Brit. J. prev. soc. Med. (1964), 18, 59-74

INTELLIGENCE IN CHILDREN OF VERY LOW BIRTH WEIGHT

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As there have been conflicting reports about intelligence in children of very low birth weight, advantage was taken of an opportunity to study the intelligence of 1,066 children weighing 4 lb. or less at birth who were the subjects of an investigation into the aetiology of cerebral palsy and other disorders* (McDonald, 1962, 1963).

The many surveys of the intelligence of premature children were reviewed by Benton (1940) and more recently by Wiener (1962). In most studies premature children, who by definition have a birth weight of not more than 5½ lb. (2,500 g.), have been found to have a lower mean I.Q. than heavier children. However, since socio-economic status is correlated with birth weight (Baird, 1962), and strongly correlated with performance in intelligence tests (Jones, 1954), it is by no means easy to ascertain whether there is an independent correlation between birth weight and intelligence.

Benton (1940) concluded that, although the prevalence of mental defect was undoubtedly higher in premature than in heavier children, there was no evidence of any general intellectual inferiority among them. In particular, the careful survey by Mohr and Bartelme (1934) of the mental development of 250 children who had been admitted as infants to a premature baby unit supported this conclusion. Wiener (1962), on the other hand, considered that the evidence indicated that premature children were intellectually inferior to full-term children. He based this conclusion mainly on the surveys of Harper, Fischer, and Rider (1959) and Drillien (1961), in which, allowing for the effect of social factors, premature children were found to have lower mean scores than heavier children.

In a national sample of births, Douglas (1960) found that, compared with controls matched for social class and other characteristics, premature children had lower scores in a group intelligence test given at the age of 8 years than heavier children, and that at the age of 11 years the gap had widened. He concluded, however, that the difference between the two groups was more likely to have been due to social factors not taken into account in the original matching of controls than to birth weight. Wiener considered that this conclusion was unjustified and thought that birth weight rather than social factors was responsible for the inferior performance of the premature children.

There is also contradictory evidence as to whether, in premature children, intelligence is correlated with birth weight. Mohr and Bartelme found that the lightest babies were slightly but not significantly inferior to the heavier premature children. Lofthus (1930) found no correlation between birth weight and intelligence in premature children, but both Brander (1935) and Schöberlein (1938) found a positive correlation. In Douglas's survey the majority of the premature children had a birth weight of around 5 lb., but the 35 children weighing less than 4 lb. including only four weighing less than 3 lb. did not differ in intelligence from the heavier premature children.

The studies of Harper and others (1959) and Drillien (1961) were longitudinal in type and both included a relatively large proportion of very small babies. Harper and others, using both the Gesell Developmental Schedule and the revised Stanford-Binet test (form L), found that at between 3 and 5 years of age the 57 children with a birth weight of 1,500 g. (3 lb. 5 oz.) or less had substantially lower scores than heavier premature children. Drillien compared 334 single premature children aged 4

* This survey was undertaken in collaboration with the Society of Medical Officers of Health.

years, including 36 whose birth weight was 3½ lb. (1,600 g.) or less and 57 weighing from 3½ to 4½ lb. (1,600–2,040 g.), with a random sample of children weighing over 5½ lb. (2,500 g.). She used a combination of items from the Gesell scales and from the revised Stanford-Binet test (form L), and found a positive correlation between intelligence and birth weight, greater in children from poor working-class homes than in those from middle class and superior working-class homes.

There seems no doubt that severe mental deficiency is commoner in premature than in full-term children, particularly in children with a very low birth weight. Asher and Roberts (1949) found a considerable excess of very low birth weights among mentally-handicapped children from a residential institution and from a school for educationally sub-normal pupils. However, children with a very low birth weight are known to have a very high rate of physical defects, including cerebral palsy, deafness, and (when prolonged oxygen treatment was given) blindness. It is therefore desirable to examine the extent to which these defects may be responsible for mental deficiency and also for the correlation between intelligence and birth weight found by Harper and others, and by Drillien.

The present survey afforded an opportunity to investigate the relationship between intelligence, low birth weight, and cerebral palsy and other defects, and also the association between intelligence and factors operative around the time of birth in these very small babies. This was of particular interest in view of associations which were observed between these factors and cerebral palsy, deafness, retrolental fibroplasia, and cataract (McDonald, 1963, 1964a, b).

Materials and Methods

The Children

The children studied were originally the subjects of an investigation of retrolental fibroplasia by the Medical Research Council (1955), and comprised all infants weighing 4 lb. or less at birth who were born between October 1, 1951, and May 31, 1953, and admitted to nineteen premature baby units in different parts of Great Britain. Of these children, 1,128 were alive at the age of 6 months. During 1959 and 1960, when the children were from 6 to 8 years old, they were surveyed with the help of the Society of Medical Officers of Health to detect neurological and other disorders; 28 children had died before this age and nineteen could not be traced, but clinical reports were obtained on 1,081 (98·3 per cent. of survivors) (McDonald, 1962). Excluding fifteen children whose families had emigrated before the survey, there were 1,066 children available for the present study of intelligence; 752 were single births, 300 were twins, and 14 were triplets.

Social Class Distribution

Occupation of the father from the birth registration form was used to classify the children according to the Registrar General's social class categories. The distribution by social class of legitimate births in the sample was found to be similar to that in England and Wales in 1951 (Registrar General, 1958), and there was little difference between single and multiple births (Table I).

Table I

PERCENTAGE SOCIAL CLASS DISTRIBUTION OF LEGITIMATE BIRTHS IN THE SAMPLE COMPARED WITH ENGLAND AND WALES, 1951

Social Class	Sample		England and Wales (1951)
	Single Births	Multiple Births	
I and II	17·0	17·2	16·5
III	53·5	55·9	56·4
IV and V	29·5	26·9	27·1
Total No. of Children ..	701	308	673,261

The rate of illegitimacy in the sample was 6·1 per cent. compared with 4·8 per cent. in England and Wales in 1952 (Registrar General, 1953). The excess was limited to single births; in these the rate was 7·1 per cent. and in multiple births 3·7 per cent. Illegitimate children were classified by the father's occupation when it was recorded, and failing this by the mother's occupation. In all, seventeen single children and six twins could not be classified; of these, thirteen single children and four twins were known to have been illegitimate. These was no appreciable difference in I.Q. between the single illegitimate children who could be classified by social class and those who could not, although both groups had somewhat lower scores than legitimate children.

Revised Stanford-Binet Test (Form L)

The second revision by Terman and Merrill (1937) of the Stanford-Binet test was chosen for this survey because it had been more extensively used than any other test. It was standardized in 1937 with a mean of 100 and a standard deviation of about 17 points on a representative sample of children aged 1½ to 18 years living in different parts of the United States. In Britain it had been used twice on population samples. The Scottish Council for Research in Education (1949) examined a random sample of 11-year-old school children and found a mean of 102·5 (Table II, p. 62). More recently, Crawford

(1963) used the test in a survey of ability and reading achievement in a random sample of Liverpool children aged 7 and 8 years attending primary and special schools. This survey was undertaken at about the same time and on children of approximately the same age as those in the present study. The mean I.Q. of 104·4 that was found in Liverpool and the mean of 102·5 found in the Scottish survey suggest that in Britain at the present time a mean I.Q. of above 100 is to be expected—perhaps about 103. Because of the large standard deviation and positive skewness that were found in the 11-year-old children studied in the Scottish survey, it is not easy to compare the distribution of scores in this survey with that of the present sample in which the children were younger. In the Liverpool survey the standard deviation approximated more closely to that of the standardization sample, but since only children attending primary or special schools were included there was a deficiency of very low scores, and there was also some positive skewness. Therefore, although the mean score of the population of Britain at the present time is probably above 100, the sample on which the Terman and Merrill revision was standardized in the United States in 1937 appears to be the most satisfactory one with which to compare the distribution of I.Q.s in the present survey.

