A LONGITUDINAL STUDY OF THE GROWTH AND DEVELOPMENT OF PREMATURELY AND MATURELY BORN CHILDREN

PART III. MENTAL DEVELOPMENT

BY

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This paper describes the mental development of a group of nearly 600 premature and maturely born children from 6 months to 2 years of age. Approximately two thirds of the sample were 5½ lb. or less at birth. The sample includes 100 pairs of twins. The composition of the sample and the method of investigation are described elsewhere (Drillien, 1958).

Mental Testing Employed

The children were visited at home at six-monthly intervals. They were given a selection of tests based on the Gesell and Amatruda (1941) and Griffiths (1954) scales. On the basis of these tests and answers given by the mothers, each child was allotted a developmental quotient at each visit. In the case of prematurely born children, weeks of prematurity have been deducted from the chronological age to give the real age.

Developmental quotient (D.Q.) is expressed as a percentage according to the following formula:

$$\text{D.Q.} = \frac{\text{Developmental age}}{\text{Real age}} \times 100.$$

The tests were selected to include locomotion, manipulation, general understanding and speech, and social adjustment. A brief description of the routine carried out is given below:

(1) **At 6 Months.** The baby is observed in the following positions: supine and pulled to sitting, sitting supported or alone, prone and standing supported. He is offered a small shining bell and his method of reaching, grasping and manipulation observed. Finally he is offered a one-inch red wooden block, and if he grasps it, a second block. The mother is questioned about age of smiling, vocalization and recognition of people.

(2) **At 12 Months.** The child is observed crawling or shuffling on the buttocks, pulling to standing, cruising and walking with one or two hands held. A minority will stand or walk a few steps alone. He is sat on the floor and offered in turn, three one-inch blocks. He is then given a metal cup containing six blocks. If he fails to return any cubes to the cup after removal this is demonstrated. Some children will attempt a tower of two blocks at this age. The mother is questioned as to any words or sounds used with meaning, whether he waves or claps his hands, and whether he responds to any simple questions (e.g. 'Where is Daddy?').

(3) **At 18 Months.** The child is observed walking, trotting or running. His method of climbing stairs and of throwing and kicking a ball is elicited by question. He is presented with six blocks and encouraged to build a tower. The mother is asked to enumerate all the words he uses and any two-word phrases. He is presented in turn with two cards containing four and six coloured pictures of common objects, and asked, 'Show me the doggie', etc. The more advanced children will first be asked to name the pictures. If he will not respond he is shown a box containing seven small objects and told to 'Take the spoon to Mummy', etc. He is asked to point out parts of the body on a doll. The mother is questioned about feeding and toilet habits.

(4) **At 2 Years.** The mother is questioned about the method of climbing stairs and ability to jump, ride a tricycle and kick a ball. It is noted whether the child is speaking in single words, two-word phrases ('Daddy away!', 'Bad boy!') or broken

sentences ('Me want out, coat Mummy', or 'Peter bad, hit baby'), and whether he uses pronouns (I, me, you) and prepositions (under, over there). It is realized that the child's speech depends to a certain extent on the type of speech heard in the home, and this has been taken into account when assessing speech development. He is presented with the same picture cards and asked to name the objects. If he fails, he is asked to point them out. Similarly the objects in the box are presented. He is given 10 blocks and encouraged to build a tower and a train of three blocks aligned. The mother is questioned as to self-feeding, co-operation in dressing and toilet habits.

Co-operation of the children is on the whole very good up to the age of 18 months. At 2 years the proportion of unco-operative children has increased. The amount of weight attached to the mother's estimation of her child's ability varies considerably with the type of mother and whether her answers have been proved reliable in the past. The testing of twins becomes difficult at the age of 2 years, as it is not often possible to separate them. The twins are either tested on alternate tests, or else one twin is tested thoroughly and the mother questioned as to differences between them. In this case an attempt is made to test the other twin at the next visit. In general, it was found that the mother's estimation of the difference in ability between twins corresponded closely with test findings. In some cases owing to lack of co-operation it was impossible to make an assessment of D.Q. at 2 years and these children have not been included in the subsequent analysis. In nearly all these cases testing has been possible at later ages.

