7 Multivariate techniques and classification of speech delay

Introduction

This chapter, in many ways, summarizes complex arguments previously mentioned and therefore, in order to make it clear for our readers, we shall repeat the salient features of the method. The total population of children born in Newcastle upon Tyne in 1962 were screened to identify those who proved to be speech retarded at the age of three years (as reported by health visitors). The speech retarded group comprised 102 children who were studied at six years and again at seven years and the control group comprised 102 children still living in Newcastle at the age of seven. They had been matched for age, sex and neighbourhood (postal district). Of the 102 speech retarded children a subgroup was identified whose functioning was so abnormal that they had to be analysed separately. This latter group constitutes what we have labelled the pathologically deviant group and the remaining children have been labelled the 'Residual Speech Retarded Group' or, alternatively, the 'developmental speech disorder syndrome group'. Unlike Ingram (1972) we made no specification about intelligence or home background in our definition of the developmental speech disorder syndrome.

Aim of the present chapter

It is commonly assumed that speech delayed children constitute a homogeneous group, the majority of whom improve spontaneously by the time they go to school, but a small remainder will suffer from the consequences of this early delay. However, this has now been disproved by other workers (Ingram, 1963; Mason, 1967; Morley, 1965; Rutter 1967) and by our own research. It is clear, in fact, that children

who have speech delay at three are a heterogeneous group (Ingram, 1972). The aim of this chapter is to attempt to delineate relatively separate subgroups within this Residual Speech Retarded Group.

This is a particularly difficult exercise because, although this is a longitudinal study, there were long gaps when the children were not under scrutiny so that it can more accurately be described as a series of cross-sectional assessments. While one systematically gathers evidence at these cross-sectional assessments there are times during which unmonitored major changes may take place. In these circumstances assessment is tied to current available data and can only cautiously draw on retrospective data.

Method

Two major approaches have been used in the past to classify behaviour. First, there is the time-honoured but not necessarily scientifically validated clinical approach. Second, there is the multivariate approach pioneered in relation to child psychiatric disorders by Hewitt and Jenkins (1944) and subsequently extensively used (Kolvin *et al.*, 1973a; Garside *et al.*, 1975).

Clinical approach to classification

Here the clinician carefully sifts the data associated with the child's early life experiences, social background features, other biological phenomena and natural history and then comes to a clinical decision about identifiable subdivisions. He can then in a particular series ascertain if the features of the subgroups that he has identified statistically hang together by means of simple quantitative or qualitative comparisons.

The central question is whether speech retarded children are a homogeneous group. First, we had isolated the pathological deviant group comprising children whose functioning was so abnormal that it had to be analysed separately. Even this group is not internally homogeneous from the clinical point of view (see previous chapter). This leaves the Residual Speech Retarded Group which we consider has many characteristics in common with the developmental speech disorder syndrome as described by Ingram, provided we ignore his stipulation that the children have to be of 'average or above average intelligence' and must come from normal home backgrounds. We further consider that this group may comprise a number of clinical subgroups such as: a subgroup with general milestone delay (i.e. delay in speech

and walking) and a subgroup with specific milestone delay (i.e. delay in speech alone).

At this stage we had no way of ascertaining whether these two subgroups were mutually exclusive or overlapping, and whether there were features which were characteristic of these subgroups. If the latter were the case, it might well be that we could identify a number of relatively discrete syndromes. There is no ideal way of solving the problem which presented at this stage. The solution which we devised was two-fold. First, to identify the children falling into the two subgroups described above and then to find out the extent of the differences between the subgroups themselves and between each subgroup and the remaining group of children.

Factor analytical approach

After allocation of children to one of these two subgroups, discriminant function analysis was undertaken in an attempt to pinpoint the features which discriminate the subgroups from each other. A further statistical solution consists of analysis of selected features in order to ascertain whether statistically determined factors can be identified which are clinically meaningful. The most common statistical technique for such purposes is factor analysis which clusters features rather than people, and for theoretical reasons we have preferred to use the method of principal component analysis.

In the following sections, after the preliminary correlation analysis, we have recoded all variables so that a high score always indicated a positive value in the sense of good social and family functioning or achievements on psychological or other tests. For the sake of simplicity we have presented only selections of the multivariate analysis data, in table or graph form.