In the sample on which the revised Stanford-Binet test was standardized and in subsequent surveys, boys have obtained higher scores than girls. In the Liverpool survey boys scored about 3 points more than girls and, in the Scottish survey, 2 points. Large social class differences in mean I.Q. have been observed repeatedly—for instance Terman and Merrill found that the mean I.Q. of children of professional fathers in the standardization sample was 116 compared with 94 in the children of unskilled workmen.

Although no hard-and-fast line can be drawn, Lewis (1929) and Roberts, Norman, and Griffiths (1938) have suggested that I.Q.s of below 45 to 50 should be considered to be pathologically low and not to belong to the normal distribution of Stanford-Binet I.Q.s. In the present survey an I.Q. of 50 was chosen as the dividing line, since this is the figure chosen by educational psychologists as the lower limit of educability (Goodman and Tizard, 1962). Lewis (1929) found that 0·4 per cent. of children of school age living in urban areas had an I.Q. of less than 45 to 50. Goodman and Tizard (1962), in a recent study in Middlesex, found a similar prevalence of 0·36 per cent., although the ratio of mongolism to other forms of defect was considerably greater than in Lewis's sample. These rates suggest that mental defectives were under-sampled in the children on which Terman and Merrill revised the Stanford-Binet test, and that the proportion should have been about 0·4 per cent. instead of 0·2 per cent.

Method of Testing

It might have been desirable for all the children to have been tested by one examiner, but this would have protracted the investigation and would have been difficult to organize. Instead, principal school medical officers who had collaborated in the clinical survey were asked whether they would arrange for the intellectual assessment of the children, either by educational psychologists or by approved and experienced school doctors. In some places the work involved was substantial but, in spite of this, nearly all local education authorities undertook it. In a few areas where shortage of staff made the task impossible, other arrangements had to be made for the children to be tested; in most of these psychologists were specially employed for the purpose.

Since some of the handicapped children could not be given the revised Stanford-Binet test and many had already been given intelligence tests, it was decided that for children with cerebral palsy, blindness, or deafness the results of any appropriate tests should be used. Only rough assessments were possible in severely handicapped children. All children without cerebral palsy, blindness, or deafness were to be given the revised Stanford-Binet test (form L).

Many different persons carried out the tests but, since the examiner was determined by the area of residence of the children, and not by any other characteristic, inter-observer differences were not likely to result in any important bias. Perhaps a more serious risk was that there might be a consistent difference between the results of doctors and psychologists which might make pooling of their scores unsatisfactory. Little difference was found in fact. The numbers of children tested were approximately equal in all social class and birth weight groups, and the overall means were respectively 102·0 and 102·6 with standard deviations of 16·6 and 17·3.

85 per cent. of the children were tested when they were 7 or 8 years old, 2·5 per cent. at 6 years, and 12·5 per cent at 9 years. The adjustment proposed by Roberts and Mellone (1952) to minimize the effect of varying variance and skewness at different ages was not used because it would have made little difference to the results, and no consistent bias was likely to arise from its omission.

Completeness of Testing

Of the 1,066 children available for study, 111 were blind or deaf or had cerebral palsy. A measure of the intelligence of 107 of these children was obtained, although in many cases the score was only an approximate figure; two children had emigrated and the parents of the other two refused to allow them to be tested. Three of the 955 children without the handicaps mentioned were found to have emigrated, eight children could not be traced, the parents of thirty children refused to allow them to be tested, and one child had died. In five children the results were thought to be unreliable and three were given the Wechsler Intelligence Scale for Children and could not be retested. This left 905 children (95 per cent.) who were tested satisfactorily with the revised Stanford-Binet test (form L).

Adjustment for Prematurity

Two intelligence quotients were calculated for each child, one using chronological age, and the second corrected for prematurity by subtracting from the chronological age the number of weeks by which the length of gestation, calculated from the last menstrual period, fell short of the expected 40 weeks. The mean adjustment amounted to 1·6 points of I.Q. in both single and multiple births; 51 children whose length of gestation was not known were allotted a mean correction according to their birth weight.

Results

The 721 single children who were tested had a mean I.Q. of 96·8, or corrected for prematurity of 98·4, and compared with the sample on which the revised Stanford-Binet test was standardized they had an increased proportion of scores below 50 and a correspondingly decreased proportion of scores above 110 (Tables II and III). The 286 twins had a mean score of 95·6 (corrected 97·2) and the thirteen triplets of 89·7 (corrected 91·2). As it was considered more logical to adjust the scores for prematurity than not to adjust them, corrected scores are given below unless otherwise stated.

All available scores in both single and multiple births were included in the distributions of I.Q.s in children handicapped by cerebral palsy, blindness, deafness, and specific visual defects, but the main analysis was confined to children with satisfactory Stanford-Binet I.Q.s, and single and multiple births were studied separately. Scores of less than 50 were excluded in calculating mean I.Q.s because these were considered to be pathologically low. Information about some of the prenatal and perinatal characteristics examined was incomplete; each tabulation includes all cases for which the factors under consideration were known.

Table II

MEAN I.Q. AND DISTRIBUTION OF SCORES IN THE SAMPLE ON WHICH THE SECOND REVISION OF THE STANFORD-BINET TEST WAS STANDARDIZED AND IN THE SCOTTISH AND LIVERPOOL SURVEYS

Sample	Age of Children (yrs)	Number of Children	Mean I.Q.	Standard Deviation	Percentage Distribution of Scores					
					Less than 50	50–69	70–89	90–109	110–129	130 and Over
Standardization Sample (1937) ..	1½–18	3,184	100·0	17	0·2	2·4	20·1	46·5	26·3	4·4
Scottish Survey (1947)	11	1,215	102·5	20·1	—	2·9	24·3	39·9	22·8	10·0
Liverpool Survey (1959)	7 and 8	789	104·4	17·4	—	0·8	19·5	44·7	27·1	7·8

Table III

MEAN I.Q. AND PERCENTAGE DISTRIBUTION OF SCORES IN SINGLE CHILDREN AND IN TWINS AND TRIPLETS WITH AND WITHOUT CEREBRAL PALSY, BLINDNESS, OR DEAFNESS.

Births		Number of Children	Mean I.Q.	Standard Deviation	Percentage Distribution of Scores					
					Less than 50	50–69	70–89	90–109	110–129	130 and Over
Single	With cerebral palsy, blindness, or deafness ..	90			14·4	11·1	30·0	37·8	4·4	2·2
	Without cerebral palsy, blindness, or deafness ..	625	102·4*	17·1*	1·8	1·3	20·8	45·6	23·3	7·3
	All Single Children†	721	98·4	21·4	3·3	2·9	21·8	44·7	20·9	6·5
Twins	With cerebral palsy, blindness, or deafness ..	17			29·4	—	23·5	11·8	35·3	—
	Without cerebral palsy, blindness, or deafness ..	267	98·3	16·8	—	1·9	29·6	44·2	20·6	3·7
	All Twins†	286	97·2	18·7	1·7	2·1	29·4	42·0	21·3	3·5
Triplets		13	91·2		—	—	46·2	38·5	15·4	—

* Excluding scores of less than 50 † Including six single children and two twins with unsatisfactory test results.

