CHAPTER 4: RESULTS AND DISCUSSION OF THE RESULTS

4.1 INTRODUCTION

In order to determine the nature of the relationship between central auditory processing disorders, learning disabilities, language disorders and sensory integration dysfunction (list of references in Appendix A), it was decided to use phylogenetic analysis in addition to conventional statistical methods to determine the correlation. Conventional frequency incidence correlation statistics display the incidence of the problem areas, but do not display trends in the grouping of problem areas found in children with developmental learning disorders which are of a diverse nature as is typical of a syndrome condition.

The assessment data (refer to Chapter 3) was analysed by using frequency incidence correlation statistics and phylogenetic analysis to determine correlation patterns or groups of problems. Two sets of data exist, namely the results of the assessment done before admission to the school and the results of the most recent evaluation done to determine progress in the school programme. The results of the study are presented according to the sub-aims, namely:

- the use of conventional frequency incidence factor analysis to determine the correlation and patterns existing in evaluation results obtained from the school files,
- determine symptom sub-groups existing in the problem areas under investigation by means of phylogenetic analyses,
- relate the resulting symptom patterns grounded on the theoretical neuro-physiologic and developmental patterns to develop a model of evaluation and intervention for children with a developmental learning disorder.

4.2 FREQUENCY INCIDENCE CORRELATION STATISTICS

The first sub-aim was to determine the incidence and correlation of the data by means of conventional statistics. The conventional statistics obtained to determine the nature of the data are displayed in tables and figures in this section to explain frequency incidence and correlation between the existing problems. Important aspects are the analysis of the result of the data of the admission evaluation to obtain a baseline of the nature and incidence of the problem areas before intensive intervention and analysis of the results of the most recent evaluation prior to the study to obtain information on the progress of the subjects in the school programme. To compare and analyse these two sets of results can also give information concerning the nature of the progress in the different problem areas.

Table 4.1 shows the detail of the different variables as measured for each member of the group (n=19 as discussed in section 3.4). In *Table 4.1*, the colours in the problem areas indicate the different aspects under investigation obtained from different professional fields, namely, the field of the communication pathologist (yellow) and the occupational therapist (turquoise) and also the supra-modal problem areas (white). Difficulties in problem areas are indicated by "1" and no difficulties present in problem areas are indicated by "0". Two main groups of information are presented in *Table 4.1*, namely, those of the admission evaluation results and those of the most recent evaluation results. The problem areas are displayed in descending order of frequency of occurrence under the row entitled "total" as determined during the admission evaluation. The information obtained in this table was used to compile *Figure 4.1a* and *Figure 4.1b*. *Table 4.1* and *Figure 4.1a* and *Figure 4.1b* display the nature and distribution of the problem areas under investigation and should be read together.

Table 4.1: Problem areas presented in the order of frequency of occurrence

	Subject	Age at evaluation date	Period between admission and most recent evaluation	I Q	Non-English mother tongue	Medical history	Language reception	Auditory closure	Verbal expression	Auditory analysis	Fine motor	Auditory memory	Eye-hand co-ordination	Concentration	Visual motor integration	Figure-ground perception	Visual closure	Body awareness	Form constancy	Visual analysis and synthesis	Auditory discrimination	Auditory sequencing	Spatial perception	Auditory blending	Emotion	Motor planning	Balance	Bilateral integration	Eye movement	Tactile defensive	Total
							Problem areas																							
Admission evaluation	A	4.4		102	0	1	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	21
	B	7.6		94	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	1	21
	C	6.3		105	1	0	1	0	0	1	1	1	0	1	1	1	1	1	1	0	1	1	1	0	0	0	1	0	1	1	16
	D	6.5		101	0	1	1	1	0	0	1	1	1	1	1	0	1	1	0	0	0	0	0	0	1	1	1	0	1	0	13
	E	6.6		95	0	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	20
	F	9.7		116	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	8
	G	5.1		87	0	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	21
	H	7.5		120	0	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	7
	I	5.6		94	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	22
	J	11		104	1	0	1	1	1	1	1	1	1	0	0	1	0	0	1	1	0	1	0	1	0	0	1	0	0	0	13
	K	7.2		114	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	0	0	0	0	17
	L	8.1		122	0	1	1	1	1	1	1	1	1	1	0	0	0	1	1	0	1	1	0	1	0	0	0	0	0	0	13
	M	9.1		101	0	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	0	1	1	0	0	18
	N	5.6		93	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	1	0	0	19
	O	6.5		117	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1	1	0	1	20
	P	5.2		106	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	23
	Q	5.2		103	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	1	0	1	20
	R	7.6		103	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	21
	S	6		95	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
	Total				5	16	18	18	17	17	17	16	16	15	15	15	14	14	14	14	13	13	13	13	12	12	12	11	9	9	337
Most recent evaluation	A	9.8	4.4				0	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	1	0	0	7
	B	12.6	5				0	1	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	5
	C	7.4	1.1				0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2
	D	7.2	0.9				1	0	0	0	1	1	1	1	1	0	1	1	0	0	0	0	0	0	1	1	1	0	1	0	12
	E	7.5	0.11				1	1	1	0	0	1	1	0	1	0	1	0	0	0	1	1	1	0	1	0	1	1	1	0	14
	F	10.2	0.7				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	G	6.7	1.6				1	1	1	0	0	0	1	0	1	1	1	1	1	1	0	0	1	0	1	1	1	1	0	0	15
	H	8.2	0.9				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	I	7.2	1.8				1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1	20
	J	12.5	1.5				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	K	8.5	1.3				1	0	1	0	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	8
	L	9.1	1				1	0	1	0	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	6
	M	9.9	0.8				0	1	1	0	1	0	1	0	1	0	0	0	0	1	0	1	1	0	1	0	1	1	0	0	11
	N	7.6	2				1	0	1	1	0	1	1	0	1	0	1	1	0	1	0	0	0	0	1	0	0	0	0	0	10
	O	7	0.7				1	0	1	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	1	0	1	8
	P	5.8	0.6				1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	0	20
	Q	5.8	0.6				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	1	0	1	20
	R	10.3	2.9				1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	6
	S	6.11	0.11				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	22
	Total						12	10	12	6	7	12	10	7	9	5	12	7	6	9	4	7	8	2	9	7	8	9	5	3	118

Figure 4.1a is a column graph, which displays the number of occurrences in percentages and presents the problem areas in descending order for the admission evaluation data. The inclusion of the results of the most recent evaluation data in this figure provides a visual presentation of the progress made in the particular problem area. The aspect of progress in the school programme is discussed in section 4.2.1.3. In *Figure 4.1b* (a radar graph) the same data from *Table 4.1* as in *Figure 4.1c* were used to display the percentage of problems identified in the evaluation of the subjects prior to admission to the school and the problems identified in the most recent evaluation of the subjects prior to the study. This provides a different visual view of the percentage of difficulties experienced by the subjects during the different evaluations.

Of importance in *Table 4.1*, *Figure 4.1a* and *Figure 4.1b* is, therefore, the number of subjects experiencing a problem in the different problem areas under investigation for the two evaluation situations. These results will be discussed by looking at the admission evaluation results, the most recent evaluation and the difference between the two results to determine progress in the school programme.