Ingram, one of the leading authorities on the subject of classification of speech and language disorders in childhood, hoped that such classification would eventually be primarily based on linguistic and phonetic criteria (Ingram 1972). Until this could be achieved he considered it practical (and expedient) to base his classification on the disordered speech function and associated clinical findings. We doubt if what is in essence a unifactorial classification (i.e. based on linguistic and phonetic criteria alone), without consideration of associated clinical phenomena, would have sufficient compass to do justice to Ingram's secondary speech disorders category. Nor would such a typology have adequate aetiological, or possibly even therapeutic, utility. In brief, whatever the linguistic and phonetic basis of a typology, it undoubtedly

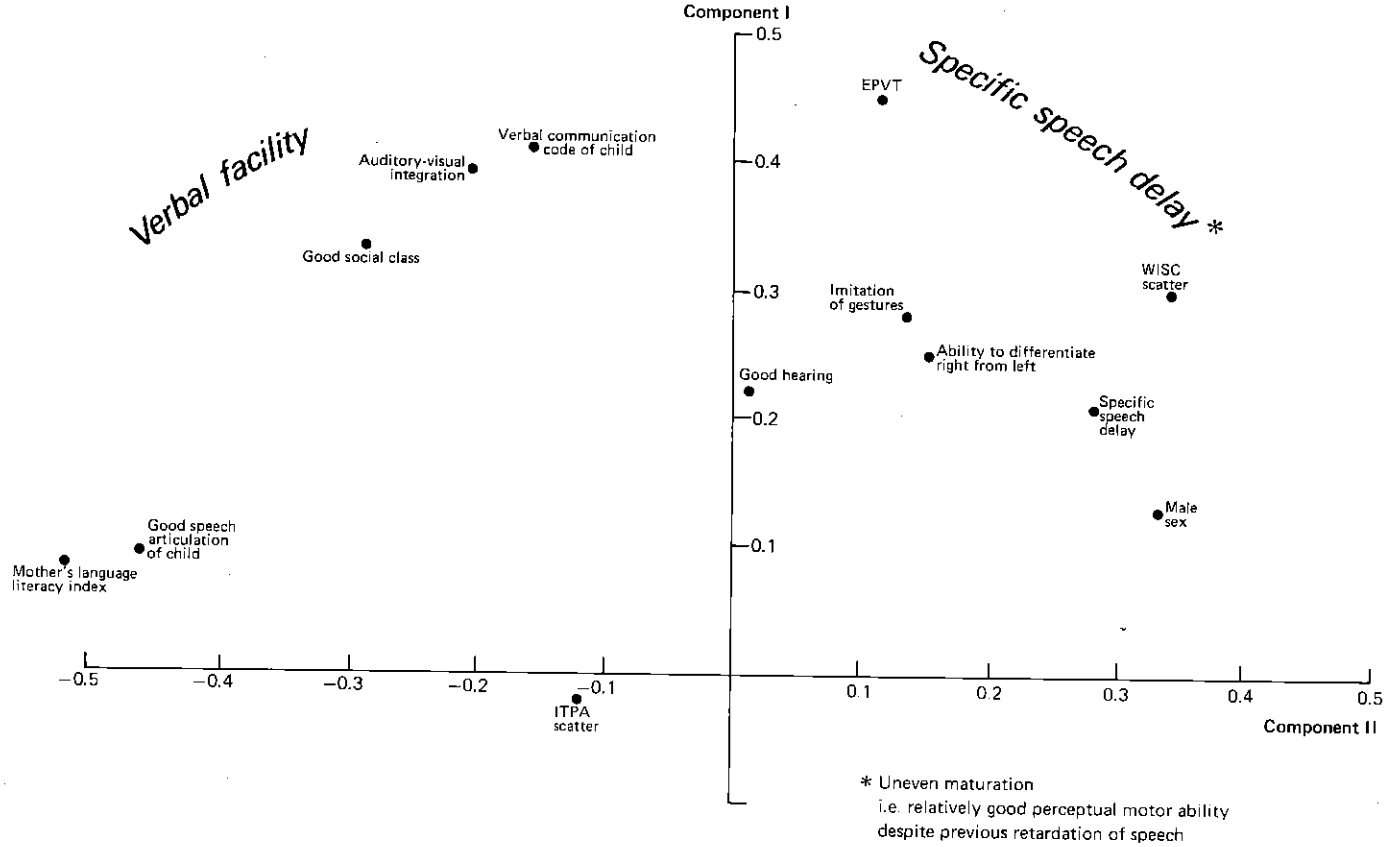

Fig. 1 First principal component analysis (Residual Speech Retarded Group)

