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

PART VII: MENTAL DEVELOPMENT 2-5 YEARS

BY

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This paper describes the mental development between the ages of 2 and 4 years of singletons and twins of different birth weight. The children, who were born in the years 1953 to 1955, are included in a longitudinal study of growth and development, now in its seventh year. Details of selection and procedure are given elsewhere (Drillien, 1958). Of the 600 children originally enrolled, 92% of surviving children remained in the survey at 3 years, and 90% at 4 years. The children have been examined at home at six-monthly intervals up to the age of 2, and yearly thereafter. Children who appeared to be retarded at 2 years, or who have a physical defect affecting development, have been seen every six months up to 4 years. Others who were uncooperative in mental testing at 3 or 4 years were re-examined six months later.

Method

Mental Testing Employed. A selection of tests based on the Gesell scale (Gesell and Amatruda, 1941; Gesell, 1940) with some items from the Terman-Merrill L form scale (Terman and Merrill, 1937) have been used. In addition, a full developmental history has been taken from the mother at each visit.

In selecting or rejecting certain standard test items, it was necessary not only to consider which tests were acceptable to the child and easily applied in the home, but also which tests were acceptable to the mother. The continued co-operation of the mother was thought to be of more importance than the application of a full standard scale, in cases where she appeared to resent a too obvious probing into her child's ability. For this reason it was considered diplomatic to avoid tests where absolute failure was evident to the mother (e.g. digit and sentence repetition, picture and object memory) and utilize those tests where some degree of success was to be expected, and where a qualitative as well as a quantitative assessment could be made. The developmental age was assessed not only on test response, but

also on the mother's history, and on observation of the child's behaviour and speech throughout the interview. In assessing verbal responses and the history of speech and social development allowance was made for the type of home, amount of opportunity, and the type of speech which the child heard at home.

For statistical purposes the estimated D.Q. (Developmental Quotient) has been recorded as an exact number, but it is considered that pre-school testing can do no more than allot the child to certain broad groups, with some inevitable overlapping between groups, as follows:

- (1) D.Q. < 60 = gross defect.
- (2) 60-69 = mental retardation: ineducable in normal school.
- (3) 70-79 = border-line defect.
- (4) 80-89 = dull.
- (5) 90-99 = low average.
- (6) 100-109 = average or good average.
- (7) 110 and over = superior.

A brief description of points elicited in taking the history and tests used at 3 and 4 years is given below, with responses expected for the child of average ability. Retarded children were tested at a lower level, as described in a previous paper (Drillien, 1959). It was not possible to test children of superior intelligence through the full range of their ability, except in a few cases where the mother was sufficiently interested to allow the test to be done alone with the child.

History*

(1) **Locomotion.** At 3 years the child is reported to run well without stumbling, pedal and steer a tricycle, jump on both feet off a low step, and walk up and down stairs independently. He usually walks up alternating feet to consecutive treads, and down bringing both feet to the same tread and holding on to the wall or rail. At 4 years he runs up and down stairs alternating feet, and will jump the last two or three steps.

* As expected for a child of average ability.

(2) **Speech.** At 3 years he is reported as speaking in short complete sentences, with only minor defects of construction (e.g. 'me' for 'I'). Pronunciation may not be perfect, but the child is comprehensible to strangers. With some prompting at beginnings of lines he can repeat a few rhymes, songs or commercials from the television. By 4 years he is able to use quite long, well constructed sentences, and repeats rhymes with little help.

(3) Social

Feeding. At 3 years the child feeds himself with little spilling, using a spoon and fork. He holds his cup by the handle, and pours from a jug. At 4 years, if allowed, he can use a knife.

Dressing. At 3 years he pulls off shoes, socks, and pants, undoes accessible buttons, and can put on shoes (not always on the correct feet). At 4 years he can dress and undress with little assistance, can fasten buttons and buckle his shoes.

Toilet. By 3 years he is reliable by day, and will go to the toilet alone, but still needs help with wiping, and adjusting clothes. He is usually dry at night without lifting by $3\frac{1}{2}$ years, and at 4 years will take full responsibility for his toilet needs.