Analysis of the Data

Developmental Ability in Different Birthweight Groups. Table 1 gives mean D.Q.s at ages up to 2 years, for male and female singletons and twins,

divided into four birthweight groups. As no significant difference was found in D.Q. levels for children of different birthweights who were mature at birth, they have all been included in one group. Mean D.Q. falls steadily with decreasing birthweight in all four groups. In the group 4½ lb. or less at birth, there is a steady improvement in developmental ability, especially among female singletons, but later analysis showed that this difference between males and females is a purely fortuitous finding associated with the fact that in this sample there happens to be a greater number of mothers of apparently low intelligence in the smaller male premature groups. This will be referred to again in a later section. At all ages male and female twins show consistently lower scores than singletons of like birthweight. This finding has been recorded by other investigators (Mehrotra and Maxwell, 1949).

It is not suggested that the D.Q. ratings obtained can be considered accurate as absolute figures. A more accurate picture is probably obtained by placing the children in broader groups.

Fig. 1 shows the proportion of children by birthweight who at 2 years were considered to be : (1) grossly defective (D.Q. 55 or less), (2) mentally retarded (D.Q. 56 to 75), (3) backward or dull (D.Q. 76 to 95), (4) average or good average (D.Q. 96 to 115) and (5) definitely superior in intelligence (D.Q. 116 or more). The excess in dull, retarded and grossly defective children as birthweight decreases is very striking.

Developmental Ability Related to the Intelligence of the Mother. As has been noted before in a study of the physical development of these children (Drillien, 1958), there is a predominance of poor type homes amongst the prematurely born and also of obviously less intelligent mothers. Ideally one would have liked to have obtained the I.Q.s of the parents, but the best estimation possible of the

TABLE 1
MEAN DEVELOPMENTAL QUOTIENTS BY AGE, SEX AND BIRTHWEIGHT

Birthweight (lb. oz.)	Age in months				Age in months			
	6	12	18	24	6	12	18	24
	Female Singletons				Male Singletons			
3·8 and under ..	73·8	80·7	88·6	90·4	77·5	79·5	88·2	81·2
3·9 to 4·8 ..	85·8	94·0	98·3	99·4	84·0	86·9	90·6	88·9
4·9 to 5·8 ..	99·8	102·4	102·9	102·3	97·1	96·4	96·7	97·8
5·9 and over ..	104·5	104·3	103·7	104·9	106·7	109·2	107·8	109·1
	Female Twins				Male Twins			
3·8 and under ..	66·9	69·4	72·6	75·1	74·0	74·7	78·3	79·7
3·9 to 4·8 ..	88·6	94·9	93·7	94·7	80·1	86·2	90·8	88·3
4·9 to 5·8 ..	96·8	95·3	97·5	99·3	91·5	96·7	94·7	93·8
5·9 and over ..	98·5	101·3	100·4	101·6	102·5	105·0	101·2	100·5

mother's intelligence has been made by dividing them into three grades: middle class and superior working class, average working class, and poor working class. It is hoped at a later date to obtain some idea of the intelligence levels of school age sibs.

Fig. 2 shows mean D.Q.s at ages up to 2 years by birthweight and grade of mother. Numbers, especially in the poor working class grade, were not large enough to subdivide further into male and female singletons and twins, though what analysis was possible showed that the differences for maternal grades were similar in all four groups. For all maternal grades, mean D.Q. at 2 years rises steadily with increasing birthweight. In the smaller premature groups (i.e. those $4\frac{1}{2}$ lb. or less at birth) there is an improvement in developmental ability up to the age of 18 months in children born to the more intelligent mothers. Those who were over $4\frac{1}{2}$ lb. at birth show little variation in mean D.Q. at different ages in any maternal grade group except in the mature controls where children in the worst homes score higher at 1 year than at 2 years. This is due to backwardness in speech in this group and will be referred to later. Children who were $3\frac{1}{2}$ lb. or less at birth in the average and poor working class groups show no improvement comparable to that in the best maternal grade, the differences at 2 years between the three maternal grade groups being much more marked in the smaller prematures than in those over $4\frac{1}{2}$ lb. at birth. In spite of the improvement noticed in the prematurely born children of the more intelligent mothers, they still appear to have some handicap at the age of 2 as compared with the mature control group.

