twins and single births must be sought in the postnatal environment.

The same conclusion emerges from comparison of twins raised together with twins raised singly because of the death of the co-twin before or soon after birth. This comparison overcomes many difficulties of interpretation, by eliminating variation in prenatal experience and allowing attention to be focused exclusively on postnatal influences. This approach was thought to be sufficiently important to make it desirable to increase the number of twins from the period first investigated (1950–54) by adding those from three additional years (1954–57). The finding that twins raised singly have V.R. scores which are higher than those for twins raised together and almost equal to those of single births provides evidence that the handicapping of twins in respect of measured intelligence is determined after birth.

The verbal backwardness of twins has been a subject of interest in the psychological literature for many years. Although it has not hitherto been possible to exclude prenatal influences it has been suggested that the retardation may be due to the frequent contact between twin and co-twin, and reduced opportunities for verbal communication with adults and older sibs. This explanation, although still speculative, is consistent with the data presented here.

SUMMARY

Mean V.R. (verbal reasoning) scores recorded in the eleven-plus examination for Birmingham multiple births in the years 1950–57 were 95·7 for 2164 twins and 91·6 for 33 triplets. The mean for 48,913 single children born in the years 1950–54 was 100·1.

The low scores of twins are not explained by differences from single births in their distributions by maternal age and birth order or by birth weight and duration of gestation. They are also not accounted for by the increased risks associated with monozygosity (assessed by comparison of like- and unlike-sex twins) or with delivery of the second twin. Taken together these observations, like the previous ones on single births, suggest that variation in experience before and during birth has little influence on measured intelligence and that the explanation of the large difference between twins and single children must be sought in the postnatal environment.

There were 148 twins whose co-twins were stillborn or died within 4 weeks after birth; their mean score was 98·8, only a little lower than that of single births (99·5) standardized to the maternal age and birth rank distribution of twins. From this evidence it is concluded that the handicapping of twins, reflected in their low verbal reasoning scores, is due to postnatal rather than prenatal influences.

These conclusions are of course based on children who took the eleven-plus examination and cannot be accepted without reservations for those who did not.

We are greatly indebted to Dr E. L. M. Millar, Medical Officer of Health for Birmingham and Mr K. Brooksbank, Chief Education Officer for Birmingham, for permission to use the records of their departments. We should also like to express our thanks to Mr P. C. Fletcher of the Birmingham Education Department for his generous assistance in obtaining data for the past few years and to Mrs Karen Glenn for preparing computer programs.

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