Defective Children

Cerebral Palsy.—About 80 per cent. of the seventy children with cerebral palsy in the sample were considered to belong to the syndrome of spastic diplegia (McDonald, 1962). Of the 67 children whose intelligence was assessed, the thirty with lower but not upper limbs affected had somewhat lower scores than unaffected children, and the scores for the 24 children with affected upper and lower limbs and for the thirteen children with other types of cerebral palsy were even lower (Table IV).

Deafness.—All the nineteen children suffering from perceptive deafness of a moderate or severe degree were tested, although in a few cases the examination could be only roughly carried out because of the difficulties involved. No deaf child was found to have an I.Q. below 50, but one child was considered to be borderline. There was an excess of scores in the range 50 to 89, and a deficiency above this level (Table IV).

Visual Defects

(1) *Causing Blindness.*—27 of the 28 children found to be blind at the time of the survey were assessed. In twenty children the blindness was due to retrolental fibroplasia and of these eight had scores of less than 70, but the distribution of scores in the remaining twelve children did not appear to be abnormal (Table V). Four children with bilateral cataract who were thought to be blind had scores below 50—one of them was also suffering from cerebral palsy. Two grossly-handicapped children with microcephaly and double hemiplegia were thought to have blindness of cerebral origin; another child with microcephaly had optic atrophy and ectopia lentis. The child who was not assessed had optic atrophy of unknown cause and was making satisfactory progress in a blind school; her level of intelligence was considered to be at least average.

(2) *Not Causing Blindness.*—Single children without cerebral palsy or deafness who had visual

TABLE IV

PERCENTAGE DISTRIBUTION OF I.Q.s IN CHILDREN WITH AND WITHOUT CEREBRAL PALSY, BLINDNESS, OR DEAFNESS

Defect*			Total No. of Children	Percentage Distribution of I.Q.s					
				Less than 50	50–69	70–89	90–109	110–129	130 and Over
Cerebral Palsy	Spastic Diplegia	(*i*) Lower limbs only ..	30	—	10·0	26·7	50·0	6·7	6·7
		(*ii*) Lower and upper limbs	24	16·7	16·7	25·0	41·7	—	—
	Other Types		13	30·8	7·7	30·8	23·1	7·7	—
Blindness			27	48·2	7·4	11·1	18·5	14·8	—
Deafness			19	—	15·8	47·4	26·3	5·3	5·3
Children without Cerebral Palsy, Blindness, or Deafness			905	1·2	1·4	23·7	45·0	22·5	6·1

* Six children had more than one defect.

TABLE V

DISTRIBUTION OF I.Q.s IN CHILDREN WITH VISUAL DEFECTS, EXCLUDING THOSE WITH CEREBRAL PALSY

Visual Defect			No. of Children	I.Q.											
				Less than 50		50–69		70–89		90–109		110–129		130 and Over	
				No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.
Retrolental Fibroplasia	Blind		20	6	30·0	2	10·0	3	15·0	5	25·0	4	20·0	—	—
	Not blind		35	1	2·9	—	—	7	20·0	9	25·7	16	45·7	2	5·7
Cataract (bilateral)	Blind		3	3	—	—	—	—	—	—	—	—	—	—	—
	Not blind		5	—	—	1	—	4	—	—	—	—	—	—	—
Other Defects	(*i*) Severe	Blind (optic atrophy and ectopia lentis) ..	1	1	—	—	—	—	—	—	—	—	—	—	—
		Not blind (nystagmus)	4	—	—	1	—	2	—	1	—	—	—	—	—
	(*ii*) Not severe	With a squint ..	79	3	3·8	1	1·3	25	31·7	33	41·8	13	16·5	4	5·1
		Without a squint ..	34	—	—	—	—	12	35·3	18	52·9	4	11·8	—	—
Children with No Reported Visual Defect			772	7	0·9	13	1·7	176	22·8	354	45·9	173	22·4	49	6·4

defects which did not cause blindness had a mean I.Q. of 98·7, which was lower than the mean score of 103·1 in children with no visual defect. Allowing for social class and birth weight, which were both found to be correlated with I.Q. (see below), there was a statistically significant correlation between I.Q. and visual defect (Appendix). In females the partial regression coefficient was significant at a 1 per cent. level whereas it was not statistically significant in males, but there was no significant difference between males and females.

Children with retrolental fibroplasia who were not blind, but in many of whom the visual acuity was severely impaired, had no excess of very low scores (Table V), and their mean I.Q. resembled that of children without visual defect (Table VI). The mean score adjusted for social class and birth weight of the 23 single children with this disease was 101·3 compared with 103·0 in children with no visual defect.

TABLE VI

MEAN I.Q. OF SINGLE CHILDREN* WITHOUT CEREBRAL PALSY, BLINDNESS, OR DEAFNESS, OR AN I.Q. BELOW 50 ACCORDING TO SOCIAL CLASS AND TYPE OF VISUAL DEFECT

Visual Defect			Social Class			
			I and II	III	IV and V	All Classes
Retrolental Fibroplasia		Mean I.Q.	115·0	102·6	99·7	104·0
		No. of Children	4	13	6	23
Other Visual Defects (excluding severe defects)	With a squint	Mean I.Q.	110·4	100·1	97·3	100·7
		No. of Children	7	28	16	51
	Without a squint	Mean I.Q.	99·0	95·7	87·7	94·0
		No. of Children	4	10	6	20
None		Mean I.Q.	113·1	103·2	97·4	103·1
		No. of Children	83	267	148	498

* Excluding fifteen children of unknown social class and seven children with severe visual defects.

Five children with bilateral cataract all had scores below 90 (Table V). Four children with very poor visual acuity associated with gross nystagmus also tended to have low scores.

The children with minor refractive errors, both with and without a squint had a distribution of scores which suggested a downward shift (Table V). Compared with a mean I.Q. adjusted for social class and birth weight of 103·2 in children without visual defect, the 51 single children with a squint had a score of 99·8 ($t=1·43$; $P < ·2 > ·1$). The seventeen single children with minor refractive errors but without a squint had an even lower mean adjusted score of 93·8 ($t=2·38$; $P < ·02 > ·01$).

CHILDREN WITH AN I.Q. OF LESS THAN 50

In all, 24 single children and five twins were found to have scores below 50. All five twins and thirteen of the single children had either cerebral palsy or blindness or both. Eight children had cerebral palsy, three being also blind, and the other ten were blind (see above).

Three of the eleven single children without cerebral palsy or blindness had mongolism; the other eight had no gross physical abnormalities, although one child was very small and resembled her mother who was in an institution for mental defectives. One other case was possibly genetically determined as the father was a certified mental defective. Three of the eight children without gross physical abnormalities had a history of neonatal convulsions.

CHILDREN WITHOUT CEREBRAL PALSY, BLINDNESS, OR DEAFNESS

(1) *Single Births.*—When the 90 single children who had cerebral palsy or were blind or deaf and the six in whom testing was unsatisfactory were excluded, the distribution of scores in the remaining 625 children differed little from that of the standardization sample except in the raised proportion of children with an I.Q. below 50 (Tables II and III). Excluding scores of this level on the grounds that they are pathologically low, the mean Stanford-Binet I.Q. of single children without the handicaps mentioned was 102·4 corrected for prematurity or 100·8 not adjusted for prematurity.

SEX

As is generally found with this test, boys had a higher mean score (104·5) than girls (101·1) (Table VII, opposite).

The difference of 3 points was similar to that found in the Liverpool survey. The difference was present in all birth weight and social class groups, but it was greater in Social Classes IV and V than in Classes I to III, and in children weighing not more than 3 lb. than in heavier children (Tables VII and VIII, opposite).

Because of the considerable preponderance of girls, the mean I.Q. of the whole sample was lower than it would have been had the sexes been equally distributed.