4.2.1 Admission evaluation data results

The results obtained by analysing the admission evaluation data will be discussed by means of the frequency of occurrence (*Table 4.1*, *Figure 4.1a* and *Figure 4.1b*) and by analysing the display of the dominant groups of problem areas obtained by manual manipulation of the data in *Table 4.1* to obtain these groups (*Table 4.2*). Both these methods of presentation provide information regarding the nature of the problem areas.

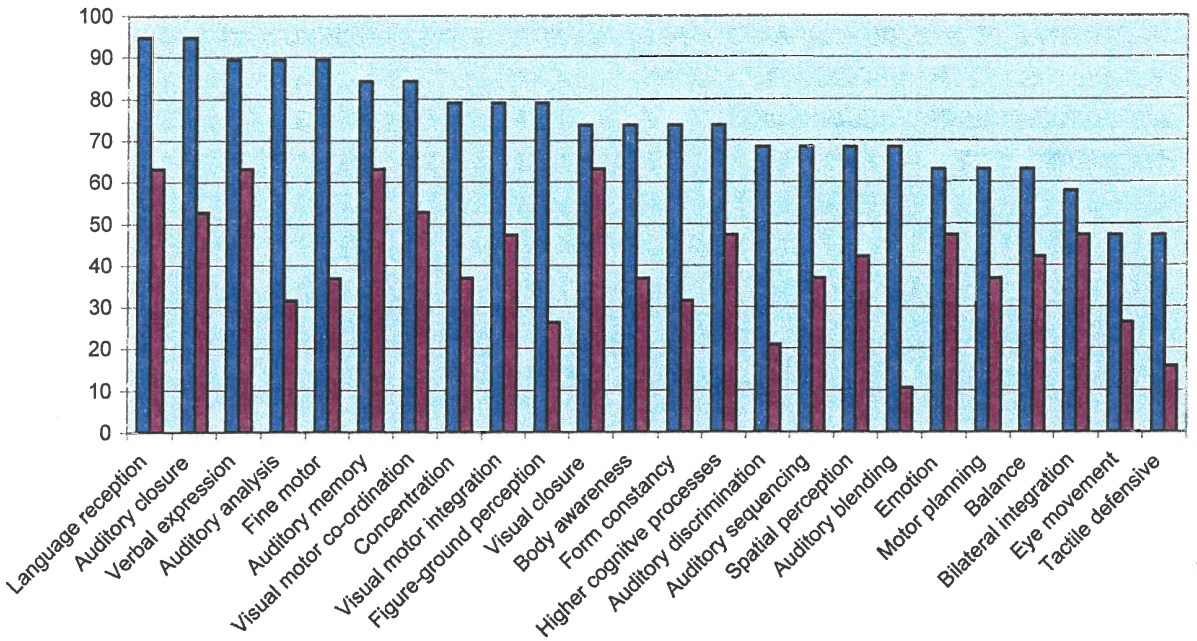


Figure 4.1a: Percentage problems identified during tests presented in descending order of frequency of occurrence

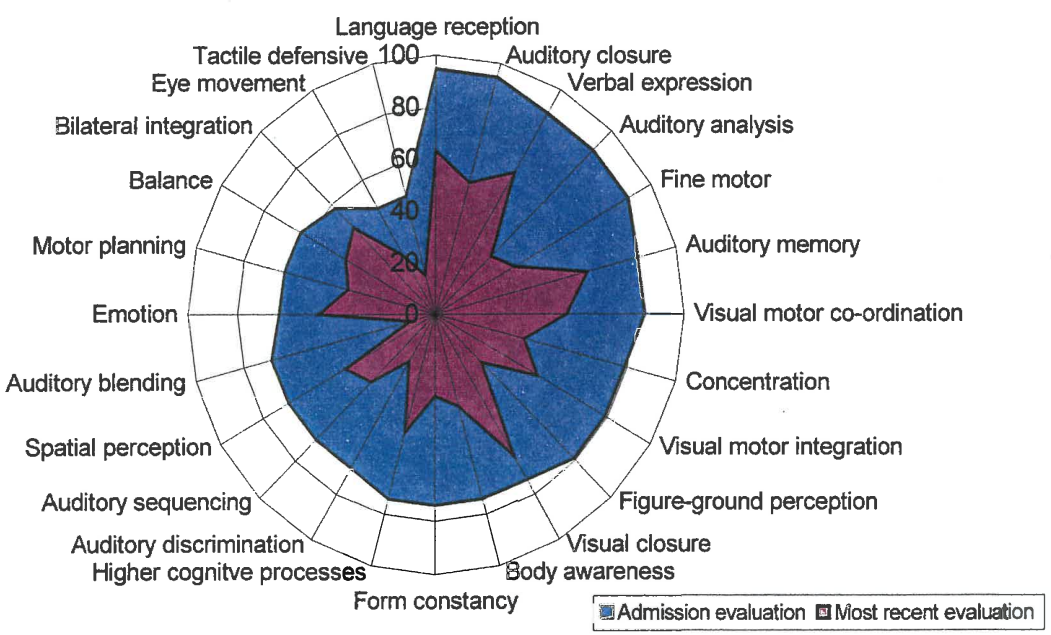


Figure 4.1b: Percentage problems identified during tests presented in descending order of frequency of occurrence

Table 4.2: Determination of maximum size groups, starting from left for the admission test results

Subjects	Language reception	Auditory closure	Verbal expression	Auditory analysis	Fine motor	Eye-hand co-ordination	Auditory memory	Concentration	Visual motor integration	Visual analysis and synthesis	Figure-ground perception	Visual closure	Body awareness	Form constancy	Spatial perception	Motor planning	Auditory discrimination	Bilateral integration	Auditory sequencing	Auditory blending	Balance	Emotion	Eye movement	Tactile defensive	Number of problems per subject
A	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	21
C	1	0	0	1	1	0	1	1	1	0	1	1	1	1	1	0	1	0	1	0	1	0	1	1	16
D	1	1	0	0	1	1	1	1	1	0	0	1	1	0	0	1	0	0	0	0	1	1	1	0	13
E	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	0	20
F	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	8
H	1	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	7
G	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	21
J	1	1	1	1	1	1	1	0	0	1	1	0	0	1	0	0	0	0	1	1	1	0	0	0	13
L	1	1	1	1	1	1	1	1	0	0	0	0	1	1	0	0	1	0	1	1	0	0	0	0	13
M	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	0	1	1	1	1	1	1	0	0	18
O	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	1	1	1	1	0	1	20
N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	0	1	1	0	19
I	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	22
K	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	17
P	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	23
Q	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	20
B	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	1	21
R	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	21
S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
Total	18	18	17	17	17	16	16	15	15	14	15	14	14	14	13	12	13	11	13	13	12	12	9	9	337
Percentage	95	95	89	89	89	84	84	79	79	74	79	74	74	74	68	63	68	58	68	68	63	63	47	47	

Group 1	1																								18
Group 2	1	1																							34
Group 3	1	1	1																						48
Group 4	1	1	1	1																					60
Group 5	1	1	1	1	1																				65
Group 6	1	1	1	1	1	1																			78
Group 7	1	1	1	1	1	1	1																		84
Group 8	1	1	1	1	1	1	1	1																	88
Group 9	1	1	1	1	1	1	1	1	1																90
Group 10	1	1	1	1	1	1	1	1	1	1															100
Group 11	1	1	1	1	1	1	1	1	1	1	1														99
Group 12	1	1	1	1	1	1	1	1	1	1	1	1													108
Group 13	1	1	1	1	1	1	1	1	1	1	1	1	1												117
Group 14	1	1	1	1	1	1	1	1	1	1	1	1	1	1											112
Group 15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1										120
Group 16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1									112
Group 17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1								102
Group 18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							90
Group 19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1						57
Group 20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1					40
Group 21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				42
Group 22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			22
Group 23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		23
Group 24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24

Total number of problems per group

Analysis of *Figure 4.1a* and *Figure 4.1b* shows that the most frequent problems occur in the field of the *communication pathologist*, namely language reception (ninety five percent), auditory closure (ninety five percent), verbal expression (eighty nine percent), and auditory analysis (eighty nine percent). Equal in frequency of occurrence with these problems are problems in fine motor abilities (eighty nine percent). Most of the subjects (more than eighty nine percent) experience difficulty in these problems areas.