Testing Procedure

(1) Speech

(a) 18 coloured pictures of common objects: at 3 years he names 12+, and at 4 years 16+.

(b) Six action pictures (e.g. a boy throwing a ball, a girl pouring tea): in answer to the question 'what is the boy doing?' the 3-year-old will give some indication of action in three or more pictures (e.g. 'playing', 'getting tea') and names objects freely. At 4 years actions are described for five or six at a more advanced level (e.g. 'he's throwing the ball up in the sky', 'she's pouring tea for her dollies').

(c) Comprehension questions: uses of five common objects (penny, matches, spoon, ball, pencil). In answer to the question 'what do we use this for?' the 3-year-old responds to 3+ at a simple level (e.g. 'sweeties', 'smoke it') and the 4-year-old to all five, at a more advanced level (e.g. 'to buy a lollipop', 'light the gas'). In answer to the questions 'what must you do when you are hungry? tired? cold?' the average 4-year-old will respond correctly to at least two, and to the questions 'why do we have books? houses?' to at least one.

(2) Adaptive

(a) Block building: he will build a tower of nine to 10 at 3 years. A bridge is imitated at 3+ years, and copied from a model at 4 years. Blocks are also used for colour and counting.

(b) Drawing: most 3-year-olds will hold the pencil correctly. At this age they can copy a circle and imitate a cross. At 4 the child will copy a cross, may attempt a square, and score 1+ on the incomplete man test.

(c) Colour forms: a score of 3+ is expected at 3 years; a demonstration of the circle may be needed.

(d) Geometric forms: the 4-year-old scores 8+.

Correlation between Pre-school Testing and Intelligence Testing in School

A full analysis of the predictive value of early developmental testing in children of different birth weight from different types of home will be carried out when the necessary data have been obtained for the whole group. It is also hoped to relate school performance to observed pre-school and early school ability in children from different types of environment. However, it was thought useful to examine briefly here the findings in those children born in 1953 and 1954 who have already been tested in school.

To date 206 children who were adequately tested at 3 and/or 4 years have been given the Terman-Merrill L form test. The biggest disparity in scores was found in 18 cases who were considered superior (i.e. D.Q. 110 to 120) at 3 to 4 years, and scored 125 to 140 on the T.M.L. test. After excluding these cases, 68% of the remainder showed a disparity of eight points or less between the average of the 3 and 4 year tests and the T.M.L. test (Table 1). In all, 60 children showed a disparity of more than eight points. Of these, 33 stayed in the same broad grouping or moved up or down one group, there being no change in expected school disposal. In these cases the difference in scores was between nine and 14 points. Twenty-seven children (13%) showed a disparity of 15 points or more. Seven children scored higher in the pre-school period; of these, six are under supervision at a child guidance clinic for behaviour problems in school, and the seventh suffered a major domestic upheaval shortly before school entrance. It seems likely that the T.M.L. score is an underestimate in these cases. Twenty children scored 15 points or more lower at 3 to 4 years. Of these, five had suffered marked deprivation in the pre-school period (e.g. death or desertion of the mother, gross neglect, or attendance in a day or residential nursery since birth). Five showed slow development in speech, and were saying practically nothing at 3 years, although average in other respects, or had speech defects rendering them incomprehensible at 4 years. One

TABLE 1
DIFFERENCE BETWEEN AVERAGE OF D.Q. SCORES AT 3 AND 4 YEARS AND T.M.L. SCORE AT 5 PLUS YEARS

Points Difference	No. of Cases	%	Cumulative %
0-4	78	41	41
5-8	50	27	68
9-12	22	12	80
13-16	20	11	90
17-20	11	6	96
21 and over	7	4	100

small premature from a good home showed steady improvement from 6 months. Her scores at 1, 2, 4, and 5½ years were 61, 94, 100, and 120 respectively. Seven children (3·4%) who were tested adequately at 3 and 4 years, and appeared to be definitely slow, in the absence of unfavourable environmental influences which might affect development, were considered to be average or good average in school.