SOCIAL CLASS

Children belonging to the Registrar-General's Social Classes I and II differed from Classes IV and V by about 15 points of I.Q. (Table IX, overleaf).

The difference was greater in girls than in boys

TABLE VII

MEAN I.Q. OF SINGLE CHILDREN* AND TWINS* WITHOUT CEREBRAL PALSY, BLINDNESS, OR DEAFNESS, OR AN I.Q. BELOW 50, ACCORDING TO SEX, SOCIAL CLASS, AND BIRTH WEIGHT

Birth	Birth Weight	Social Class: I and II Boys	I and II Girls	III Boys	III Girls	IV and V Boys	IV and V Girls	All Classes Boys	All Classes Girls
Single	3 lb. or Less	113·1 (13)	101·5 (16)	100·3 (19)	97·6 (45)	96·2 (13)	90·3 (25)	102·8 (45)	96·2 (86)
	3 lb. 1 oz. to 3 lb. 8 oz. ..	109·6 (8)	133·4 (8)	104·1 (39)	101·7 (56)	101·9 (26)	95·0 (30)	103·9 (73)	102·2 (94)
	3 lb. 9 oz. to 4 lb. ..	114·6 (20)	110·1 (34)	105·0 (59)	103·7 (102)	101·1 (36)	96·0 (50)	105·4 (115)	102·8 (186)
	All Weights	113·1 (41)	111·0 (58)	103·9 (117)	101·8 (203)	110·5 (75)	94·4 (105)	104·5 (233)	101·1 (366)
Twins	All Weights	109·8 (16)	111·1 (23)	98·6 (61)	95·3 (93)	100·8 (27)	92·6 (42)	100·9 (104)	96·9 (158)

* Excluding fifteen single children and five twins for whom social class was not known. No. of children given in parentheses.

TABLE VIII

MEAN I.Q. AND PERCENTAGE DISTRIBUTION OF SCORES ACCORDING TO SEX AND BIRTH WEIGHT IN SINGLE CHILDREN AND ACCORDING TO SEX IN TWINS EXCLUDING CHILDREN WITH CEREBRAL PALSY, BLINDNESS, OR DEAFNESS

Birth	Birth Weight	Sex	No. of Children	Mean I.Q.*	Percentage Distribution of I.Q.s: Less than 50	50–69	70–89	90–109	110–129	130 and Over
Single	3 lb. or Less	Boys	49	102·9	4·1	4·1	16·3	44·9	28·6	2·0
		Girls	91	96·4	3·3	1·1	33·0	42·9	16·5	3·3
		Both	140	98·6	3·6	2·1	27·1	43·6	20·7	2·9
	3 lb. 1 oz. to 4 lb. ..	Boys	196	104·4	2·0	1·5	13·3	48·0	25·5	9·7
		Girls	289	102·7	0·7	0·7	22·8	45·0	23·2	7·6
		Both	485	103·4	1·2	1·0	19·0	46·2	24·1	8·5
Twins	All Weights	Boys	105	100·9	—	1·9	21·9	48·6	22·9	4·8
		Girls	162	96·6	—	1·9	34·5	41·4	19·1	3·1
		Both	267	98·3	—	1·9	29·6	44·2	20·6	3·7

* Excluding children with scores below 50.

because of the very low mean score already mentioned in girls belonging to Social Classes IV and V (Table VII).

BIRTH WEIGHT

A trend with birth weight was found in both sexes in Social Class III and in Classes IV and V (Table VII). In Classes I and II there was some evidence of a trend in girls but none in boys, but the number of children involved was small. There was, in general, only a small difference between children weighing from 3 to 3½ lb. and those weighing from 3½ to 4 lb. Children weighing 3 lb. or less, however, had considerably lower mean scores, and the distribution of their scores showed a shift to the left (Table VIII). Scores of below 70 were found in 5·7 per cent. of children weighing not more than 3 lb. at birth, compared with 2·2 per cent. of children weighing between 3 and 4 lb. ($P = \cdot 07$), and scores of 130 or more were found in 2·9 and 8·5 per cent. respectively ($P = \cdot 04$). A further analysis by multiple regression, allowing for factors found to be correlated with I.Q. (namely social class and presence of visual defect), showed that there was a significant correlation between I.Q. and birth weight in both sexes combined and in females, but not in males (Appendix). There was, however, no significant difference between males and females.

LENGTH OF GESTATION

There was no indication of any consistent association between mean I.Q. and length of gestation (Table IX) and no significant correlation with length of gestation (Appendix), although in females there was a slight but not significant negative correlation. In children weighing 3 lb. or less at birth, although not in those weighing from 3 to 4 lb., the mean scores of children with short gestations were higher in each social class group than those of children with long gestations; the differences were not, however, of a significant order. Since scores corrected for chronological prematurity were used, it was necessary to ensure that no association with gestational age had been obscured. An analysis by

TABLE IX

MEAN I.Q. ACCORDING TO SOCIAL CLASS, LENGTH OF GESTATION, AND BIRTH WEIGHT

Birth	Social Class	Gestation (wks)	Birth Weight: Up to 3 lb.	Birth Weight: 3 lb. 1 oz. to 3 lb. 8 oz.	Birth Weight: 3 lb. 9 oz. to 4 lb.
Single*† ..	I and II	Less than 33	108·8 (24)	118·6 (10)	116·5 (20)
		33 and Over	93·7 (3)	126·3 (6)	108·9 (31)
		All	107·1 (27)	121·5 (16)	111·9 (51)
	III	Less than 33	100·0 (49)	99·6 (57)	104·2 (61)
		33 and Over	92·6 (13)	106·9 (36)	104·1 (95)
		All	98·5 (62)	102·4 (93)	104·1 (156)
	IV and V	Less than 33	92·2 (22)	97·6 (19)	101·7 (28)
		33 and Over	90·3 (13)	98·9 (34)	97·5 (52)
		All	91·5 (35)	98·5 (53)	99·0 (80)
Twins*† ..	I and II	Less than 33	123·0 (2)	110·5 (8)	109·2 (6)
		33 and Over	93·0 (1)	113·5 (2)	109·4 (19)
		All	113·0 (3)	111·1 (10)	109·4 (25)
	III	Less than 33	100·0 (21)	94·7 (24)	99·5 (30)
		33 and Over	97·1 (8)	97·2 (21)	93·4 (39)
		All	99·2 (29)	95·9 (45)	96·0 (69)
	IV and V	Less than 33	99·0 (2)	96·2 (11)	94·9 (9)
		33 and Over	92·5 (4)	92·5 (11)	99·2 (25)
		All	94·7 (6)	94·4 (22)	98·0 (34)

* Excluding children with cerebral palsy, blindness, deafness or I.Q. below 50. No. of children given in parentheses.
† Excluding 42 single children and 24 twins for whom either social class or length of gestation was not known.

multiple regression confirmed that there was no significant correlation between I.Q. not adjusted for prematurity and length of gestation when social class, birth weight and the presence of visual defects were taken into account.

PREGNANCY AND BIRTH FACTORS

Toxaemia of pregnancy, which in this survey was defined as a blood pressure reading of at least 150/100, was present in about a quarter of the single pregnancies, and labour was surgically induced in about two-thirds of these cases. The mean I.Q. of the children with a maternal history of toxaemia was 104·7 compared with 101·9 in children with a maternal history of bleeding during pregnancy and 102·5 in children with no maternal history of bleeding or toxaemia. There were, however, relatively more mothers belonging to Social Classes I and II and fewer children weighing 3 lb. or less at birth in the toxaemic group, and allowing for these factors the corrected mean I.Q.s did not differ significantly (Table X). Neither was there any excess of children with very low scores in the toxaemic group (Table XI, opposite).

