CHAPTER 2

The Study Population: Biological and Social Characteristics

The first purpose of this chapter is to record the characteristics of our three groups of children in terms of the continuous variables (gestational age and birthweight) which were used to define them. The next, and more important, purpose is to record the associated biological, clinical and social characteristics which might account for any significant differences between the groups and which might plausibly be regarded as capable of modifying the children's performance or quality, as we have measured these between the ages of five and seven years.

As mentioned earlier, we subdivided the light-for-dates group into a 'rather light-for-dates' (birthweight between 5th and 10th centiles) and a 'very light-for-dates' group (birthweight on or below 5th centile). Because of the relatively large numbers in the original group, the two subgroups are still of adequate size for the purposes of most of our statistical analyses. The effect of this subdivision is to make it possible to see if progressively more severe slowing of the nett rate of intra-uterine growth appears to produce progressively more severe impairment of performance, as compared with the control group. It also means that the degree of slowing of the nett intra-uterine growth rate in the 'very light-for-dates' group can be considered comparable to the degree of shortening of the period of gestation in the whole short-gestation group, in the sense that the numbers of children are comparable and each group therefore represents the most deviant 5 per cent of the original population (because the very light-for-dates group does so by definition). This fact, that our two extreme abnormal groups represent roughly the same degree of the abnormalities in terms of which they have been defined, makes them very suitable for directly comparing the magnitude of the later effects of these two abnormalities of intra-uterine growth. If anything, the degree of abnormality is greater in the short-gestation group, since the numbers are appreciably smaller (59, compared with 74 very light-for-dates).

Gestational Age and Birthweight

The characteristics of the children actually seen by us at the age of five years are summarised in Table 2.1. Those of the children correctly selected as members of these groups, but not seen by us, did not differ significantly from the values shown.

The expected differences between the groups are clearly present, and are statistically significant. The expected resemblances are also confirmed — and it is noteworthy that the mean birthweights of the short-gestation group and the very light-for-dates group differ by less than 20g.

In view of the extent to which absolute ('horizontal') birthweight limits have

dominated nearly all previous published work in this field, it is also noteworthy that our abnormal groups have been selected by criteria which are so far from being extreme that about half the children's birthweights cannot be called 'low' (WHO 1961), let alone 'very low' (*e.g.* Eaves *et al.* 1970). Even when we subdivide the light-for-dates group for purposes of analysis, the mean birthweight of the 'very light-for-dates' group is 350g above the upper limit of the population studied by Eaves *et al.* (1970). In other words, any deficiencies of performance or of quality which we may demonstrate, even in our two extreme groups (short gestation or 'very light-for-dates'), are much more likely to be encountered among children in other populations similar to that of the total community from which our groups were selected, than are the findings of published studies of children of 'very low birthweight'. In fact, our two extreme abnormal groups constitute about 10 per cent of our population.

TABLE 2.1

Gestational age and birthweight characteristics of the three groups of children seen by us at age five years

Characteristics	*Random control*	*Short gestation*	*Light-for-dates*	*Rather light-for-dates*	*Very light-for-dates*
No. of children	187	59	141	67	74
Gestational age (days)					
mean	281	244	281	281	281
standard deviation	12.6	11.7	12.7		
Birthweight (g)					
mean	3508	2415	2537	2701	2397
standard deviation	462	522	289	163	304

Associated Biological and Clinical Factors

The theoretical importance of associated biological and clinical factors is that they might modify the physical structure and potential for growth of the brain or of other organs whose functions are reflected in our assessment programme. Thus they might modify any structural changes produced by either or both of the abnormalities of intra-uterine growth, and as a result either exaggerate or mask differences in the children's performance at the age of five to seven years.

In Table 2.2 we have shown those associated biological and clinical factors in which there is at least one significant difference between our groups and which plausibly seem capable of producing an effect upon the child's performance. We have included the data for breech delivery and delay in establishing regular respiration because these were shown to have a complementary effect in our Newcastle population (Neligan *et al.* 1974). There was no significant difference between our groups in respect of the mother's age, or her history of abortion and stillbirths, cardio-pulmonary disorders, diabetes mellitus, urinary tract infection, pregnancy toxaemia and Rhesus iso-immunisation.