Correlation coefficients between pre-school tests at different ages and T.M.L. testing in school are given in Table 2. Considering that more than half of the children tested were premature infants, many of whom tended to improve between 6 months and 4 years, and also the inability to carry out full testing on children of superior ability, the correlations obtained are remarkably high. The correlation for test-retest on the Terman-Merrill L against M form at the same age is given as 0·88 in the age period 2 to 6 years (Terman and Merrill, 1937).

The agreement at the lower end of the scale is very close, as shown in Fig. 1. Sixteen children are considered to be ineducable in normal school (T.M.L. <70); of these, 12 were assessed at this level at 6 months and at every examination thereafter; no child scored higher than very dull on any test at any age. Sixteen children are considered border-line defective in school (T.M.L. 70-79); 12 of these were rated at this level or lower from 6 months; no child scored higher than very dull at any examination after 2 years. Fourteen children are rated as very dull and will need adjustment help or retardation in class; at 6 months 10 scored at this level or lower; only two children were considered to have a D.Q. above 95 at 3 and 4 years.

TABLE 2
CORRELATION COEFFICIENTS BETWEEN T.M.L. SCORES
AND D.Q. SCORES AT DIFFERENT AGES

Age	Correlation Coefficient	No. of Cases
6 months	0·54	237
1 year	0·57	240
2 years	0·66	234
3 years	0·78	192
4 years	0·82	171

All authorities agree that the early assessment of superior ability is much less accurate. To date, 60 children have scored 115 or higher on the T.M.L. test. Of these, 11 were 4½ lb. or less at birth, 14 between 4½ and 5½ lb., and 35 over 5½ lb. Fig. 2 shows pre-school assessments for these superior children at ages from 6 months to 4 years, by birth weight. In the smallest birth weight group over 60% were rated as low average or below at 6 months. Some of them were considered quite markedly retarded, but at each subsequent examination the number of below average children decreased. At 4 years one child was considered average and 10 above average. Most of these children came from middle-class homes, and the rest from superior working-class homes. In the mature control group one-half of the children were rated as above average at 6 months, and three-quarters by 3 years. At 3 and 4 years three children were considered below average on test responses, all of them coming from very poor homes with restricted opportunities.

In attempting to predict future ability in the pre-school period it is necessary to take full cognisance of birth weight, degree of opportunity available to the child, and any handicapping features in the environ-

FIG. 1.—Pre-school assessments on developmental testing in children considered ineducable, border-line defective, and dull in the first year in school.

ment. Experience from this group indicates that retarded children who will later prove to be ineducable in normal school should be recognizable by 1 year, and nearly all border-line or very dull children by 2 years. A number of children, mainly small prematures, who subsequently proved to be of average or superior ability in school, were rated at equally low levels at 6 months, and came under close observation for this reason. Nearly all showed obvious improvement at 1 year, and all showed progressive improvement after this age. In cases of suspected retardation the trend of development is of greater importance than the actual score at any one age. The early detection of mental retardation is the most important function of developmental testing, the prediction of average or above average ability being mainly of academic interest. Nevertheless, if those factors in the child's life experience which may affect development are known, it should be possible to reach a quite high degree of accuracy in predicting future ability in fairly broad groupings by the age of 2 or 3 years.

A comprehensive commentary on the recent literature about the predictive value of early developmental testing is given by Illingworth (1960) in a recent book. He stresses the importance of con-

sidering the child and his environment as a whole, of assessing not only the child's ability to perform a certain act but the maturity of his response, and the danger of relying on a single examination instead of assessing rate of development. Illingworth concludes that early developmental testing is of great value in the detection of mental retardation and neurological conditions with a considerable degree of certainty, though he has found little evidence that mental superiority can be detected in infancy.

Developmental Ability in Different Birth Weight Groups

Tables 3 and 4 give figures for mean D.Q. at ages 3 and 4 years, and mean score at 5 plus years on the T.M.L. test for singletons and twins in four birth weight groups.