The mean score of the 62 children delivered by caesarean section was 106·2 and that of the 63 children that were breech deliveries 99·6, compared with 102·2 in the 465 vertex deliveries. However, the caesarean sections tended to have been done on mothers of superior social class, and the breech deliveries tended to have been small babies; allowing for social class and birth weight no significant differences were found between the adjusted mean I.Q.s (Table X). No excess of low scores was found in either the caesarean sections or the breech deliveries (Table XI). Complications of various types occurred during labour in 43 single children and in 22 twins or triplets. There was no evidence that the

TABLE X

MEAN I.Q.s ADJUSTED FOR SOCIAL CLASS AND BIRTH WEIGHT ACCORDING TO CERTAIN PERINATAL FACTORS*

Perinatal Factor		No. of Children	Mean I.Q.: Actual	Mean I.Q.: Adjusted	Difference between adjusted means ÷S.E. of difference
Toxaemia	Present ..	142	104·7	103·7	0·5
	Absent ..	399	102·4	102·8	
Delivery	Vaginal ..	528	101·9	102·0	1·3
	Caesarean section	62	106·2	105·0	
	Vertex ..	465	102·2	102·2	1·0
	Breech ..	63	99·6	99·9	
"White asphyxia"	Present ..	25	94·6	95·2	2·4 P<·02
	Absent ..	520	103·0	103·0	

* Calculated by analysis of co-variance (Snedecor, 1956) for the total number of children for whom social class and the factor under consideration were known.

TABLE XI

PERCENTAGE DISTRIBUTION OF I.Q.s ACCORDING TO BIRTH HISTORY AND NEONATAL SIGNS IN CHILDREN WITHOUT CEREBRAL PALSY, BLINDNESS, OR DEAFNESS

Birth	Neonatal Signs		Total No. of Children	Distribution of I.Q.s					
				Less than 50	50–69	70–89	90–109	110–129	130 and Over
Single	Maternal Toxaemia ..	No. ..	145	1	1	27	71	34	11
		Per cent.	100	0·7	0·7	18·6	49·0	23·5	7·5
	Complications of Labour ..	No. ..	43	1	—	9	19	11	3
		Per cent.	100	2·3	—	20·9	44·2	25·6	7·0
	Caesarean Section	No. ..	62	—	—	11	30	14	7
		Per cent.	100	—	—	17·7	48·4	22·6	11·3
	Breech Delivery	No. ..	66	2	1	16	30	14	3
		Per cent.	100	3·0	1·5	24·2	45·5	21·2	4·5
	"White Asphyxia" ..	No. ..	27	1	1	8	13	3	1
		Per cent.	100	3·7	3·7	29·6	48·1	11·1	3·7
	Convulsions	No. ..	44	3	—	13	16	8	4
		Per cent.	100	6·8	—	29·5	36·4	18·2	9·1
	Jaundiced 16 days or More	No. ..	33	—	—	2	20	7	4
		Per cent.	100	—	—	6·0	60·6	21·2	12·1
	Cyanotic Attacks	No. ..	56	1	1	13	18	18	5
		Per cent.	100	1·8	1·8	23·2	32·2	32·1	8·9
	Respiratory Distress ..	No. ..	54	—	—	14	25	11	4
		Per cent.	100	—	—	25·9	46·3	20·4	7·4
	All Single Births	No. ..	625	11	8	130	285	146	45
		Per cent.	100	1·8	1·3	20·8	45·6	23·3	7·3
Twins and Triplets	Complications of Labour ..	No. ..	22	—	—	8	10	1	3
		Per cent.	100	—	—	36·4	45·5	4·5	13·6
	Breech Delivery	No. ..	94	—	3	27	42	16	6
		Per cent.	100	—	3·2	28·7	44·7	17·0	6·4
	"White Asphyxia" ..	No. ..	10	—	—	1	3	5	1
	Convulsions	No. ..	9	—	—	2	5	2	—
	Jaundiced 16 days or More	No. ..	9	—	1	1	6	1	—
	Cyanotic Attacks	No. ..	20	—	—	12	6	2	—
		Per cent.	100	—	—	60·0	30·0	10·0	—
	Respiratory Distress ..	No. ..	35	—	2	8	15	7	3
		Per cent.	100	—	5·7	22·9	42·9	20·0	8·6
	First Twin	No. ..	140	—	3	38	63	30	6
		Per cent.	100	—	2·1	27·1	45·0	21·4	4·3
	Second Twin	No. ..	124	—	2	39	54	25	4
		Per cent.	100	—	1·6	31·4	43·6	20·2	3·2
	All Multiple Births ..	No. ..	280	—	5	85	123	57	10
		Per cent.	100	—	1·8	30·4	43·9	20·3	3·6

distribution of I.Q.s in these children differed from that of the whole sample (Table XI).

NEONATAL FACTORS

More than a quarter of the infants whose colour immediately after birth was recorded were said to have been in a state of "blue asphyxia". The mean I.Q. of these children was 103·8 compared with 102·7 in children whose colour was said to have been normal, but the 25 children reported to have been born in a state of "white asphyxia" had a mean I.Q. of 94·6. Allowing for social class and birth weight, the corrected mean I.Q. of children with "white asphyxia" was significantly lower than in the rest (Table X). There was a slight but not statistically significant excess of very low scores in single children with "white asphyxia" (Table XI).

55 children with a history of cyanotic or apnoeic attacks had a mean I.Q. of 104·0 and 52 with signs of respiratory distress (rib recession or grunting respirations) a mean score of 101·2 compared with 101·8 in children who were not said to have shown cyanosis or respiratory difficulty. There was thus no indication that either cyanotic attacks or respiratory

distress were associated with any lowering of mean I.Q., and there was no excess of children with very low scores (Table XI).

Forty children with a history of convulsions or signs of cerebral irritation had a mean I.Q. of 101·8 compared with the mean of 102·4 in children who did not have convulsions, but of the total of 44 children with a history of convulsions three (6·8 per cent.) had an I.Q. below 50 compared with eight (1·4 per cent.) of 581 children who did not have convulsions ($P < \cdot 05$).

There was no indication that children who had been jaundiced in the neonatal period differed from children who had not been jaundiced—the overall means were 102·0 and 102·8 respectively. Recording of severity and duration of jaundice was incomplete, but forty single children were known to have been jaundiced for more than 16 days. Seven of these were found to have either cerebral palsy or deafness or both, but the distribution of scores in the remaining 33 children did not suggest intellectual damage (Table XI). Children with generalized oedema in the neonatal period had a mean I.Q. (101·5) similar to that of children without oedema (102·3).

The only measurement of oxygen therapy which was satisfactorily recorded in the sample was its duration. No association was found between I.Q. and length of oxygen therapy; children who were not given oxygen or who had oxygen for less than 48 hours had a mean I.Q. of 102·8, those given oxygen for from 3 to 10 days a mean of 102·2, and for 11 or more days a mean of 102·2. The lack of any correlation between I.Q. and oxygen treatment was confirmed in a multiple regression analysis allowing for the effect of social class, birth weight, and the presence of a visual defect.

(2) *Multiple Births*.—The mean score of all the twins who were tested was only one point below that of the single children, but there were comparatively few handicapped twins and exclusion of those who were blind or deaf or who had cerebral palsy raised the mean I.Q. by only one point to 98·3; the resulting difference between single children and twins was 4·1 points (Table III). All five twins with a score below 50 suffered from one of the defects mentioned. None of the fourteen triplets was blind or deaf or had cerebral palsy or an I.Q. below 50.