Fig. 3 illustrates this point in another way and shows the proportion of children considered to be of average or above average intelligence at 2 years, by birthweight and maternal grading.

Fig. 4 divides the children at 2 years by birthweight and maternal grading, into the broad groupings given above, and again shows the striking excess in the proportion of dull, retarded and grossly defective prematurely born children found where the mother's intelligence appears to be average or poor. In the mature control group there is an excess of children of obviously superior ability in the best maternal group, but the differences by maternal grade are not nearly so obvious. It seems likely that a combination of inferior genetic endowment and a poor environment with restricted opportunities has a more marked effect on early development in those who were small at birth than on maturely born children from a similar background. It will be interesting to see whether at a later age the differential between the children of the best and worst

FIG. 1.—Developmental grading at 2 years. By sex and birthweight.

mothers in the smaller premature groups will approximate more nearly to that found in the mature group.

Milestones of Development. Table 2 gives the proportion of children of different birthweights who, at certain ages, had reached six milestones of development. The milestones recorded are as follows: (1) Sitting unsupported on a hard surface for 10 minutes. (2) Standing unsupported for 30 seconds. (3) Walking alone across a room. (4) Five definite words used with meaning, apart from Mamma, Dadda and Ta-ta. (5) At least 20 meaningful words and several two-word phrases. (6) Speaks in broken sentences.

Children in the smallest weight group are more than 6 months retarded at 2 years as compared with

FIG. 2.—Mean development quotients by age, birthweight and grade of mother.

FIG. 3.—Proportion of children of average intelligence at 2 years by birthweight and grade of mother.

maturely born children. Prematurely born boys appear to be especially retarded as regards speech, but this again seems to be due to an excess of poor type mothers. It seems impossible to devise developmental tests, the results of which are unaffected by opportunity and environment. Perhaps at 6 months of age the infant's reactions are least affected by his upbringing, but even at that age frequent illness, which is much more common in poor homes, may produce an apparent retardation.

The attainment of these milestones has been tested in relation to birthweight and maternal grading, and the results are shown in Table 3. Males and females have been combined to provide bigger numbers. Milestones have been selected for the ages at which about one-half of the children might be expected to have reached this stage. It is obvious that in locomotor activities, the children from the worst homes are not retarded to anything like the degree that they are in speech. It seems likely that as soon as the child reaches the age when verbal testing becomes important, the D.Q. gradings of those in the best homes are being artificially boosted by the fact that they are spoken to frequently, and shown books, whereas children from the worst homes are

FIG. 4.—Developmental grading at 2 years by birthweight and grade of mother.

given a D.Q. grading which is too low, owing to their lack of opportunity.

The Relation of Developmental Ability to Family Placing. It is well known that firstborn children obtain higher scores on intelligence tests than later born children (Scottish Council for Research in Education, 1949; Burt, 1950). Table 4 gives mean D.Q. scores at 2 years, according to place in family, for premature and maturely born children.

Table 5 further subdivides the children according to grade of mother. Here family placing is given as first or later born, as there are not sufficient numbers to divide into the four family placing groups given in Table 4. The difference between first and

later born children is greatest in the smallest premature group, except for those with the least intelligent mothers where the difference between first and later born children is as high, or higher in those over $4\frac{1}{2}$ lb. at birth. The proportion of first births decreases with grade of mother in all birthweight groups, and this may account for some of the difference in mean D.Q. levels for different maternal grades shown in Fig. 2.

In Table 6 the mean D.Q. levels at 2 years are shown for different birthweight and maternal grades that would be expected if the parity distribution of all groups were the same as that found in the total sample. This standardization reduces the difference between maternal grade groups, but not to any great extent.