The neonatal factors for which we have systematic information and in which there was no significant difference between the groups include hyperbilirubinaemia,

delay in regaining birthweight, and hypoglycaemia. However, the last of these factors was only just beginning to be systematically investigated at the time when our children were born (Neligan *et al.* 1963), so the relevant information is incomplete. There were also no significant differences in the incidence of infections or injuries of the nervous system in later childhood.

The extent to which there is evidence to support the plausibility of these factors as modifiers of the children's performance varies with the individual factors. The mother's height has been shown to be related to the child's performance at the age of seven years (Illsley 1967), and her smoking habits during pregnancy affect both birthweight and perinatal mortality rate (Butler and Alberman 1969). Male sex is well known to affect growth, and was shown to be associated with impaired performance in simple IQ tests, and with less satisfactory behaviour in our Newcastle population (Neligan *et al.* 1974). The effect of the child's sex upon the results of test procedures has been discussed by Gruenberg (1964) and Hutt (1972). Fortunately, the proportion of males is very similar in the three groups in our present study between which we wish to make the most important comparisons, but the significantly lower proportion of males in the 'rather light-for-dates' group may need to be allowed for in comparing the results of sex-sensitive tests with those of other groups. We know of no direct evidence concerning the effects of antepartum haemorrhage upon performance in later childhood. Both breech delivery and delay in onset of regular respiration were found to have some harmful effects in the NSCD population, but these became insignificant when associated biological and social factors were allowed for (Neligan *et al.* 1974). The only information we know of concerning fetal distress (defined as slowing of the fetal heart-rate to below 100 beats per minute, with or without passage of meconium) suggests that it produces no significant harmful effects at the age of four years (Berendes 1969).

Social Class and Associated Factors

Again we have been selective in the factors shown in the Tables, only showing those which plausibly may be considered likely to have directly modified our children's performance. In this case we are concerned less with effects upon the physical structure of the brain and other organs than with modification of the child's ability to demonstrate his innate potential by his performance of our series of tests.

In Table 2.3 we have shown the social-class distribution of the children in our four groups. The father's occupation was recorded in the Newcastle Maternity Survey data and was coded in accordance with the Registrar General's Classification of Occupations (Great Britain 1951). We have accepted this classification for the purpose of our study in order to enable direct comparisons to be made with the population from which our children were derived. The birth social-class distribution of all children followed by the NSCD (born in 1961-62 and in Newcastle schools at the age of five years) is included in Table 2.3 to show that in this respect our random control group does closely resemble the population from which it was selected. We have combined classes I and II (professional and managerial), and classes IV and V (semi-skilled and unskilled manual workers) to avoid having too few children in some of the cells.

TABLE 2.2

Associated biological and clinical factors

Factors	*Random control (a)*	*Short gestation (b)*	*Rather light-for-dates (c)*	*Very light-for-dates (d)*	*Significant differences* $p<0.05$	$p<0.01$
	%	%	%	%		
Mother's height ⩽61ins.	24.7	33.9	39.0	40.5	a/c, a/d	—
Mother smoked more than five cigarettes per day	29.5	59.3	53.1	71.6	—	a/b, a/c, a/d
Child's sex male	51.3	57.6	32.8	54.1	a/c, b/c, c/d	—
Antepartum haemorrhage	6.4	11.9	3.0	1.4	—	—
Breech delivery	3.7	6.8	6.0	2.7	—	—
Delay in regular respirations ⩾5 mins.	2.7	3.4	6.0	5.4	a/c	—
Fetal distress	4.8	10.2	11.9	18.7	a/c	a/d

TABLE 2.3

Social-class distribution of our four study groups and of the five-year-old Newcastle population from which they were derived

Social class at time of birth	*Newcastle children born 1961-62*	*Random control (a)*	*Short gestation (b)*	*Rather light-for-dates (c)*	*Very light-for-dates (d)*	*Significant differences* $p<0.05$ $(2\times3\ \chi^2)$
	%	%	%	%	%	
I and II	10.4	9.0	3.4	6.0	13.3	
III	62.8	61.5	49.2	61.5	55.8	a/b, b/d
IV and V	26.8	29.5	47.4	32.5	30.7	