The problem areas which have the highest incidence of occurrence in the field of the *occupational therapist* are abilities which require both visual and motor skills, namely fine motor abilities (eighty nine percent) and eye-hand co-ordination skills (eighty four percent). On the other hand the problems with a lower incidence, but still of significance for this study (between forty-seven and sixty-three percent) are problems involving motor planning, balance, bilateral integration, eye movement and tactile defensive reactions.

An important aspect in the field of the *psychologist* concerns the subjects that experience concentration problems. It is possible that some of these subjects may have an attention deficit disorder, because the inability to sustain attention is one of the most prominent features of children diagnosed with attention deficit disorder (Comings, 1990; Keller, 1992; Chermak, et al.,1999). These subjects also constitute a significant percentage (seventy nine percent) of number of occurrences. Subjects with emotional problems are also of significance for this study (sixty three percent).

The same colour code as in *Table 4.1* was used in *Table 4.2*, this is, the communication pathologist (yellow), the occupational therapist (turquoise) and the supra-modal problem

areas (white). Difficulties in problem areas were indicated by "1" and no difficulties present in problem areas were indicated by "0".

In *Table 4.2* the sequence of the problem areas and the subjects were rearranged, starting from the left to obtain the maximum size groups which were the largest groups of subjects with difficulties in the same problem areas. This sequence was used for the phylogenetic analysis (will be discussed in section 4.2.2). The size of the groups in *Table 4.2* was determined by multiplying the total number of subjects showing problems in the particular problem area by the total number of problem occurrences within that group.

Two groups can be highlighted in *Table 4.2* to explain how the groups were analysed. The first example (in *Table 4.2*) is the subjects who have in common problems in language reception, auditory closure, verbal expression and auditory analysis in common (group 4), this is problems involving only *language and central auditory processing disorders*. This group is similar to group C in the pilot study (section 3.6.1.3). The second example is the largest group of problem areas per subjects (group 15). The subjects in this group can be described as having supra-modal deficits (McFarland and Cacace, 1995) (language reception, auditory closure, verbal expression, auditory analysis, fine motor abilities, eye-hand co-ordination, auditory memory, concentration, visual motor integration, visual analysis and synthesis, figure-ground perception, visual closure, body awareness, form constancy and spatial perception problems) and are similar to group A as described in the pilot study (section 3.6.1.3). These subjects have problems in both the auditory and visual domains as well as involvement of motor skills and an attention deficit.

4.2.2 Most recent evaluation data results

Figure 4.2 displays the percentage of problems identified with the most recent assessments done on the subjects. The importance of these results is that they indicate the progress of the subjects in the school programme.

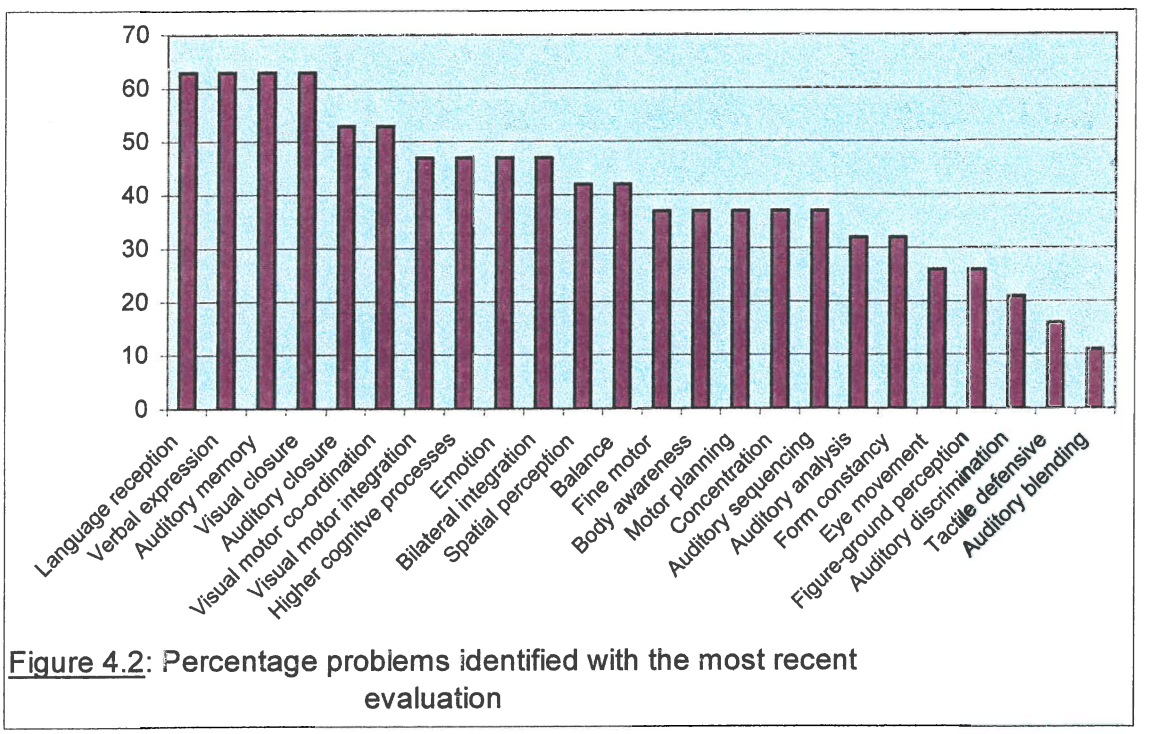


Figure 4.2: Percentage problems identified with the most recent evaluation

The sequence of occurrence from highest to lowest percentage has changed in comparison with the results of the first evaluation. The highest incidence of problems is still in the field of the *communication pathologist*. Language reception, verbal expression and auditory memory problems are present in sixty-three percent of the subjects. The problem which occurs most frequently in the field of the *occupational therapist* is the visual closure problem (sixty-three percent). Also of significance is the high occurrence of auditory closure and visual motor co-ordination problems. On the right hand side of *Figure 4.2* it can be seen that the lowest incidence and now no longer of significance for

this study, are problems in auditory discrimination, tactile defensive and auditory blending (less than twenty-six percent).

The data was then manually manipulated, using the same heuristic technique as was used with the admission assessment results (Section 4.2.1.1), by rearranging the sequence of subjects to determine the maximum size of groups to indicate patterns of problems occurring in the same subjects. In *Table 4.3* the sequence of *Table 4.2* (Section 4.2.1.1) used for the most recent assessment result, shows that the group with supra-modal deficit is still similar to group A (described in Section 3.6.1.3). It is interesting that the problems remaining with the group of subjects which are almost rehabilitated are problems in the field of the occupational therapist, with the exception of auditory memory and auditory sequencing problems.