TABLE 2
MILESTONES OF DEVELOPMENT BY SEX AND BIRTHWEIGHT

Birthweight (lb. oz.)	Months	Locomotion			Speech			No. Cases
		Sit	Stand	Walk	5 Words	Phrases	Sentences	
Girls								
3·8 and under ..	12	70·4	3·7	—	—	—	—	27
	18	88·9	70·4	40·7	51·9	7·4	—	
	24	96·3	81·5	81·5	81·5	40·7	14·8	
3·9 to 4·8 ..	12	95·7	21·3	4·3	—	—	—	47
	18	97·9	91·5	78·7	78·7	19·1	—	
	24	97·9	95·7	93·6	95·7	68·1	21·3	
4·9 to 5·8 ..	12	98·1	40·0	8·7	4·9	—	—	103
	18	100·0	97·1	93·2	82·5	28·2	—	
	24	100·0	99·0	99·0	98·1	80·6	39·8	
5·9 and over ..	12	100·0	36·8	12·6	8·4	1·1	—	95
	18	100·0	98·9	96·8	83·2	38·9	1·1	
	24	100·0	100·0	100·0	100·0	90·5	44·2	
Boys								
3·8 and under ..	12	56·0	4·0	—	—	—	—	25
	18	92·0	44·0	36·0	24·0	—	—	
	24	100·0	84·0	84·0	64·0	20·0	4·0	
3·9 to 4·8 ..	12	78·1	7·3	—	—	—	—	55
	18	98·2	72·7	61·8	36·4	3·6	—	
	24	98·2	94·5	90·9	85·5	49·1	14·5	
4·9 to 5·8 ..	12	96·7	17·4	6·5	—	—	—	92
	18	98·9	89·1	85·9	67·4	10·9	—	
	24	98·9	98·9	97·8	97·8	66·3	26·1	
5·9 and over ..	12	99·0	58·4	21·8	9·9	—	—	101
	18	100·0	98·0	97·0	95·0	35·6	1·0	
	24	100·0	100·0	100·0	99·0	85·1	48·5	

TABLE 3
MILESTONES OF DEVELOPMENT BY BIRTHWEIGHT AND GRADE OF MOTHER

Birthweight (lb. oz.)	Maternal Grading	Standing Alone	Walking	5 Words	20 or More Words 2-3 Word Phrases	Broken Sentences	No. Cases
4·8 and under	1 2 3	12 months	Percentage reaching milestones at:				57 57 40
			18 months	24 months	24 months		
			65 60 50	70 44 30	54 39 20		
4·9 to 5·8 ..	1 2 3	31 25 18	89 90 87	86 77 55	82 73 68		66 91 38
		12 months			18 months	24 months	100 65 31
		45 48 58			47 34 13	55 42 8	
5·9 and over ..	1 2 3						

TABLE 4
MEAN DEVELOPMENTAL QUOTIENTS BY FAMILY PLACING AND BIRTHWEIGHT

Birthweight (lb. oz.)	Place in Family							
	1st		2nd		3rd		4th or later	
	Number	Mean D.Q.	Number	Mean D.Q.	Number	Mean D.Q.	Number	Mean D.Q.
5·8 and under ..	191	99·2	70	89·0	44	89·4	33	89·8
Over 5·8	98	106·9	39	102·3	20	103·5	21	98·3

TABLE 5
MEAN DEVELOPMENTAL QUOTIENTS BY FAMILY PLACING, GRADE OF MOTHER AND BIRTHWEIGHT

Birthweight (lb. oz.)	Maternal Grading	First Births (%)	Family Placing		Difference in Mean D.Q.
			First	Later	
4·8 and under	1	58	101·9	91·4	10·5
	2	51	93·1	85·4	7·7
	3	41	84·3	75·0	9·3
4·9 to 5·8	1	70	104·6	98·0	6·6
	2	62	100·7	96·6	4·1
	3	43	100·6	87·5	13·1
5·9 and over	1	65	108·3	105·1	3·2
	2	46	104·8	101·0	3·8
	3	40	104·0	94·7	9·3