TABLE 2.4

Associated social and cultural factors

Factors	*Random control* (*a*)	*Short gestation* (*b*)	*Rather light-for-dates* (*c*)	*Very light-for-dates* (*d*)	*Significant differences* $p<0.05$	$p<0.01$
No. of children in family	3.3	2.9	3.2	3.0	a/b	—
Care of child "poor"	2.7%	11.9%	2.9%	5.4%	a/b, b/c, b/d	—
Relatives baby-sit	89.3%	79.3%	78.0%	78.3%	a/c, a/d	—
Parents read to child regularly at six years	79.5%	62.7%	71.6%	73.6%	—	a/b, b/c, b/d

TABLE 2.5

Mothers' self-rating on Eysenck Personality Inventory and Maryland Parent Attitude Survey: mean group scores of scales where there were significant inter-group differences

	Random control (*a*)	*Short gestation* (*b*)	*Rather light-for-dates* (*c*)	*Very light-for-dates* (*d*)	*Significant differences* $p<0.05$	$p<0.01$	$p<0.001$
	%	%	%	%			
Eysenck							
Neuroticism	12.30	12.5	12.6	14.4	b/d, c/d	a/d	—
Maryland							
Disciplinarian	22.2	19.5	23.7	21.7	b/d	a/b	b/c
Rejecting	17.0	20.2	16.1	18.4	b/d	c/d	a/b, b/c

When the random control group is compared with the abnormal groups, however, there are obvious social-class differences. The only differences which reach conventional levels of statistical significance are those in which the short gestation group is concerned. This group has a significant deficiency of children in social classes I and II, and a corresponding excess in social classes IV and V, as compared with the control and the 'very light-for-dates' groups. These differences were not present in the original survivors of the first month of life, and are accounted for by the distorted social-class distribution of the original members of the short-gestation group who were not seen by us at the age of five years — 18.5 per cent in social classes I and II compared with 28.3 per cent in classes IV and V. The resultant distortion of the social-class distribution of the children in the short-gestation group who were seen by us at the ages of five, six and seven years must clearly be allowed for in assessing the results of any test procedures which are sensitive to social factors. It is convenient that neither of the light-for-dates groups differs significantly from the control groups in this respect, and the need to make such allowances is therefore less in their case. In fact, the social-class distribution of the extreme ('very light-for-dates') group is more favourable than that of the control group and so will tend to minimise the impairment of performance, which is our evidence of an organic defect.

However, though very widely used and a powerful discriminator (Birch *et al.* 1970), occupational social-class is very broad in its implications and non-specific with regard to mechanisms, and so is unhelpful with regard to preventive action. We have therefore studied the effects of a number of more specific factors. In Table 2.4 we show the only factors for which there was a significant difference between any of the groups, and which plausibly may have modified the children's performance of our tests. We have not shown the significantly lower proportion of the children in the short-gestation group whose parents owned their own house, for instance, because we regard this as simply a reflection of their different social-class distribution, not a plausible direct cause of impaired performance. The social factors for which we found no significant difference between the groups were the proportion who were living with both natural parents at age five years (88 to 92 per cent), or who had been separated from one or both parents for more than three months (17 to 22 per cent), or who had been admitted to hospital at least once by the age of three years (17 to 22 per cent).

The source of the information concerning all but the second of the factors shown in Table 2.4 was our research health visitor's interview with the mother. The number of children in the family included those younger as well as those older than our index cases. Help from relatives in the form of baby-sitting had to be available on a regular basis for this factor to be scored as positive: we regarded it as an indicator of the general level of help and support being received from the extended family. Reading to the child, by one or both parents, was scored as 'regular' only if it occurred more-or-less daily.

The source of the assessment of the quality of the mother's 'care of child' was the third year proforma submitted by the City's health visitors for all NSCD children who had been born in 1961 and 1962 and with whom they were still in touch at that age. The written instructions about this item (which was graded as 'good', 'average' or 'poor') stated:—

"This is intended to include adequacy of food and clothing and of supervision by a responsible adult or older child: cleanliness: seeking appropriate help in case of illness: evidence of affectionate parental interest in the child".