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In the multivariate analyses we adopted a multiple stage strategy. The first stage consisted of utilizing the 11 key measures delineated below. To these we added social class and sex to make up 13 variables in all. The variables can be arbitrarily grouped as follows:

(a) *Social factors*
1 Social class
2 Language literacy index of mother as rated by social interviewer

(b) *Physical cum developmental factors*
3 Sex
4 Right–left differentiation difficulties as rated by psychologist
5 Hearing impairment as rated audiologically
6 Milestone delay (ranging from specific speech to general delay)

(c) *Cognitive cum language factors*
7 English Picture Vocabulary Test (EPVT)
8 Usage of communication code by the child (cf. Bernstein, 1962)
9 Test of Ability to Imitate Gestures (Berges and Lezine, 1965)
10 Ratings of frequency of immature errors of articulation
11 WISC scatter score (as defined on p. 157)
12 ITPA scatter score
13 Audiovisual integration (Birch and Belmont, 1964; Kahn and Birch, 1968)

Principal component analyses

First principal component analysis—Residual Speech Retarded Group only (Table 16, Appendix 1, and Fig. 1)

This included only those 71 cases in the Residual Speech Retarded Group that had full data on every one of the 13 variables. As we had a relatively small sample we decided to concentrate on the first two components only.

The first component is a general one of social factors and cognitive achievements and takes up 21% of the variance. The second component is bipolar and takes up 13% of the variance; we have interpreted it as a pole of verbal facility and social influences versus a pole of uneven maturation (i.e. specific speech delay). The former is represented by the mother's language, the child's communication code, good speech and articulation and parental social class; and the latter represented by a specific delay of speech (as opposed to general delay of milestones), ability to differentiate between right and left side of the body, to imitate

Fig. 1 First principal component analysis (Residual Speech Retarded Group) despite previous retardation of speech

gestures, a high WISC scatter score and, finally, sex of child (boys). In other words, this pole is represented by relatively good motor perceptual abilities but poor verbal abilities. All these features could be considered to be a cluster representative of uneven maturation which has been described as occurring in greater or lesser degrees in groups of children clinically diagnosed as dysphasic.

Second principal component analysis—Residual Speech Retarded Group only (see Table 17, Appendix 1)

The second set of variables used for principal component analysis were 22 in number. These included a series of cognitive variables, social class, mother's language literacy index, a series of measures of social functioning, milestone delay, hearing, right–left differentiation abilities and good speech and articulation of the child. The first two components took up some 46% of the variance. As in the previous analysis, the first component is a general one with the high loadings occurring almost entirely on the cognitive variables. The second component is bipolar. At one pole are features representative of language literacy of mother, a number of measures of the child's syntax (e.g. sentence complexity) and verbal communication code and also social factors. At the other pole are a combination of measures of non-verbal abilities such as WISC performance IQ, visual concepts or visual perception, right–left differentiation ability, together with specific speech delay (Fig. 2).

Interim comment

In both principal component analyses, but especially in the first, where a lesser number of variables are used, the general factor represents positive environmental experience, early development and high achievements which all vary together. But we also have clear factorial evidence, on the second component, of a clustering of features representative of uneven maturation, i.e. specific speech delay. These are all meaningful findings and will be discussed in detail later.

Third principal component analysis—Residual Speech Retarded Group only

The next set of variables included the original 13 plus another 11 of behaviour as tested or perceived by teachers (Rutter), parents (behaviour and temperament) and the child (JEPI). The first component