Social class and sex differences in I.Q. were of the same order in twins as in single children, but there was no trend with birth weight in twins (Table IX). No trend was apparent with length of gestation (Table IX) and, although there was a negative partial regression coefficient nearly significant at a 5 per cent. level in females, there was none in males, and in both sexes combined the coefficient was not of a significant order (Appendix). Children of multiple birth generally resembled those of single birth in the absence of abnormal distributions of scores according to birth and neonatal factors, although in contrast to single children there was no evidence of an excess of very low scores in the twins who had "white asphyxia" at birth or convulsions in the neonatal period, but the numbers involved were very small.

The distribution of scores in first-born twins differed little from that in second-born twins (Table XI), and the mean I.Q. in first-born twins was 98·9 compared with 98·4 in second-born twins. There was an opportunity to examine whether the greater accuracy achieved by the elimination of inter-observer differences affected this finding. In 53 twin pairs both children were tested by the same examiner: in fourteen they had the same score, in nineteen the first twin's score was higher, and in twenty the second twin's score was higher. There was a mean difference of only 0·2 points of I.Q. in favour of first-born twins. Similarly, when the heavier twin in each pair was compared with the lighter twin, a mean difference of only 0·3 points was found in favour of the heavier twin: in twelve pairs the I.Q. was the same, in twenty pairs the heavier twin had the higher score, and in seventeen cases the lighter twin.

The 56 twins whose co-twin died—mostly in the first few days—had a slightly higher mean I.Q. (101·3) than the 184 twins whose co-twin survived (98·0). This difference of 3·3 points of I.Q. was reduced to 2·8 points if the scores were not corrected for prematurity. The difference was also reduced when the influence of social class and sex was allowed for, and was not of a statistically significant order (Appendix).

Although children with visual defects had a lower mean score (97·5) than children without visual defects (98·7), the difference was not statistically significant in multiple births. In fact, in females there was a difference in the opposite direction. The relationship between visual defects and intelligence was further explored allowing for the influence of social class and survival, and no significant difference between twins with and twins without visual defect was detected.

Discussion

Birth Weight

The revised Stanford-Binet in common with other intelligence tests is known to give results which vary widely according to social background. Both genetic endowment and the environment in which children are brought up appear to contribute to the large differences that are found (Jones, 1954). The resemblance to the general population in the distribution of the Registrar General's social classes made it possible to compare the sample of children studied with other samples representative of the general population. As social class is a crude index of social and genetic influences such comparisons must be made with caution.

The mean I.Q. of 98·4 found in single children in the sample was substantially lower than the mean of about 103 which would be expected in Great Britain at the present time. Most of the difference, however, could be accounted for by children with cerebral palsy, blindness, or deafness, of whom there was a large excess in the sample compared with the general population. Without these children and the small group with pathologically low scores of below 50, the mean I.Q. of single children corrected for prematurity was 102·4. This figure was similar to that expected in the general population, and bearing in mind possible population differences even the figure of 100·8 which was obtained when no adjustment for chronological prematurity was made could not be considered unduly low.

If it is a fact that, when children with gross motor and sensory handicaps are excluded, the mean intelligence of children with a birth weight of 4 lb. or less is not lower than that of the general population, it is unlikely to be lower than that of children with a birth weight of from 4 to 5½ lb. In the studies by Harper and others and by Drillien, handicapped children were not distinguished from the rest and the correlation between mean I.Q. and birth weight could have been due to increasing proportions of children with severe motor and sensory handicaps with decreasing birth weight. The lack of a gradient in the sample of Douglas (1960), although not very reliable because of the small numbers involved, was consistent with the results of the present survey. At the same time, Douglas's findings are not necessarily incompatible with those of Harper and others (1959) and of Drillien (1961) since no grossly handicapped children were included in his sample.

Although there was no evidence that children with a birth weight of not more than 4 lb. were intellectually inferior to the general population, the children in the sample who weighed less than 3 lb. at birth had lower scores than those weighing from 3 to 4 lb. The finding was not consistent since, although the correlation coefficient was highly significant in females, it was not statistically significant in males. In view of the evidence against a general correlation between I.Q. and birth weight, it seems probable that the lower intelligence of children weighing 3 lb. or less may be due to an aggregation in this birth weight group of various disorders which tend to lower intelligence. Perhaps the better survival of females than males might account for the difference between the sexes.

In the present survey the difference in mean scores according to birth weight was constant in the three social class groups, whereas in Drillien's sample there was a substantially greater difference in the lower social class groups (Table XII). There is no obvious explanation for this discrepancy. Drillien's sample was smaller and the children were younger when they were tested; since her survey was longitudinal in type it will be possible to see whether the trend persists as the children grow older.

TABLE XII

MEAN I.Q. ACCORDING TO SOCIAL CLASS AND BIRTH WEIGHT FOUND BY DRILLIEN (1961) COMPARED WITH PRESENT SAMPLE (SINGLE AND MULTIPLE BIRTHS INCLUDING HANDICAPPED CHILDREN)

Drillien (1961) Children aged 4 years			Present Sample Children aged 6–9 years			
Social Class	Birth Weight		Social Class	Birth Weight		
	3 lb. 8 oz. and Less	3 lb. 9 oz. to 4 lb. 8 oz.		3 lb. or Less	3 lb. 1 oz. to 3 lb. 8 oz.	3 lb. 9 oz. to 4 lb.
Middle and Superior Working Class	100 (104)*	102 (112)	I and II	102	112	108
Average Working Class	73 (74)	93 (93)	III	95	98	100
Poor Working Class	64 (59)	84 (87)	IV and V	88	92	95

* Figures in parentheses are mean scores of sub-samples of children given revised Stanford-Binet test (form L) at the age of 5 years.

Gestational Age and Perinatal Factors

The mortality of children weighing not more than 4 lb. at birth is very high; according to Gibson and McKeown (1950), 50 per cent. of children of this weight born in Birmingham in 1947 failed to survive the first year of life. In premature children survival appears to be closely related to length of gestation, and a respiratory cause—either failure of the lungs to expand or the respiratory distress syndrome—probably accounts for well over half of the neonatal deaths (Brown, 1960). Immaturity, measured by length of gestation, was found in this sample to be an important factor in the aetiology of both spastic diplegia and perceptive deafness (McDonald, 1963, 1964a). Both disorders were commoner among children with a history of cyanotic attacks or respiratory distress in the neonatal period, and diplegia was also associated with jaundice. In twins, diplegia tended to occur in children whose co-twin failed to survive. These two disorders therefore, the one affecting upper motor neurones, and the other presumably the cochlear nuclei, tended to occur in children who were at high risk of dying.

The children who just survived might have been expected to show evidence of intellectual damage, but this was not so. The intelligence of children with very short gestations and of those who had cyanotic attacks or respiratory distress was not different from that of the rest, and the intelligence of twins whose co-twin died was if anything higher than that of twins whose co-twin survived. Mortality has been reported to be about 50 per cent. higher in second-born than in first-born twins (Tow, 1959); intellectual damage to second-born twins might therefore have been expected, but none was found.

Serious oxygen deprivation is likely to have been experienced by some of the children with a history of cyanotic attacks or respiratory distress. Because of their higher mortality, second-born twins were more likely to have suffered in this way than first-born twins, and children reported to have been cyanosed at birth more than those with a good colour at birth. The average level of intelligence found in all these groups suggests that, in small premature babies at around the time of birth, the oxygen requirements of those parts of the brain responsible for intellectual functioning are lower than those of the vital centres. Furthermore, apart from the small group of children with "white asphyxia" in which there was possible evidence of damage, there was no indication that anything that happened around the time of birth in these small babies had any influence on later intelligence, except when neurological or sensory defects were present. Perhaps those parts of the brain concerned with intelligence were at too early a stage of development to be damaged by any but gross intracranial lesions.