Testing was inadequate, and no score allotted for 17% of singletons at 3 years and 26% at 4 years, and for 37% of twins at both ages. In 10% of singletons and 19% of twins no score was allotted at either 3 or 4 years. This was as often due to the attitude of the mother as it was to lack of co-operation from the child. Failure to make an accurate assessment was more common for mature controls,

and in the poorest homes; but from results of T.M.L. testing in school it appears that there is little difference between mean scores of children of like birth weight and social grade who were or were not tested at 3 to 4 years.

As at 2 years there is still an obvious difference in mean score between the premature groups and the mature control group. The difference by birth weight is approximately the same as it was at 2 years. Again, twins score lower than singletons of like birth weight at each age. Fig. 3 shows the proportion of children in the four birth weight groups who come into the broader categories given above. The increase in dull, retarded and defective children as birth weight decreases is still very obvious at 4 years.

Developmental Ability by Birth Weight and Maternal Grade

In the 2-year analysis it was found that developmental ability was related both to birth weight and grade of mother, the difference between children from the best and worst homes being greatest for those who were smallest at birth. This difference by social grade is still obvious at 3, 4, and 5 plus years, as shown in Table 5. The difference in mean D.Q. at 4 years for children from the best and worst homes is 32 points for those who were $3\frac{1}{2}$ lb. or less at birth (the difference was 17 points at 2 years) and nine points for those who were over $5\frac{1}{2}$ lb. at birth. The mean score at 3 to 4 years for the mature controls in the best maternal grade group is likely to be an underestimate, owing to the difficulty

FIG. 3.—D.Q. groups at 4 years by birth weight.

TABLE 3
MEAN SCORES ON INTELLIGENCE TESTING BY BIRTH WEIGHT (SINGLETONS)

Birth Weight	3 years			4 years			5+ years	
	No. of Cases	No. Tested	Mean D.Q.	No. of Cases	No. Tested	Mean D.Q.	No. of Cases	Mean I.Q.
(1) 3 lb. 8 oz. and under ..	38	34	84·5	36	30	82·5	17	76·9
(2) 3 lb. 9 oz.—4 lb. 8 oz. ..	57	52	95·3	57	52	97·2	23	100·8
(3) 4 lb. 9 oz.—5 lb. 8 oz. ..	136	109	99·6	133	89	100·1	78	102·1
(4) 5 lb. 9 oz. and over ..	111	90	106·8	108	77	108·7	59	113·1
Difference 4-1			22·3			26·2		36·2

TABLE 4
MEAN SCORES ON INTELLIGENCE TESTING BY BIRTH WEIGHT (TWINS)

Birth Weight	3 years			4 years			5+ years	
	No. of Cases	No. Tested	Mean D.Q.	No. of Cases	No. Tested	Mean D.Q.	No. of Cases	Mean I.Q.
(1) 3 lb. 8 oz. and under ..	12	9	74·2	12	10	73·3	9	73·4
(2) 3 lb. 9 oz.—4 lb. 8 oz. ..	41	29	93·2	41	25	95·9	22	99·1
(3) 4 lb. 9 oz.—5 lb. 8 oz. ..	58	36	95·9	57	34	97·0	14	99·2
(4) 5 lb. 9 oz. and over ..	78	45	102·6	78	49	103·5	23	106·3
Difference 4-1			28·4			30·2		32·9

TABLE 5
MEAN SCORES ON INTELLIGENCE TESTING AT DIFFERENT AGES BY BIRTH WEIGHT
AND MATERNAL GRADE

Maternal Grade	Age (years)	Birth Weight			
		3 lb. 8 oz. and under	3 lb. 9 oz.-4 lb. 8 oz.	4 lb. 9 oz.-5 lb. 8 oz.	5 lb. 9 oz. and over
1 and 2 Middle class and superior working class	3	98	101	102	108
	4	100	102	104	110
	5+	104	112	110	118
3 Average working class	3	80	92	99	103
	4	73	93	101	103
	5+	74	93	104	106
4 Poor working class	3	66	80	93	97
	4	64	84	88	98
	5+	59	87	93	95

previously mentioned of assessing children of superior ability. On T.M.L. scores there is a mean difference of 45 points of I.Q. between children from the best and worst homes who were 3½ lb. or less at birth, and 23 points for those who were mature controls.