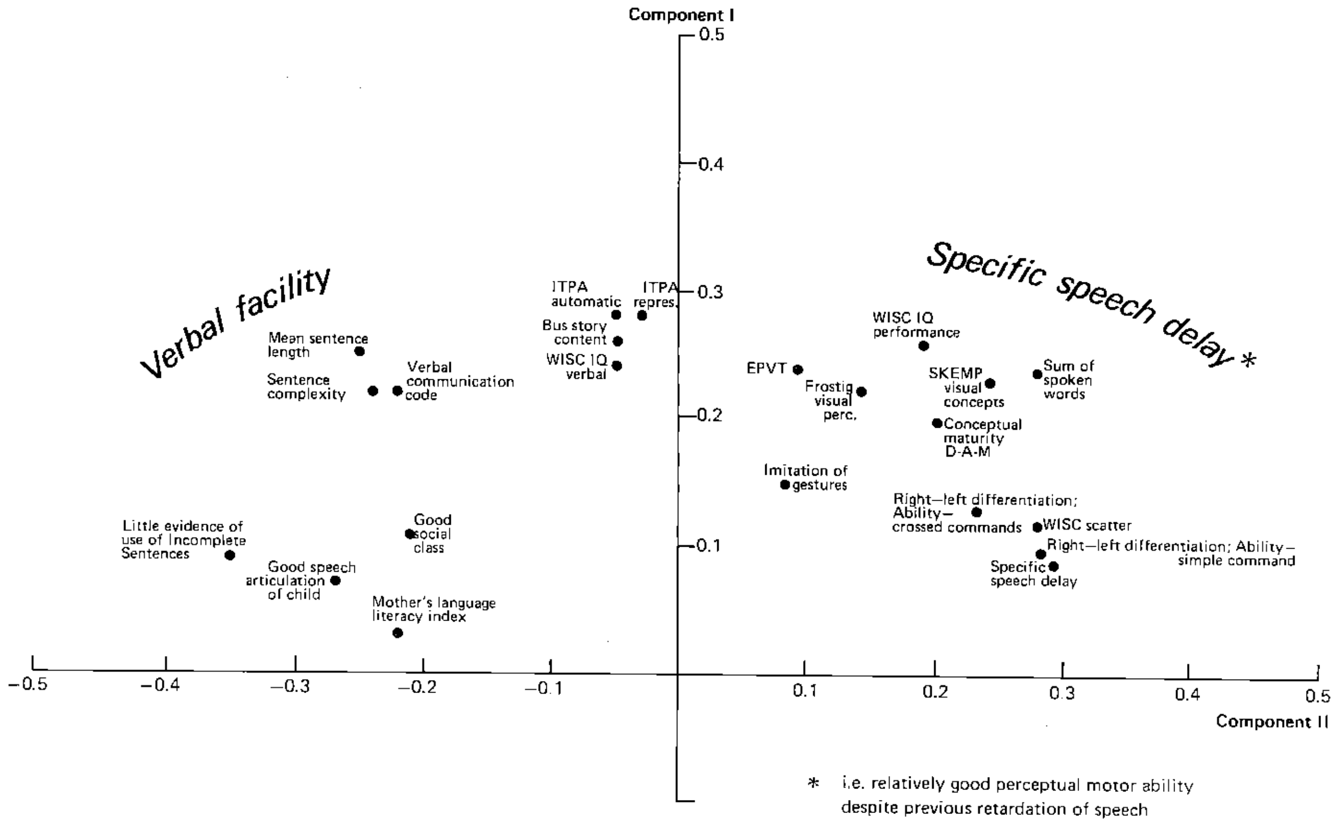

Fig. 2 Second principal component analysis

extracted was again a general one with the highest loadings on cognitive and behavioural variables taking up 16·3% of the variance. The second was bipolar taking up 11·3% of the variance. At one pole the highest loadings were of language and other cognitive and behavioural variables and at the other pole were features again representative of uneven maturation. As this analysis is similar to that for other components, we have not described it in detail or provided a table.

Final overall principal component analysis

From the previous principal component analyses we selected 33 variables for a final overall principal component analysis, combining cases falling into the Residual Speech Retarded Group and those falling into the control group. Only 158 cases in which there were complete data were included.

The first component was general, with the highest loadings on cognitive development of the child, middle loadings on family development variables and lowest on behavioural variables. The second component was bipolar and seems to contrast positive behavioural characteristics against a combination of cognitive positive social and family variables. A rotation of the axes indicates these two clusters of features more clearly. The most prominent features of the one cluster are lack of antisocial behaviour, lack of moodiness, normal activity and a tendency to regularity. The most prominent features of the second cluster are speech and language and absence of family history of developmental difficulties (see Fig. 3).

Pictorial presentation of factorial data

The clustering of features in a factor analysis can be depicted pictorially. Many clinicians find this more understandable than tables of factor loadings. In this section we provide comments on the graphs of the first and second components on the various principal components analyses described above.

Figure 1 (see first principal component analysis) The graph clearly demonstrates how features representative of specific speech delay and some non-verbal cognitive abilities cluster together, while those representative of parental and child language and social characteristics also cluster together.