Visual Defects

It is generally found that a considerable proportion of children blind with retrolental fibroplasia prove to be ineducable, but that others are among the cleverest of the blind children. In the present sample 40 per cent. had I.Q.s below 70, but the sample was too small to give useful information about those with I.Q.s above 70. Table XIII shows the I.Q. distribution of 102 children blind with retrolental fibroplasia, weighing 4 lb. or less at birth and born in 1951–53, who were examined by psychologists for the Royal National Institute for the Blind (Bowley, 1960). The lower proportion of very low scores than in the present sample was no doubt due to the fact that severely subnormal children were not eligible for the homes of the Institute. Among those with scores above 70, there was a slight but not a gross excess of scores below average. A considerable proportion of children blind with retrolental fibroplasia were thus grossly subnormal intellectually, but the remainder appear to have been little affected.

TABLE XIII

DISTRIBUTION OF I.Q.s (WILLIAMS OR LANGAN TEST) OF 102 CHILDREN BLIND WITH RETROLENTAL FIBROPLASIA BORN IN 1951–53 AND WEIGHING NOT MORE THAN 4 LB. AT BIRTH (BOWLEY, 1960), COMPARED WITH PRESENT SAMPLE

Series		Total	I.Q. Less than 70	70–89	90–109	110 and Over
RNIB	No. of Children	102	12	25	50	15
	Distribution (per cent.)	100·0	11·8	24·5	49·0	14·7
Present Sample	No. of Children	20	8	3	5	4
	Distribution (per cent.)	100·0	40·0	15·0	25·0	20·0

The figures for the sample from the Royal National Institute for the Blind were supplied by Dr A. Bowley and relate to 98 children admitted to Sunshine Homes and four children rejected on account of mental deficiency.

If, as has been suggested, mental deficiency in children blind with retrolental fibroplasia is due to a concurrent damage to retinal and cerebral blood vessels, one would expect to find all degrees of intellectual damage in children with retrolental fibroplasia; but those who were not blind appeared to be normally intelligent. One would also expect a correlation between I.Q. and duration of oxygen treatment, but none was found. If children vary in the extent to which they use visual experience in the process of learning, blindness could be a serious obstacle to intellectual development in some children but not in others.

The most probable explanation for the low score of children with cataract in the sample is that the defect was part of a general disorder in which the brain is also affected. There was support for this hypothesis in the pronounced tendency for the children with cataract to be small for their gestational age; this suggests a disorder of prenatal origin affecting foetal growth.

The contribution of children with a squint to the generally lower mean I.Q. of children with visual defects compared with those without such defects appears to have been small, and the presence of a squint could have had little effect upon the Stanford-Binet score unless other unmeasured factors were also important. Jahoda (1962) reported that children with hypermetropia or astigmatism had lower mean I.Q.s than children without visual defects and that children with myopia had higher mean scores, and he considered that genetical influences were responsible for these differences. Myopia, apart from that associated with retrolental fibroplasia, was rarely reported in the present sample, hypermetropia and astigmatism being the common refractive errors found. The difference in I.Q. between children with visual defects and those without was therefore consistent with Jahoda's findings but was rather large to be explained in the same way. Cataract and other severe visual defects are known to be associated with mental retardation in various syndromes; perhaps the same may be true of other less severe visual defects.

Multiple Births

Twins have been found by a number of authors (*e.g.* Merriman, 1924; Lauterbach, 1925; Wingfield and Sandiford, 1928) to have a lower mean I.Q. than single children. Mehrotra and Maxwell (1949) studied the intelligence of 974 twins in the Scottish Mental Survey for 1947 and found that, using a Moray House group test, their mean score was about 5 points lower than that of single children. The difference of 4 points found in the present survey was of a similar order, and suggests that there is a consistent difference between twins and single children irrespective of birth weight, and that twins weighing 4 lb. or less do not differ in intelligence from heavier twins. There was certainly no correlation between I.Q. and birth weight within the present sample, and in surviving twin pairs there was no significant difference in I.Q. between heavier and lighter twins.

It was found in the Scottish survey (Barclay and Maxwell, 1950) that the lower scores of twins could not be accounted for by differences in social class or family size, and the authors concluded that there must be some other reason, presumably one inherent in twinning, for the relatively poor performance of twins. One possibility is that the difference is environmental in origin and due to the presence of a twin. The language development of twins was shown by Day (1932) to be considerably retarded compared with that of single children, and they were 6 points of I.Q. behind single children on the Minnesota Pre-School Scale, but a comparison of verbal and non-verbal items suggested that the depression of I.Q. was not caused by delayed language development. Davis (1937) found that the language development of twins was also retarded at school age compared with that of single children, and that single children who were only children were superior to children with sibs.

Despite the evidence of Day, it seems possible that both language development and performance in intelligence tests might be retarded in twins by the presence of a co-twin which would tend to limit contacts with adults. A means of testing this hypothesis was available, since twins whose co-twin had died could be compared with those whose co-twin had survived. The result of this comparison was essentially negative as, although twins whose co-twin died did have a higher mean I.Q. than those whose co-twin survived, the difference was not statistically significant; it was of the order of 2·5 points of I.Q. whereas the difference between single children and twins was 4·1 points.

Mental Defect

The proportion of I.Q.s below 50 in the sample was 2·7 per cent. or about seven times the rate of 0·4 per cent. for the general population. It was higher in single children than in twins and higher at birth weights of 3 lb. or less than at between 3 and 4 lb. Over one-quarter of the children with I.Q.s below 50 had cerebral palsy. Although mongolism occurred at a rate of 0·4 per cent. in the 759 single births compared with about 0·1 per cent. in children of similar age in the general population, only one-tenth of mental defectives in the sample had the syndrome compared with over one-quarter of mental defectives aged 5 to 9 years in Middlesex (Goodman and Tizard, 1962). One-third of the children with scores of less than 50 were blind; possible explanations for this association have already been discussed. Only one-quarter of mental defectives in the sample had no gross physical defect. These eight children were too few to draw any conclusions regarding aetiology, but it is noteworthy that two cases appeared to be of genetic origin.

An association between convulsions in the neonatal period and an I.Q. of below 50 was found even when cases of choreo-athetosis and double hemiplegia were excluded. There was, however, no indication whether the convulsions were caused by damage during birth or were the result of a disorder of earlier origin.

Summary

A survey was made of the intelligence of 1,066 children aged 6 to 9 years who weighed 4 lb. or less

at birth; 905 (95 per cent.) of the 955 children without cerebral palsy, blindness, or deafness were given the Terman and Merrill (form L) revision of the Stanford-Binet test, in a further eight children the result of testing was unsatisfactory, and 42 could not be tested for various reasons. 107 of the 111 children with cerebral palsy, blindness, or deafness were given intelligence tests appropriate to their handicaps; four could not be tested. The I.Q.s were adjusted for chronological prematurity resulting in a mean increment of 1·6 points of I.Q., but for comparisons involving gestational age uncorrected scores were used.

Because of the resemblance of the sample to the population of England and Wales in the distribution of the Registrar General's social classes it was possible to compare the results with surveys of population samples. The mean I.Q. of 98·4 found in the sample was lower than the expected mean of about 103 in Britain at the present time, but when the 107 children with cerebral palsy, blindness, or deafness were excluded and in addition eleven (1·8 per cent.) children with I.Q.s below 50, which may be considered to be pathologically low, the mean was 102·4. There was thus no evidence that, when children with these handicaps were excluded, the mean I.Q. differed from that of the general population.