TABLE 6
MEAN DEVELOPMENTAL QUOTIENTS BY BIRTHWEIGHT AND GRADE OF MOTHER STANDARDIZED FOR
FAMILY PLACING

Birthweight (lb. oz.)	Maternal Grading	Mean D.Q. Standardized for Parity	Difference in D.Q. from Maternal Grade 1	Mean D.Q. not Standardized for Parity	Difference in D.Q. from Maternal Grade 1
4·8 and under ..	1	96·7		97·0	
	2	89·7	- 7·0	89·3	- 7·7
	3	80·2	-16·5	78·8	-18·2
4·9 to 5·8 ..	1	101·7		102·7	
	2	98·8	- 2·9	99·0	- 3·7
	3	94·8	- 6·9	93·2	- 9·5
5·9 and over ..	1	106·9		107·1	
	2	103·1	- 3·8	102·7	- 4·4
	3	99·9	- 7·0	98·4	- 8·7

TABLE 7
INCIDENCE OF POST-NATAL SYMPTOMS BY BIRTH-
WEIGHT

Birthweight (lb. oz.)	No. of cases	Post-natal Symptoms:			
		None	1	2	3
3·8 and under ..	49	71·4	10·2	12·2	6·1
3·9 to 4·8 ..	100	79·0	10·0	9·0	2·0
4·9 to 5·8 ..	187	85·0	8·6	3·2	3·2
5·9 and over ..	192	93·7	3·1	0·5	2·6

The Importance of Birth Injury on Later Mental Development. On the basis of the later examination of mental development in 69 of a group of 102 surviving premature infants who were considered to have suffered intracranial injury at birth, Hess (1934) stated that 'premature birth unassociated with intracranial injury does not affect mental development'. This opinion has been repeated frequently, e.g. Brander (1937); Beskow (1949); Alm (1953).

A reliable post-natal history was obtained of about 528 of the total sample of 595 infants. Post-natal symptoms which Hess suggested might be attributed to intracranial injury were classified as follows: (1) Poor condition at birth, shocked, cyanosed or slow to breathe. No further complications after

the first 24 hours. (2) Cyanotic or apnoeic attacks after the first 24 hours. (3) Suspected intracranial injury, cerebral crying, twitching, irritability or convulsions.

The incidence of these symptoms in infants of different birthweight is shown in Table 7. Where the baby exhibited more than one of the groups of symptoms the case is classified under that considered most serious in prognostic significance. The incidence of these symptoms increases with decreasing birthweight.

Only 3% of the total sample and 3·3% of the total premature sample were considered to show definite signs of cerebral damage which is much lower than Hess's figure of 10·4%. If those who were shocked at birth, or later had cyanotic attacks, are included the percentage of possible cerebral damage is raised to 14·2% which is comparable with Hess's figure, considering that his sample contained fewer very small babies.

Table 8 gives mean D.Q. at 2 years for prematurely born children who showed these post-natal symptoms compared with those of similar birthweight whose progress was uncomplicated. The numbers are small, but there is little to suggest that

TABLE 8

MEAN DEVELOPMENTAL QUOTIENTS AT 2 YEARS BY BIRTHWEIGHT AND PRESENCE OR ABSENCE OF POST-NATAL SYMPTOMS

Birthweight (lb. oz.)		Post-natal Symptoms	
		None	1, 2 and 3
3·8 and under	..	72·6	82·7
3·9 to 4·8	..	92·9	90·3
4·9 to 5·8	..	99·8	92·2

birth injury has been a major factor in determining later mental development in this sample of children. The incidence of complications of pregnancy and delivery in the premature group was not significantly different in those who showed or did not show these symptoms. Six maturely born children, four with difficult deliveries showed cerebral signs or had cyanotic attacks. The mean D.Q. at 2 years for these cases was 105.

It is probable that premature babies are more likely to sustain cerebral damage as a result of birth injury, and that in some cases mental retardation and cerebral palsy may result, but it also seems likely that in more cases post-natal symptoms which are commonly attributed to cerebral damage are, in fact, due directly to the immaturity of the baby.