Table 4.3: Obtaining of maximum groups, starting from the left for the most recent test results

Subject	Language reception	Auditory closure	Verbal expression	Auditory analysis	Fine motor co-ordination	Eye-hand co-ordination	Auditory memory	Concentration	Visual motor integration	Visual analysis and synthesis	Figure-ground perception	Visual closure	Body awareness	Form constancy	Spatial perception	Motor planning	Auditory discrimination	Bilateral integration	Auditory sequencing	Auditory blending	Balance	Emotion	Eye movement	Tactile defensive	Number of problems
A	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	7
B	0	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5
C	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2
J	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M	0	1	1	0	1	1	0	0	1	1	0	0	0	0	1	0	0	1	1	0	1	1	0	0	11
D	1	0	0	0	1	1	1	1	1	0	0	1	1	0	0	1	0	0	0	0	1	1	1	0	12
K	1	0	1	0	1	1	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	8
L	1	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	6
N	1	0	1	1	0	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	10
O	1	0	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	8
E	1	1	1	0	0	1	1	0	1	0	0	1	0	0	1	0	1	1	1	0	1	1	1	0	14
G	1	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	0	1	0	0	1	1	0	0	15
R	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	6
I	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	0	0	1	1	1	1	20
P	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	0	20
Q	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	20
S	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	22
Total	12	10	12	6	7	10	12	7	9	9	5	12	7	6	8	7	4	9	7	2	8	9	5	3	
Percentage	63	53	63	32	37	53	63	37	47	47	26	63	37	32	42	37	21	47	37	11	42	47	26	16	

4.2.3 Progress in the school programme

The aim of the study is also to determine the nature of developmental patterns and their influence on the development of problem area patterns. The difference between the results of the first and of the last assessments indicates the rate of improvement that occurred for the individual problem areas, this is the progress of the subjects in the school programme and the nature of the development of skills. The time lapse between the admission evaluation results and the most recent evaluation results were different for individual subjects and varied between five years four months and five months of intervention (information in *Table 4.1*). *Figure 4.3* provides a visual representation of the difference between the admission and the most recent evaluation results and can thus be described as the percentage of capabilities gained in a particular skill.

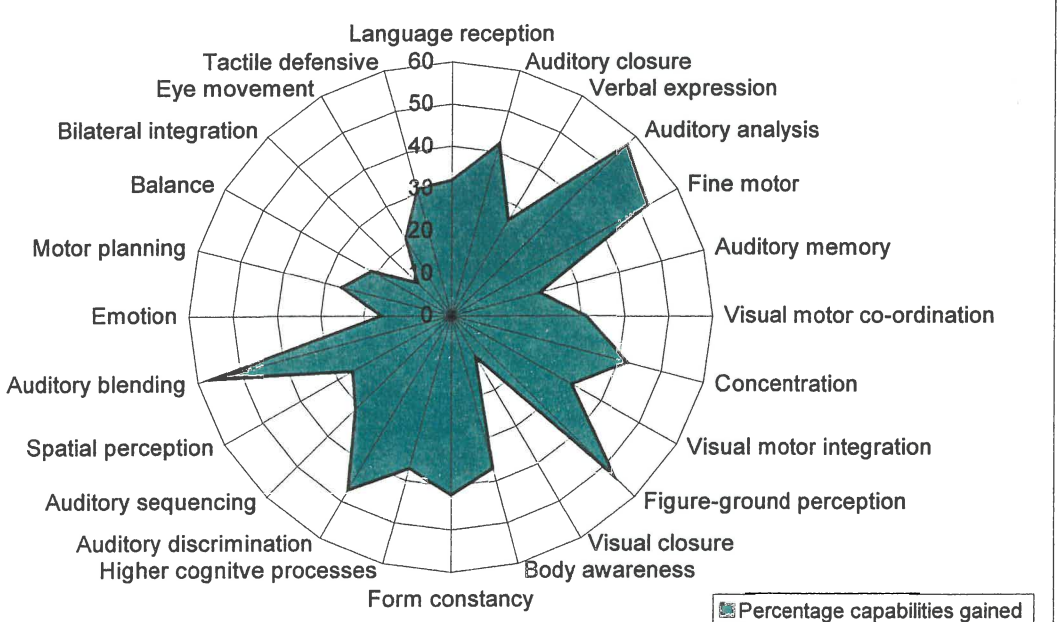


Figure 4.3: Difference between the admission and most recent evaluation

From *Figure 4.3*, it is clear that the different problem areas improved at different rates (percentage capabilities gained). The biggest improvement in skills (fifty-seven percent) can be seen in auditory blending and auditory analysis, both central auditory processing skills. Visual figure-ground and fine motor abilities improved as well, by fifty-three percent and fifty-two percent respectively. Both these skills are in the domain of the occupational therapist. The more than fifty percent improvement in these skills may be regarded as significant for this study.

Slow progress (eleven percent) can be seen in bilateral integration and visual closure. Both these problems are treated by the occupational therapist. Furthermore, emotional aspects did not show much improvement (sixteen percent). This is, however, not an aspect which received therapy routinely in the set-up of the school. Other skills showing slow progress (twenty-one percent) are balance, eye movements and auditory memory.

Analysis of the individual subject's progress as outlined in *Table 4.1*, which displays the different variables in each subject, and consideration of the information obtained from the school files reveal the following:

- subjects who showed slow progress were the subjects with problems involving the somato-sensory system. Subjects D and S, with a known pathology involving the central nervous system (Williams' syndrome, and haemolytic streptococcal septicaemia), also fall into this group,
- good progress is shown by subjects with only language and central auditory processing disorders. Subjects with a mother tongue other than English also fall into this group (subjects C, J, K, N and O),
- patterns of problems that can be related to concentration problems are also quickly resolved,

- the time span, obtained by the difference between the dates of the admission evaluation and the dates of the most recent evaluation done prior to the study in *Table 4.1* provides information regarding the progress of individual subjects. Taking into account the different amounts of intervention that each individual subject received, it becomes evident that a number of subjects improved markedly in a short time-span. These are subjects with an underlying problem other than a sensory processing problem affecting their performance, for example, attention deficit disorder and English second language. For example subject C, with Afrikaans as mother tongue, received intervention for only thirteen months and improved from having problems in sixteen problem areas, to having problems in two problem areas, both related to visual skills.

From the results of the previous three sections, it becomes clear that additional groups of problems showing correlation between the different problems can be extracted from the existing data in order to determine larger and more significant groups than those noticed in *Table 4.2.* This observation indicates that more formal grouping techniques than the subjective grouping method used in the pilot study (Section 3.6.1.3) and *Table 4.2* should be implemented. Phylogenetic analysis should be employed to identify these groups.

4.3 PHYLOGENETIC RELATIONSHIPS

The phylogenetic relationship analysis (as discussed in section 3.6.3.2) applied to the results obtained in the assessment of the subjects provides a different perspective to determine patterns of relationships. This method can be approached using two algorithms to provide single inheritance trees and multiple inheritance trees. The

resulting class hierarchy provides an additional view of how these data relate to each other.