The 267 twins without cerebral palsy, blindness, or deafness had a mean I.Q. of 98·3—4 points below that of single children. This difference was similar to that which is generally found between single children and twins; there was no obvious explanation for it. The thirteen triplets had an even lower mean I.Q. of 91·3.

The large social class differences and the superiority of boys over girls which are generally found were present in this survey. The difference between boys and girls was rather greater in Social Classes IV and V than in Classes I–III.

A significant positive correlation between I.Q. and birth weight independent of social class was found in single children but not in twins. It was highly significant in females but not in males, although a similar trend was evident in males. Single children with a birth weight of 3 lb. or less who were not blind or deaf and did not have cerebral palsy had an excess of very low scores which was not quite of a significant order, and (excluding children with scores below 50) a mean I.Q. of 98·6 compared with 103·4 in children weighing from 3 to 4 lb. It is suggested that these findings may be due to an aggregation among children weighing 3 lb. or less at birth of abnormalities which affect both foetal growth and intelligence.

No association between length of gestation and I.Q. was detected in single or multiple births, either in scores adjusted for chronological prematurity or in those not so adjusted.

When blind and deaf children and those with cerebral palsy or an I.Q. below 50 were excluded, none of the following perinatal factors was found to show an association with I.Q.: maternal toxaemia, bleeding during pregnancy, presentation, abdominal delivery, cyanosis immediately after delivery, cyanotic attacks later, signs of the respiratory distress syndrome, convulsions or signs of cerebral irritation, generalized oedema, presence of jaundice, or jaundice lasting more than 16 days. A small group of single children with a history of "white asphyxia" on delivery was found to have a mean I.Q. which was lower than that of the remaining children ($P < \cdot 02$).

No difference was detected between first and second-born twins or between heavier and lighter twins. Twins whose co-twin failed to survive had a slightly but not significantly higher mean I.Q. than twins whose co-twin survived.

I.Q. scores of below 50 were found in 2·7 per cent. of the sample compared with approximately 0·4 per cent. in the general population. In just over one-quarter of the children the mental defect was attributable to cerebral palsy and in one-tenth to mongolism; one-fifth of the children were blind with retrolental fibroplasia and one-tenth virtually blind with cataract. There remained just over one-quarter without obvious physical defect. These eight children were all single births; three had neonatal convulsions and in two there was a family history of mental defect.

A significantly lower mean I.Q. which was independent of social class and birth weight was found in single children with visual defects which did not cause blindness, compared with children without reported visual defects. In twins there was a difference in the same direction, but not of a significant order. Children with retrolental fibroplasia whose visual defect was severe in many cases, did not differ appreciably from children without visual defects; children with a squint tended to be slightly inferior but did not differ significantly in mean I.Q. from children without visual defects. Children with minor refractive errors but no squint, and a small number of children with more serious eye defects had lower scores.

No correlation between I.Q. and length of oxygen treatment was detected. The evidence therefore suggested that neither prolonged oxygen therapy, nor retrolental fibroplasia which did not cause blindness, affected the I.Q. It is suggested that deprivation of sight may have had a severely detrimental effect upon the intellectual development of some children.

The lack of any correlation between I.Q. and factors leading to oxygen deprivation around the time of birth suggests that, in small premature babies, although death or neurological disorders not infrequently follow cerebral anoxia, intellectual damage alone does not occur.

I am grateful to the principal school medical officers and education officers who co-operated in the survey, and to all the psychologists and school medical officers who examined the children, including Mrs G. E. E. Blundell, Miss M. Hayton, Mrs A. E. Sedgley, Mr T. Simm, and Dr R. R. Skemp, who carried out testing in areas where the work was not undertaken by a local Education Authority.

I wish to thank Dr J. A. Fraser Roberts for his advice, Dr C. C. Spicer for statistical advice and help, Mr M. J. R. Healy for analysing some data by electronic computer, and Miss H. Wood for carrying out statistical analyses.

The work was supported by the Spastics Society.

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APPENDIX

Partial Regression Coefficients of Various Factors* on I.Q.

(1) SINGLE BIRTHS

Sex (No. of Children)	Factor	Partial Regression Coefficient	t	P
Males (220)	Birth Weight	1·0463±1·3411	0·778	<·5 >·4
	Gestation ..	0·6245±1·0649	0·586	<·6 >·5
	Social Class ..	5·8764±1·6003	3·672	<·02 >·01
	Visual Defect	2·8035±2·8673	0·978	<·4 >·3
Females (353)	Birth Weight	3·1933±0·9819	3·252	<·01
	Gestation ..	−1·2196±0·8394	1·453	<·2 >·1
	Social Class ..	7·8027±1·3338	5·850	<·001
	Visual Defect	4·4830±2·4251	1·849	<·01
Both Sexes (573)	Birth Weight	2·5765±0·7941	3·245	<·01
	Gestation ..	−0·6128±0·6593	0·929	<·4 >·3
	Social Class ..	6·9499±1·0257	6·776	<·001
	Visual Defect	3·6681±1·8547	1·978	<·05 >·02

Difference between Males and Females

	t	P
Birth Weight ..	1·29	<·2 >·1
Gestation ..	1·36	<·2 >·1
Social Class ..	<1	
Visual Defect ..	<1	

(2) TWINS

Sex (No. of Children)	Factor	Partial Regression Coefficient	t	P
Males (93)	Social Class ..	2·519±2·914	<1	
	Gestation ..	1·388±1·848	<1	
Females (147)	Social Class ..	8·054±2·065	3·90	<·001
	Gestation ..	−2·168±1·279	1·70	<·1 >·05
Both Sexes (240)	Social Class ..	5·740±1·705	3·37	<·001
	Gestation ..	−0·979±1·051	<1	

Difference between Males and Females

	t	P
Social Class ..	1·55	<·2 >·1
Gestation ..	1·58	<·2 >·1

Co-twin (No. of Children)	Factor	Partial Regression Coefficient	t	P
Died (56)	Social Class ..	6·8182±3·869	1·76	<·1 >·05
	Sex	−2·8396±4·966	<1	
Survived (184)	Social Class ..	5·4158±1·874	2·89	<·01>·001
	Sex	−3·5197±2·455	1·43	<·2 >·1

Difference between Twins whose Co-twin Died and Twins whose Co-twin Survived

	t
Social Class ..	<1
Sex	<1

Sex (No. of Children)	Factor	Partial Regression Coefficient	t	P
Males (93)	Social Class ..	2·616 ±2·818	<1	
	Visual Defect	8·859 ±4·730	1·87	<·1 >·05
Females (147)	Social Class ..	8·167 ±2·092	3·90	<·001
	Visual Defect	−1·446 ±3·7	<1	

Difference between Males and Females

	t	P
Social Class ..	1·58	<·2 >·1
Visual Defect ..	1·72	<·1 >·05

Social Class: I and II (+1)
III (0)
IV and V (−1)

Birth Weight: 2 lb. 8 oz. and less (−1)
2 lb. 9 oz. to 3 lb. (0)
3 lb. 1 oz. to 3 lb. 8 oz. (+1)
3 lb. 9 oz. to 4 lb. (+2)

Gestation: 216 days and less (−1)
217 to 230 days (0)
231 to 244 days (+1)
245 days and over (+2)

Visual Defect: Present (−1)
Absent (0)

Sex: Males (−1)
Females (0)

Survival of Co-twin: Died (−1)
Survived (0)

Figures in parentheses give values assigned to the corresponding variable in the statistical analysis.