Discussion

There are few published studies of mental development in prematurely born children of pre-school age. Knobloch, Rider, Harper and Pasamanick (1956) examined a group of children of different birthweights at 40 weeks, using the Gesell scale, and found that the proportion of mentally retarded or defective infants was 17·6% in those less than 3·3 lb. at birth compared with 1·8% in the larger premature group, and 1·6% in the mature control group. The percentage of children of above average ability in these birthweight groups was 5·3, 16·3 and 21·8.

Douglas (1956a) concluded that prematurely born children were not retarded in the pre-school period if allowance were made for the degree of prematurity. This opinion was based on the mother's estimation

of the age of walking, elicited when the child was 2 years old. Children who were not walking at that age were excluded. Douglas divided his prematurely born children by estimated gestation time, into three groups. In the present survey no great weight has been attached to the mother's timing of milestones of development given in retrospect; however, they were all asked the age at which the child first walked unaided. To check the accuracy of these reports after an interval of one to two years, a number of mothers in the sample have been asked again at a later date to give the age at which their child first walked alone. The answers obtained bore little relation to information recorded earlier. Mothers of premature and retarded infants were particularly liable to be inaccurate.

A comparison of mean walking ages for singleton births in this investigation and that carried out by Douglas, is given in Table 9. Children who were not walking at 2 years have been excluded in both groups to make the results comparable, although if those cases had been included, average age of walking in the Edinburgh sample would have been even later in the prematurely born. The average age of walking in both the mature control groups is identical, but there is a marked disparity in the premature groups. Although these are not strictly comparable because of different methods of classification it is still obvious that either the children in the present survey are more retarded than prematurely born children in general, or else that there has been a tendency on the part of mothers of premature infants in the National Survey to overestimate their children's ability. More information is available about school age children (e.g. Beskow, 1949; Knehr and Sobol, 1949; Douglas, 1956b).

The general opinion seems to be that prematurely born children score lower on intelligence tests and do less well at school in academic subjects than their maturely born contemporaries. In many of these studies children who are educationally subnormal are excluded, and the estimation of mental ability in prematurely born children is assessed in those that remain, thus seriously underestimating the real effect of premature birth on later mental development.

TABLE 9
AVERAGE AGE OF WALKING IN EDINBURGH AND NATIONAL SURVEYS

Birthweight (lb. oz.)	Edinburgh Survey		National Survey (Douglas)		
	Average walking age (months)	No. not walking	Months of prematurity	Average walking age (months)	No. not walking
3·8 and under	18·4	6	2 or more	14·8	8
3·9 to 4·8	16·1	6	1 to 2	14·1	
4·9 to 5·8	14·7	2	0 to 1	13·4	
5·9 and over	13·4	—	Mature	13·4	

Summary

A group of children of different birthweights has been tested on the Gesell developmental scale at six-monthly intervals up to the age of 2 years. The following conclusions were reached:

Mean developmental quotient falls steadily with decreasing birthweight, at all ages, and twins show consistently lower scores than single born children. At 2 years there is a striking excess of dull, retarded and grossly defective children in the smaller premature groups (i.e. those of $4\frac{1}{2}$ lb. or less at birth).

Developmental ability is related to the apparent intelligence of the mother. At 2 years, for all birthweights, children born to the more intelligent mothers obtain higher D.Q. scores. The difference between scores of children in the best and worst maternal grades is much greater in those who were less than $4\frac{1}{2}$ lb. at birth than in the mature control group. A steady improvement in developmental ability is shown by the smaller premature infants in the best maternal grade. No comparable improvement is seen in those with the least intelligent mothers.

Prematurely born children are slower in learning to walk and talk. Children whose mothers are apparently of low intelligence are more retarded in speech than in locomotor activities.

Firstborn children show higher scores on developmental testing than later born children. The difference between first and later born children is greater for prematurely born children and for children from a poor background.

The incidence of certain post-natal symptoms suggestive of cerebral injury increases with decreasing birthweight. At 2 years there was little to indicate that mental ability differed in those of like birthweight who had, or had not, exhibited these symptoms.

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