Although in retrospect we regret having included such diverse qualities in this definition, at least there could be no confusion between these and those involved in the mother's 'care of home', since this was reported (and defined) separately. The possibility that there will be a relationship between the 'care of child' grading and social class was confirmed by Neligan *et al.* (1974), who found that the proportion of mothers graded 'poor' was 0.9 per cent in social classes I and II and 0.6 per cent in class III non-manual, but rose to 3.6 per cent in class III manual and 6.7 per cent in classes IV and V. Table 2.4 shows that the proportion of mothers so graded in our study groups, particularly in the two extreme abnormal groups, was higher than would have been expected from their social-class distribution. Certainly these differences between the groups need to be allowed for in assessing the results of our tests.

Maternal Attitudes

The third group of associated factors which we have thought it necessary to study, and if possible to allow for, were the maternal attitudes which may be expected to bear a specific relationship to the two abnormalities of intra-uterine growth in which we are interested. There are obvious reasons for supposing that a mother's emotional relationship with her baby may be disturbed if the baby is born either too soon or too small. She may experience disappointment, so severe as to amount to a significant stress, because she has failed to carry her baby to full term or to full size, with a resultant threat to his well-being, or even his life. The birth of her baby may confront her with a prolonged period of anxiety before she can experience any of the anticipated pleasures of motherhood. These factors may increase the likelihood of puerperal psychosis (Wortis and Freedman 1962), or of neurotic disorder and an anxiety state (Kaplan and Mason 1960, Caplan *et al.* 1965). A prolonged period of separation resulting from the baby's admission to a special nursery may prevent the development of vital bonds which are normally produced by close physical contact between mother and baby (Harlow *et al.* 1963, Bell 1968). These effects may be aggravated by unduly restrictive attitudes of the nursery staff (Oppé 1960), especially if the baby is being nursed in an incubator (Scarr-Salapatek and Williams 1973). Clearly such abnormal emotional reactions may adversely affect the later performance of the child; and clearly there is an increased chance of such reactions among the mothers of the babies in our abnormal groups. But before we go on to describe how we have attempted to assess their nature and severity so that we can allow for them in assessing the performance of the children, we feel it is right to repeat that the criteria by which our groups were selected were far from extreme: in fact the mean birthweights of the babies, even in our two extreme abnormal groups, were just above the level of about 2380g (5¼lbs) below which admission to a special nursery would have been automatic for all babies born in Newcastle hospitals at that time. Since gestational age would not then have been given independent weight in deciding to admit a baby to a nursery and

since some of the babies were born and nursed at home, less than half the babies (even in our two extreme abnormal groups) will have been treated as 'different' from other babies in such a way as to risk causing emotional trauma to their mothers.

The methods which we used for assessing the mothers in our study included a clinical interview with the psychiatrist when the children were five years old. At the end of the interview the psychiatrist rated the degree of psychiatric disturbance, on a three-point scale, at two periods in the mother's life: (*a*) during the puerperium following the birth of the study child, and (*b*) at the time of the interview. The method used has not been published or validated: its potential value in our study depended on the fact that the interview was 'blind'. There was a relative excess of mothers in the short-gestation group assessed as markedly neurotic both for (*a*), when the difference was not significant, and for (*b*), when the significance was ($p<0.001$) compared with the control group. For (*b*), the mothers of the very light-for-dates group also were assessed as neurotic significantly more often than those of the control group ($p<0.05$). Published methods of assessment were also used, and the two for which there were significant differences were the Eysenck Personality Inventory and the Maryland Parent Attitude Survey. Both were administered when the children were six years old.

The Eysenck Personality Inventory (Eysenck and Eysenck 1964) measures two dimensions of personality, namely extraversion (as compared with introversion) and neuroticism (as compared with stability). The questionnaire was completed by the mothers without assistance. There were no significant differences between our four groups in extraversion or the lie scale, but there was a significant excess of neuroticism (higher mean score) in the very light-for-dates group (Table 2.5, p. 13). There is no excess of neuroticism in the mothers of the short-gestation group, however, when assessed in this way.

The Maryland Parent Attitude Survey (Pumroy 1966), modified by Kolvin *et al.* (1976), gives standardised scores for the mother's attitude to her child under four headings: (1) disciplinarian, (2) indulgent, (3) protective and (4) rejecting.