Within each maternal grade group mean D.Q. increases with increasing birth weight, but the effect of small birth weight is much more marked in those

from the poorest homes. In maternal grade groups 3 and 4 there is little difference in mean score between those prematures who were over 4½ lb. at birth and the mature controls. Many of these so-called prematures are small babies born at or near term to small mothers, often of poor physique. Children from the best homes who were this weight at birth do score significantly lower. More of these children were premature by gestation time as well as by birth weight. Fig. 4 shows the same data arranged in a different way, for children from the best homes, and gives the proportion, by birth weight at 4 years, who were considered (1) defective (D.Q. <70); (2) border-line (D.Q. 70-79); (3) dull (D.Q. 80-89); (4) low average (D.Q. 90-99); (5) average or good average (D.Q. 100-109), and (6) superior (D.Q. 110 and over). Even in the best environment the proportion of children considered below average at 4 years increases markedly with decreasing birth weight although there are very few dull and retarded children in this group as compared with those of like birth weight from poorer homes. However, it should be remembered that an I.Q. of 100 in a child from a professional home with parents of superior ability may indicate as marked a degree of retardation as an I.Q. of 75 in a child from a poor home with parents of low intelligence. In a statistical analysis the former is considered normal, while the latter rates as a border-line defective.

Discussion

From the close personal observation of this group of children, their homes and families over 4 to 5 years, it appears that mental development, so far as this is measurable by developmental history, intelligence testing, and observed behaviour, is affected by birth weight, genetic endowment, and environment of upbringing.

Prematurely born children from the best homes with parents of above average intelligence show

FIG. 4.—Developmental gradings by birth weight—maternal grades 1 and 2.

a steady improvement from 6 months, which is most marked in the first two years of life. Children from the poorest homes show a lesser improvement on average up to 18 months or 2 years, and thereafter those who appear to be retarded tend to deteriorate further. A number of longitudinal studies of development in children of different birth weight are at present in progress. In this country the most comprehensive is the inquiry into later development of a representative group of premature children and full-term matched controls provided by the Maternity Survey of 1946 (Royal College of Obstetricians and Gynaecologists and the Population Investigation Committee, 1948). These children have now passed into secondary school. An assessment of mental ability was made at 2½ years (Douglas, 1956b), at 8 years (Douglas, 1956a), and at 11 years 3 months (Douglas, 1960). Although Douglas states in his most recent paper (1960) that the apparent retardation in walking and talking amongst prematures could be satisfactorily explained when the ages of both prematures and matures were calculated from conception, little weight can be attached to an assessment of early ability based on a brief history given to a health visitor when the child was 2½ years old. However, at 8 years over 80% of surviving children completed a series of standardized tests. The average score for prematures was between 1·7 and 3·0 points lower than that for controls, on a test with a mean for the whole group of 50 and standard deviation of 10. At 8 years environmental differences were considered minimal because of the matching of controls, and were not thought to account for differences in mental ability. At 11 years bigger differences were found on test scores, ranging from 3·0 to 4·2 points. Moreover, only 9·7% of prematures gained entrance to grammar school, as compared with 22·0% of controls. A reappraisal of environment revealed that certain differences existed between the premature and control groups which had hitherto been disregarded, particularly in the social and educational background of parents, and in their interest in and standards of care of their children. In conclusion, Douglas states: 'In a national study of the mental ability and primary school progress of premature children a number of striking handicaps were found, which were later shown to be of environmental origin, rather than the result of low birth weight *per se*.' One would not expect to find big differences between prematures and controls in Douglas's sample. The majority of the children selected were between 4½ and 5½ lb. at birth, and many of these were small babies born at or near term. Less than 10% of the