4.3.1 Single inheritance trees

Different existing algorithms for extracting inheritance trees (Section 3.6.3.2) can be used. The Dollop computer algorithm (Felsenstein, 1993) was chosen because it is not time consuming and provides a repeatable method. The results of the phylogenetic analysis done by using the Dollop algorithm computer program found forty-eight trees. The Consense algorithm analysis computer program (Felsenstein, 1993) was then applied to these trees, which revealed the consensus inheritance tree as outlined in *Figure 4.4*. Interpretation of *Figure 4.4* is as follows: this consensus tree is an unrooted tree and "grows" from left to right. These analyses provide the basic groupings used in the further analysis of the data.

In *Table 4.4,* the groups that emerged from the consensus inheritance tree are outlined (groups A, B, C, D, etc.). This is a presentation of the groupings found in the consensus inheritance tree using the same sequence of the problem areas as in *Table 4.2*.

In *Table 4.4*, the bold lines indicate the groupings as found by the Consense program on the Dollop analysis as in *Figure 4.4*. The colours in the problem areas indicate the field of the communication pathologist (yellow), the occupational therapist (turquoise) and the supra-modal problem areas (white). Difficulties in problem areas are indicated by "1" and no difficulties present in problem areas are indicated by "0". The other colours are

used to highlight and provide visual aids to distinguish different aspects of importance to the study. From this analysis a number of groups emerged as is evident from *Figure 4.5*.

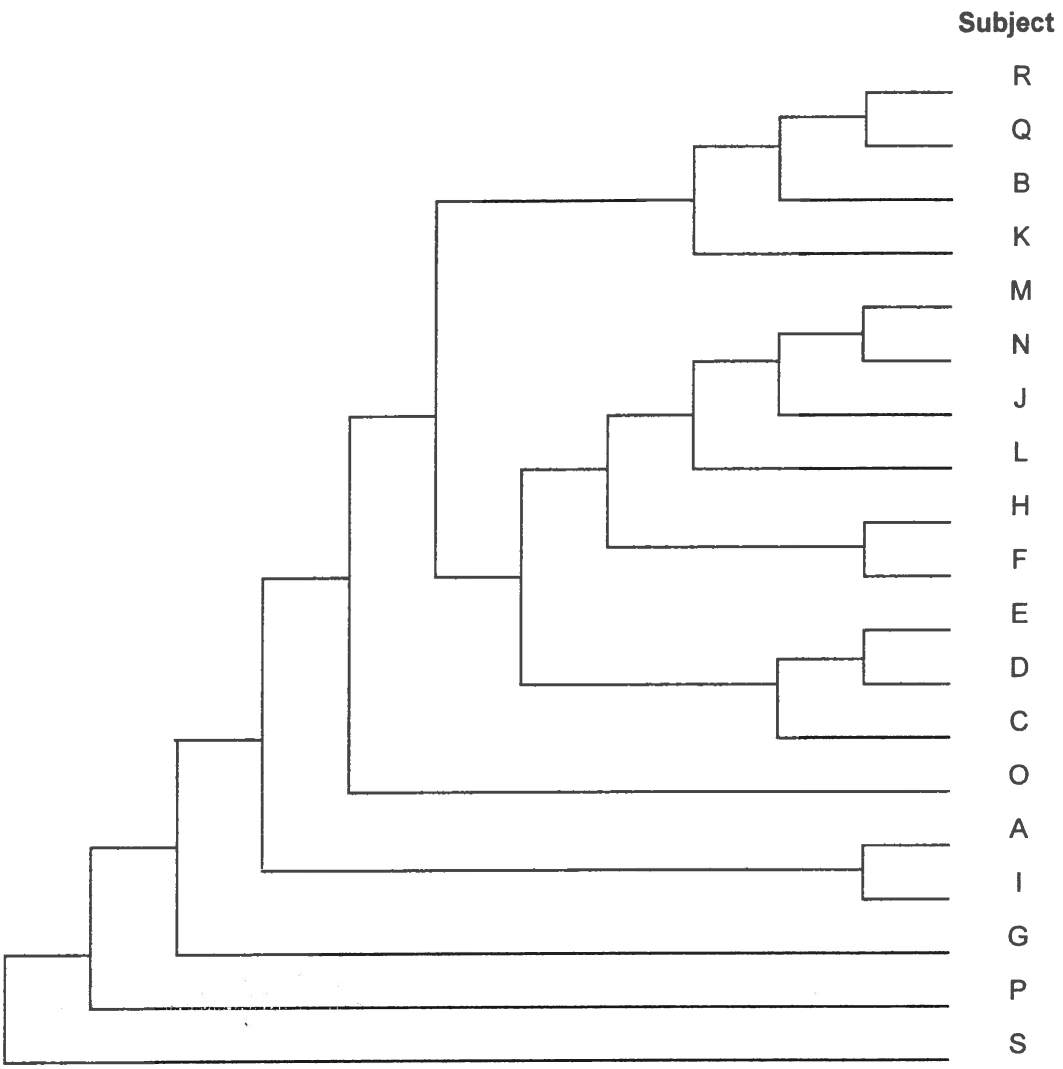
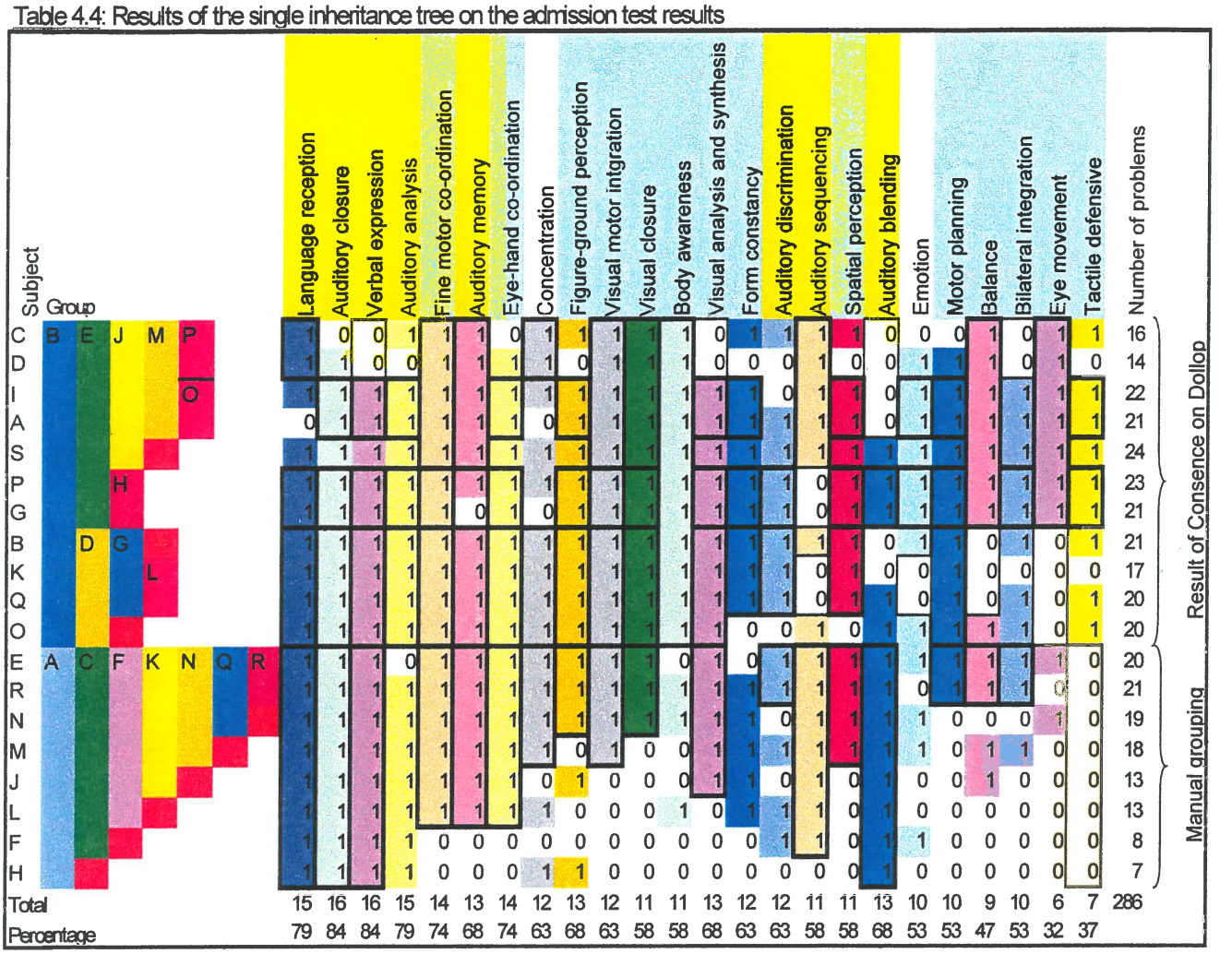