Significant differences between the mothers of children in our four groups were found under disciplinarian and rejecting headings as shown in Table 2.5. Of the two extreme groups, the mothers of the short-gestation group scored significantly low on discipline and high on rejection, which would seem to be a particularly unfavourable combination of environmental factors from the point of view of their children's adjustment to and performance in an institution such as school. It may be, to some extent, a reflection of the distorted social-class structure of this group. In the very light-for-dates group, too, the mothers have a high rejection score, but their discipline score does not differ significantly from the controls. For once, the rather light-for-dates group's behaviour is not intermediate between the controls and the very light-for-dates: their mothers scored high on discipline and low on rejection (at least in comparison with the other abnormal groups). No babies in this group will have been admitted to a special nursery or treated in any way 'differently' on grounds of weight alone, since their mean birthweight (Table 2.1) was 2701g (SD $\pm$ 163g). In effect, this finding would tend to support the possibility that the deviant attitudes of the mothers in the two extreme abnormal groups may have been, at least in part, a result of their babies' neonatal clinical management.

Discussion

Apart from the biological characteristics of our study groups (summarised in Table 2.1), which are a direct result of the criteria by which they were selected, as described in the previous chapter, we have been concerned in this chapter with identifying associated differences in 'confusing' factors. By this term we mean those factors which may confuse (either by exaggerating or by masking) the differences between the performance of our three groups, and so make it more difficult to identify the direct effects of being born too soon, or too small. The complexity of the biological and social relationships involved is summed up by Illsley (1966): "I want to stress the variety of interrelated processes which might influence the correlation of IQ with birthweight".

The theoretical basis for the possibility that the two abnormalities of intra-uterine growth in which we are interested may produce long-term impairment of performance in the children we have studied is the evidence from human (Davies and Davis 1970) and from animal studies (Widdowson and McCance 1963) that impairment of growth at a critical stage may produce irreversible effects. Studies of the timing of the 'growth spurt' in different areas of the human brain suggest that different functions may be vulnerable at different stages of development (Dobbing and Sands 1973). In the case of babies who are born too small, it may be suggested that their poor nett rate of intra-uterine growth is a reflection of a state of effective malnutrition at a critical stage, following which 'catch-up' growth (of the brain or other vulnerable tissues) may be impossible. In the case of babies who are born too soon, there is a risk of a comparable degree of effective malnutrition (due to an inadequate food intake or an inappropriate environment) producing the same effect during their stay in a special care nursery, at an age when they should still have been in the uterus. Both these mechanisms are strongly supported by the findings of Davies and Davis (1970).

Theoretically, these effects upon the structure of the brain could be directly modified by various biological factors. Of those listed in Table 2.2 for instance, any of the last four could cause anoxia of the fetal or neonatal brain; this could, in turn, produce permanent destruction of brain cells (Windle 1958). The effects of the child's sex upon subsequent performance, demonstrated in the NSCD population by Neligan *et al.* (1974), could also be on the basis of physical vulnerability to adverse prenatal or perinatal factors, or it could possibly reflect later differential interaction with social factors.

The social factors listed in Tables 2.3 and 2.4 could modify the children's performance in our tests at the age of five, six and seven years by at least two different mechanisms. Psychological effects of their environment over a number of years could either enhance or diminish their ability to demonstrate their innate physical potential in measurable ways; or associated biological factors (which we may or may not have observed and recorded) could modify the physical structures upon which this potential depends.

In view of the complexity of the possible relationships between the two abnormalities of intra-uterine growth in which we are primarily interested, their associated biological and social factors, and the results of the very extensive and detailed test programme which each child carried out, we think it desirable to carry

out and present the analysis of our findings in two stages. The first stage will be to identify the results which support a *prima facie* case for an effect of an abnormality of intra-uterine growth, and to see how this effect can be related to one or two of the associated biological and social factors (Chapters 3 to 6). In the second stage, the relationships which appear to be significant on the basis of these simple analyses will be subjected to more complex statistical analyses with a view to assessing their relative importance and to deciding whether the two abnormalities of intra-uterine growth still have any demonstrable long-term effects when the relevant associated factors have been allowed for (Chapter 8). A different type of analysis will be used (Chapter 9) to identify and compare the effects of individual associated factors, some of which may be able to be modified in the interests of improving the quality of our population.