Figure 2 (see second principal component analysis) The graph reveals two reasonably distinct clusters which are similar to the first.

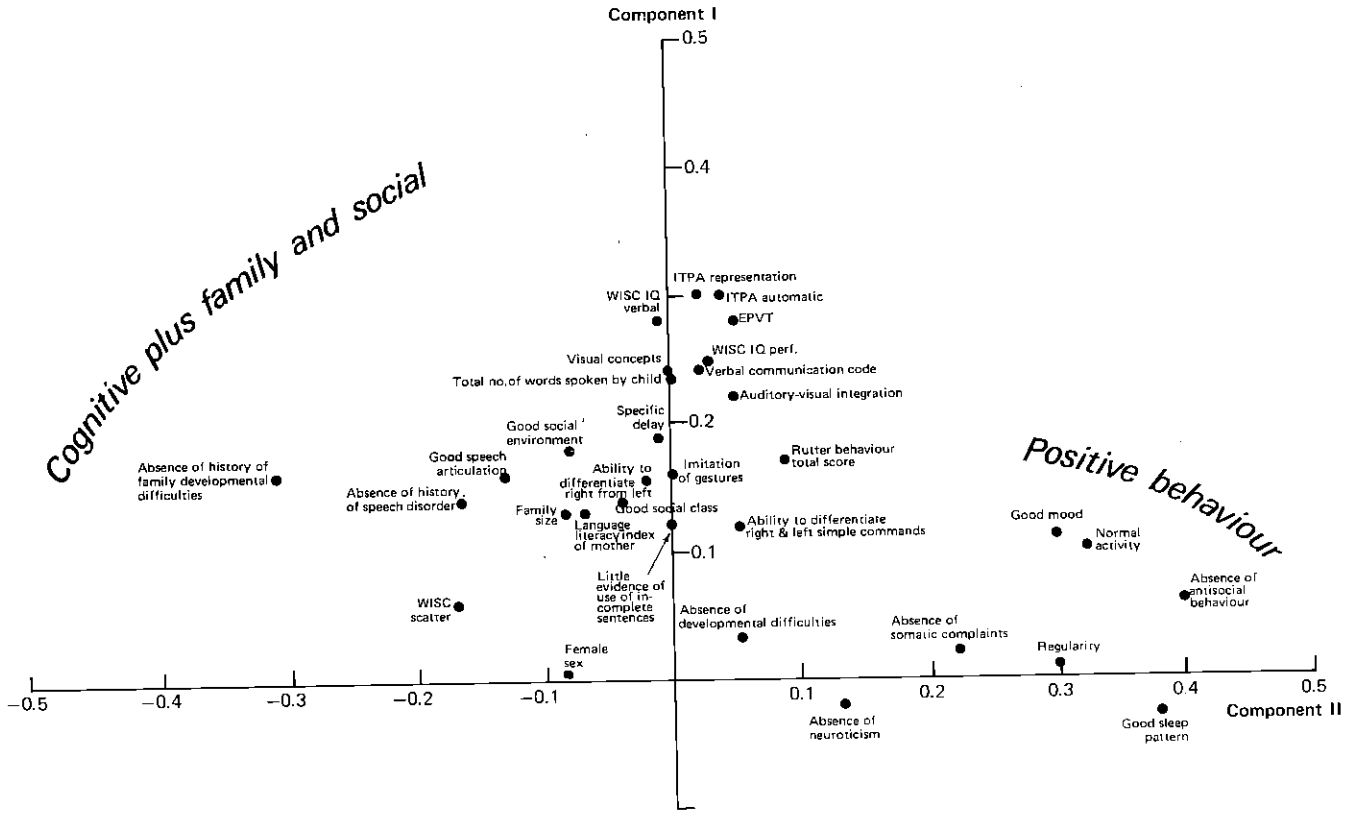

Fig. 3 Final overall principle component analysis, based on control and residual speech retarded cases

Figure 3 (see final overall principal component analysis) This graph shows how the picture becomes blurred when data from heterogeneous groups is used in a multivariate analysis. The most distinct cluster is that of behaviour. The cognitive plus social cluster is also relatively non-specific.

Discussion of findings

Those factorial findings based on the Residual Speech Retarded Group all indicate a contrast between, on the one hand, verbal ability of the child and the family and positive social influences and, on the other, uneven maturation indicated by relatively high non-verbal ability associated with specific speech delay.