Figure 4.4: The single inheritance tree as found by the Consense analysis

Table 4.4: Results of the single inheritance tree on the admission test results



Referring to the tree in *Figure 4.5,* the small block on the bottom right hand side of each larger block contains the number of subjects in that group. For example, group *B* consists of eleven subjects which have a problem with body awareness. Group *E* consists of seven subjects which have a problem with body awareness, balance and eye movement.

The Dollop analysis, however, developed a single inheritance tree (discussed in Section 3.6.3.2) for only eleven subjects (*Table 4.4*). Referring to *Table 4.4* it is evident that it is

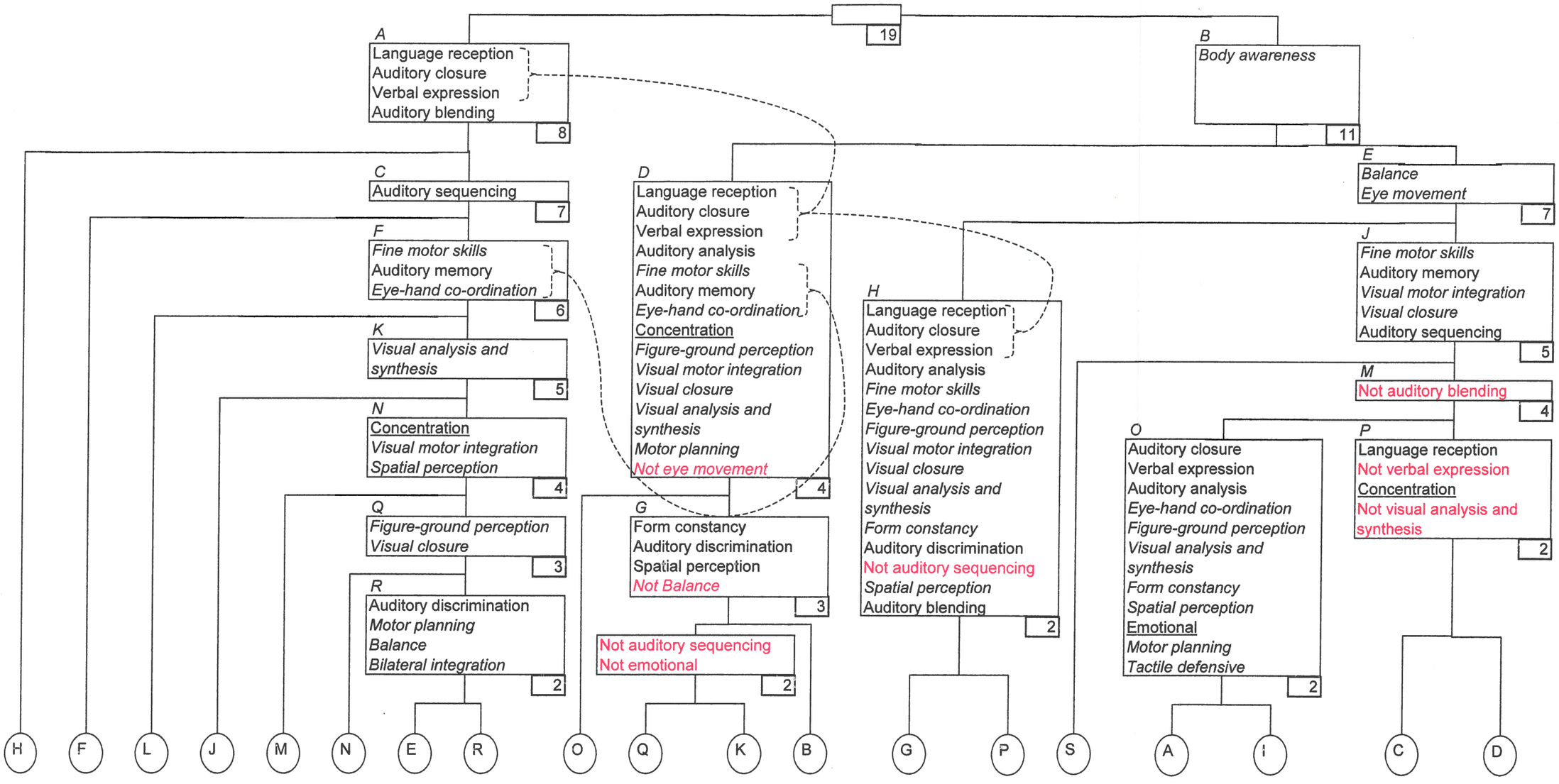


Figure 4.5: Single inheritance tree based on the results of the Consense tree obtained from the Doliop phylogenetic analysis

Key: Normal print are problems in the domain of the communication pathologist

Italics are problems in the domain of the occupational therapist

Normal, underlined text are problems in the domain of the psychologist

possible to identify a further tree with the remaining eight subjects. This manually derived tree (algorithm explained in Appendix D) is shown as group *A* in *Figure 4.5*.

Analysis of these groupings of *Figure 4.5* shows that the majority of subjects have problems in all the modalities under investigation, as shown in the single inheritance tree of *Figure 4.5,* and can be classified as belonging to the group of children with supra-modal deficiencies (Section 3.6.1.3). Only two subjects are grouped together in a group of children with only language and central auditory processing disorders.

From this analysis, it is clear that these groups are not the only groups that can be identified. Further sub-groupings may be made, for example, a new group with fourteen members with language reception auditory closure and verbal expression problems forms part of group *A, D,* and *H* (*Figure 4.5*). These examples are shown as the dotted lines connecting possible additional groups in *Figure 4.5.* This fact led to the decision to establish multiple inheritance hierarchies.