TABLE 6
PROPORTION OF PREMATURE AND MATURELY BORN CHILDREN IN DIFFERENT INTELLIGENCE GROUPINGS AT 11 YEARS: 618 CASES
(Constructed from Douglas, 1960)

Score	Premature %	Mature %
<40	21	9
40-44	15	17
45-54	39	40
55 and over	16	29
Unknown	9	5

TABLE 7
PROPORTION OF PREMATURE AND MATURELY BORN CHILDREN IN DIFFERENT INTELLIGENCE GROUPINGS AT 3-5 YEARS: 900 CASES
(Constructed from Harper *et al.*, 1959)

Mental Grade	Birth Weight (g.)		
	1,500 or less	2,001-2,500	2,501 or more
<i>White:</i>			
Defective ..	17·7	7·4	3·5
Dull or low average ..	17·6	15·0	10·6
Average ..	47·1	46·3	44·7
Above average ..	17·7	31·3	41·1
<i>Non-white:</i>			
Defective ..	27·0	11·0	6·6
Dull or low average ..	45·9	41·5	37·4
Average ..	27·0	41·0	43·2
Above average ..	—	6·5	12·8

entire group were 4 lb. or less at birth. In the Edinburgh group little difference was found between premature children over 4½ lb. and mature controls in working-class homes. In middle-class families some difference was evident, but more of these children were premature by gestation as well as birth weight. Differences in average score of the order of three to four points might be explained on the basis of the environmental differences noticed. However, when the distribution of scores between the two groups is examined (Table 6), more important differences are found. Assuming that the mean test score of 50 approximates to an I.Q. of 100, children scoring less than 40 would be considered definitely backward, those between 40 and 44 as dull, 45 to 54 average, and 55 and over above average. There are nearly twice as many above average children in the control group, and less than one-half the number of retarded children. It seems unlikely that such a marked excess of very dull or retarded children could be explained by such environmental differences as 6·5 and 3·5% paternal unemployment, or 24·7 and 17·6% previous attendance by fathers at night school. One might equally well postulate that the superiority of children whose fathers had attended night school was genetically determined. In the Baltimore study (Harper, Fischer and Rider, 1959; see Table 7) the

incidence of defective children is over four times as high in the smallest premature group as in the matched control group. In this study more detailed social indices were employed in matching than in Douglas's group, including some details of the parents' social background before marriage. Though there may still be some residual differences in environment between the two groups, it is unlikely that this could account for more than a small part of the differences in mental level observed.

Summary

The mental development of a group of over 500 singletons and twins of different birth weight has been studied at 3 and 4 years. About half the group have entered school, and results of intelligence testing between 5 and 6 years are available. The following conclusions were reached.

As at 2 years mean scores on intelligence testing fall steadily with decreasing birth weight at 3, 4 and 5 years. Twins show consistently lower scores than singletons of like birth weight. At 4 and 5 years there is a striking excess in the smaller premature groups (i.e. $4\frac{1}{2}$ lb. or less) of children who are ineducable in normal school, or will need special educational treatment within the normal school.

Mental development is related to the apparent intelligence of the mother and to the type of home. Differences between social grades appear to be greater at 4 and 5 years than at 2 years. In average and poor working-class homes there is little difference in mental ability between those prematures who were over $4\frac{1}{2}$ lb. at birth and mature controls. In superior working-class and middle-class homes

the child who was between $4\frac{1}{2}$ and $5\frac{1}{2}$ lb. at birth is still at a disadvantage. Most of these children were premature by gestation as well as by birth weight.

The predictive value of early developmental testing is discussed, and correlations given between D.Q. scores at ages 6 months to 4 years, and score on the Terman-Merrill L form test at 5 to 6 years. The expected response to pre-school developmental tests is affected by birth weight, environment and opportunity. Early developmental testing is of most value in the detection of children who later prove to be dull, retarded or defective.

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