Our findings provide factorial evidence of a meaningful cluster of features when analysing data from a group of children who previously had speech delay. Two of the analyses provide us with an understanding of some of the mechanisms involved in speech and language development. They lead to the suggestion that social and cultural factors are likely to be of importance in expanding verbal and communicative skills and verbal cognitive abilities, whereas satisfactory early physical development, even when accompanied by poor speech development is associated with relatively unimpaired practical abilities. Our final analysis contrasts behavioural and cognitive development.

Discriminant function analysis

Previously we have indicated that one way of classifying is to use a number of differentiating criteria in an attempt to define by dichotomization clinical subgroups within the Residual Speech Retarded Group. This is a very time-consuming and tedious exercise. Where the dependent (or predicted) variables can be sensibly or meaningfully dichotomized, so as to separate the cases into two distinct subgroups, the classical technique of discriminant function analysis has been used to ascertain which features have the greatest discriminant power. This has been used in relation to the two groups according to whether the speech delay is specific or not.

We used two sets of independent (or predictor) variables.

Set I comprised:

Behaviour—seven variables.

Cognition—WISC verbal, performance; Purdue; Frostig; EPVT; auditory visual integration; ITPA representational; ITPA Automatic; Skemp's visual concepts.
Communication—communication code; good articulation and speech of child.
Right–left differentiation difficulties—two measures.
Biological—sex.

Set II comprised:

Seven socio-familial factors and historical evidence of developmental delays in the family.

Findings (in relation to data Sets I and II above)

Specific versus general delay. The analyses indicate that the two groups can be differentiated one from the other. However, the only significant discriminant in Set I was the visual concept score (Skemp) and in Set II family history of developmental difficulties.

A note on the ability to discriminate between the right and left side of the body

It is interesting to note that the ability to discriminate between the right and left side of the body clusters with the advanced end (specific speech delay pole) of a milestone spectrum which ranges from delay of speech to delay of both speech and walking. Previously we have demonstrated that the categorization of the Residual Speech Retarded Group into specific speech delayed, intermediate delayed and general delayed groups subdivides them as well by ability on performance IQ. The question, therefore, is whether the ability to discriminate the right and left side of the body simply reflects intelligence. We explored this issue by comparing the ability (in terms of percentages) of the children in the various groups to cope first with a simple task of differentiating between the left and right side of the body (e.g. show me your right hand) and, second, a more demanding task involving crossed commands (e.g. show me your right ear with your left hand).

Our findings are of considerable interest (see Table I). In the simple task there is a steep upward gradient as one moves from the general delayed to the intermediate to the specific speech delayed group (see Table I). On simple commands the specific speech delayed group do even slightly better than the controls. These findings support the notion

Table I *Percent of children capable of distinguishing between right and left sides of their body*

Groups of children	Simple commands	Crossed commands
	%	%
Controls	81	80
Specific speech delayed	87·5	66
Intermediate delayed	67·7	67
General delayed	45	36

that the test of right/left differences involving simple commands, in part, at least, reflects IQ. This conclusion is reminiscent of Benton's (1968) views regarding right/left discrimination and reading disability. 'When care is taken to control the variable of intelligence level, systematic study shows no important relationship between right/left discrimination and reading ability.'

However, when we come to the more demanding task of crossed commands there is a notable deterioration of performance of the specific speech delayed group. If our specific speech delayed group had previously suffered from a developmental dysphasic disorder these findings are according to expectation. It is entirely reasonable to expect some residual difficulties of comprehension which would be reflected in poorer execution of more complicated commands because the more symbolic nature of these tasks would be more difficult to comprehend. This theory would be strengthened if the pattern of deterioration held when controlling for intelligence. Without going into details we in fact controlled for performance IQ and confirmed that the deterioration is almost entirely independent of intelligence.

Conclusion

From cluster, correlational (see previous chapter), factorial and discriminant function analyses, we have evidence of the importance of language factors linking with social development, and of uneven maturation, as reflected by specific speech delay, linking with non-verbal cognitive development. Two of the major groups identified are those with general and specific speech delay. The multivariate analyses, therefore, confirm the heterogeneity even of the group of children that remains after excluding those who suffer from evident pathological disorders. Finally, our data support the notion that the group of children who previously had specific speech delay subsequently have evident language and verbal comprehension difficulties.