4.3.2 Multiple inheritance trees

Multiple inheritance can thus provide additional information regarding groups of problem areas which may occur together. This can aid in the analysis of the data to clarify the nature of relationships which occur. The multiple inheritance trees were derived according to the algorithm outlined in Appendix D. The analysis to determine the multiple inheritance class structure was done on the data from both the admission evaluation results and the most recent evaluation results.

The multiple inheritance hierarchy for the results of both the admission evaluation and the most recent evaluation is outlined in *Figure 4.6,* and shows the classes resulting from the analysis.

In *Figure 4.6*, the number of subjects belonging to a particular group for the admission assessments is indicated in the small block at the bottom right hand side of the group block. This representation also indicates the progress of the subjects in the different groups. This is the difference between the number of subjects in groups obtained from the admission assessment results and the most recent assessment results (as indicated in the block at the bottom left side of the group block). The charts in *Figure 4.6* graphically show the number of problems per group for each group and the number of subjects per problem group. Only groups with an occurrence of more than twenty-six percent of subjects were taken into account in the outline of the multiple inheritance tree (*Figure 4.6*).

For the purpose of this study good progress was considered to be more than seventy-five percent improvement, moderate progress more than forty-five percent improvement and slow progress less than forty-five percent improvement. The groups in *Figure 4.6* are as follows:

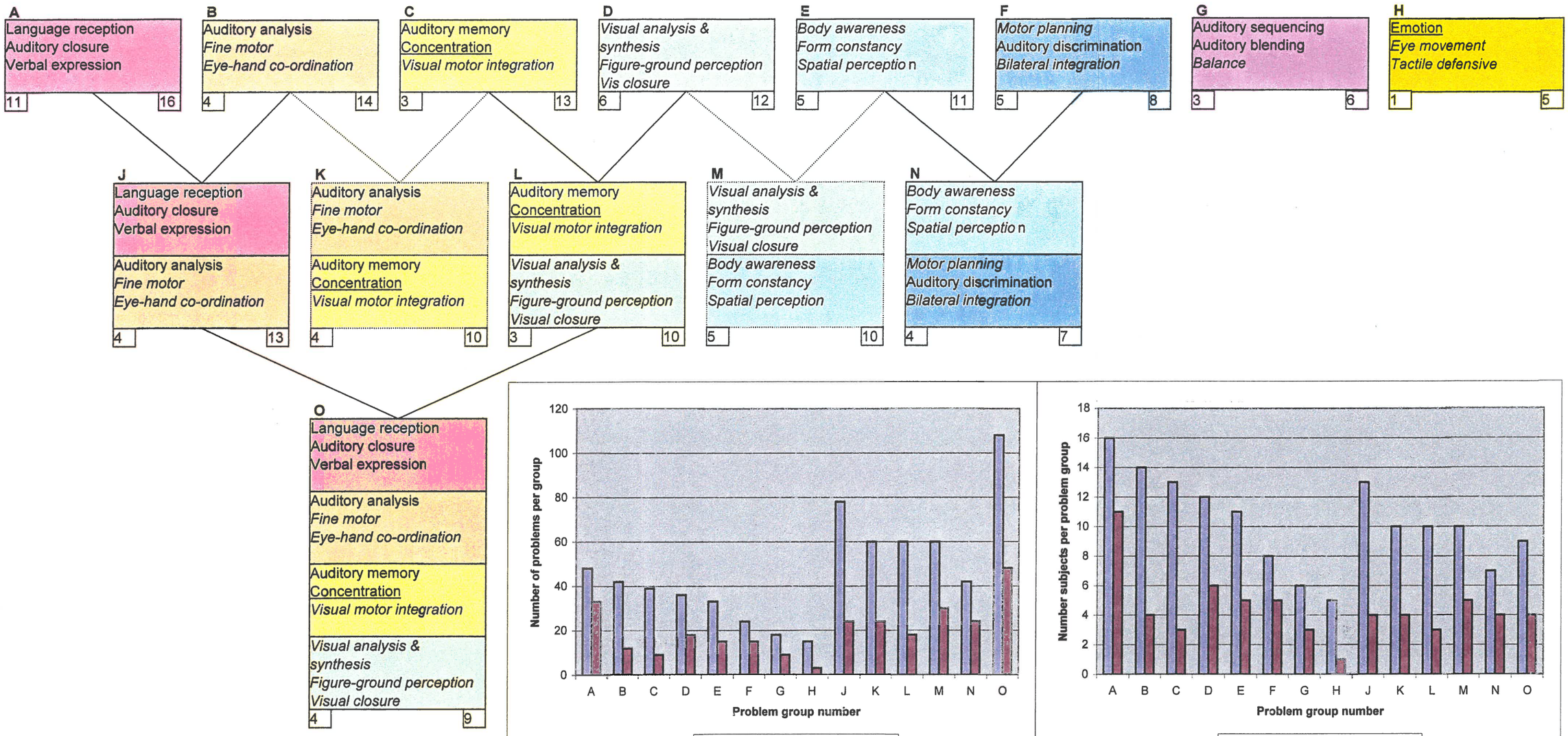


Figure 4.6: Multiple inheritance class structure

- group **A** has the largest number of subjects with the problems in language reception, auditory closure and verbal expression. This consists of sixteen subjects for the admission assessments results and eleven subjects for the most recent assessment results. Eleven subjects still belong to this group after a period of intervention (most recent assessment results). This indicates that progress was relatively poor,
- group **B** consists of the problem areas of auditory analysis, fine motor abilities and eye-hand co-ordination, which consists of fourteen subjects for the admission assessments and four subjects for the most recent assessments. This shows a significant improvement,
- group **C** consists of auditory memory, concentration and visual motor integration problems and has fourteen subjects in this group for the admission assessment results and three subjects for the most recent assessment results. This group also shows good progress in the school programme,
- group **D** is a group with visual perception problems (visual analysis and synthesis, figure-ground perception and visual closure). Twelve subjects share these problems after the admission assessments and six subjects still have these problems in the most recent evaluation. This can be interpreted as moderate progress,
- group **E** consists of body awareness, form constancy and spatial perception problems. Eleven subjects belong to this group after the admission assessment results and five after the most recent assessment results. This is also only a moderate improvement,
- the number of subjects belonging to group **F** is eight for the admission assessment results and five for the most recent assessment results, which indicates relatively poor progress for this group,

- groups **G** and **H** consist of only six and five subjects respectively for the admission assessment results. Group **G** shows a moderate improvement (three remaining subjects) and group **H** shows excellent improvement (one subject remaining),
- group **J** inherits both group **A** and **B** problems and consists of thirteen subjects for the admission assessment results. Four subjects remain in this group of problems after intervention. This can be considered a significant improvement,
- problem areas from groups **B** and **C** form group **K** and this group has ten subjects after the admission evaluation. The remaining four subjects in this group after intervention indicate a significant progress,
- the inheritance of problem areas from groups **C** and **D** forms group **L** which has ten subjects in the admission assessment results and only three remain after the most recent evaluation. This is a significant progress for the group of problems,
- group **M** consists of six problem areas, all in the domain of the occupational therapist (groups **D** and **E**). Moderate progress is indicated by the five subjects remaining after intervention,
- seven subjects belong to group **N** which inherits problem areas from groups **E** and **F**. Four subjects remain in this group of problems after the most recent assessments, which indicates poor improvement,
- an important group of problem areas is the group of problems (group **O**) consisting of twelve problem areas (inherited from groups **A**, **B**, **C** and **D**) present in nine subjects, which is a significant number of occurrences. Four subjects remain in this large group of problem areas after intervention and this can only be described as moderate progress.

Another feature presenting in the multiple inheritance analysis is that language and central auditory processing problems comprise the problem areas with the largest number of subjects (indicated in the block at the bottom right hand side of the group block in *Figure 4.6*). *Figure 4.6* shows that these problems occur mostly in the groups with a larger numbers of subjects. Noteworthy also, is the high incidence of problems with advanced visual and motor skills in conjunction with problems with central auditory processing skills (for example groups **B** and **C** in *Figure 4.6*).

Analysis of the multiple inheritance class structure of the most recent assessment results (*Figure 4.6*), shows that the pattern of incidence has changed. In the most recent evaluation the highest problem areas are still language reception, auditory closure and verbal expression (group **A**). The second largest number of problems are those in visual analysis and synthesis, figure-ground perception and visual closure (group **D**) followed by groups with problems mainly in the domain of the occupational therapist (groups **E**, **F** and **M**).

It can thus be said that progress in the group consisting of problems of language reception, auditory closure and verbal expression was the slowest. Progress in the group consisting of problems of auditory memory, concentration and visual motor integration was the fastest.

4.3.3 The relationship between results from the single inheritance analysis and the multiple inheritance analysis

Comparison of the information obtained from the single inheritance analysis to the information obtained from the multiple inheritance analysis provides further information

regarding the nature of the groupings. In *Figure 4.7*, the single inheritance structure and the multiple inheritance structure are compared to find possible relationships between the groups.

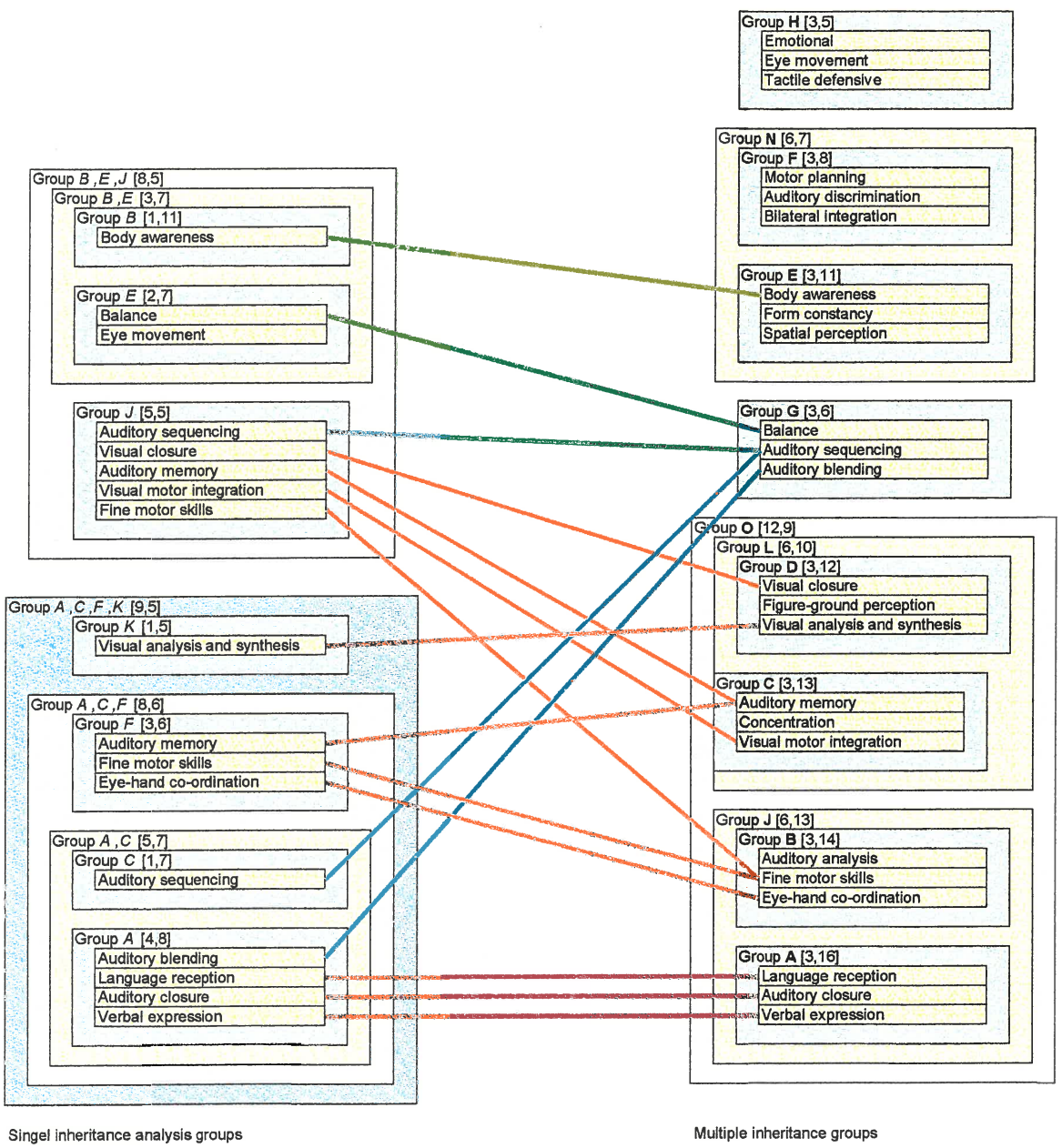


Figure 4.7: Relationship between the results from the single inheritance analysis and the multiple inheritance analysis

In *Figure 4.7* only significant groups were taken into account. The lines indicate how the grouping of problems of the single inheritance analysis relate to the grouping of the multiple inheritance analysis. The first number in brackets indicates the number of problem areas in the particular group and the second number refers to the number of subjects in the group. For example, group *B*, *E*, *J* consists of eight problem areas and five subjects belong to this group. *Figure 4.7* should be read together with the information from *Figure 4.5* and *Figure 4.6*. *Figure 4.7* shows how the application of the multiple inheritance analysis to the data changed the groupings of the single inheritance analysis into the groupings of the multiple inheritance analysis.

In respect of the transition from the single inheritance to the multiple inheritance grouping, the following interpretations from the information in *Figure 4.7* may be made:

- the multiple inheritance groups contain a larger number of problems per group, a larger number of subjects per group and a larger number of groups,
- groups *B* and *K*, containing only one problem per group, were grouped into larger groups, namely, groups **N** and **O**, respectively,
    - the nature of the relationship between the groups also presents a different picture, namely:
        - group *A*, *C*, *F*, *K* maps strongly to group **O,**
        - a new group **G** is formed, mapped from both group *A*, *C*, *F*, *K* and group *B*, *E*, *J*,
        - an essentially new group **N** is formed, with only one problem mapping from group *B* to group **N**,
        - a further new group **H** is formed with no mapping from the single inheritance structure.

It is thus clear that the multiple inheritance analysis contributes significantly to the forming of larger and stronger groups than the single inheritance analysis.

4.3.4 Analysis of the different groupings

Throughout all the results of all the analysis methods used in the previous sections, the existence of patterns of problem areas is clear. It is also clear that few subjects present with a simple single modality deficit. The majority of subjects present with a deficit involving both the visual and auditory modalities as well as problems in motor and concentration skills. Within this majority group of subjects further groups of problem areas occur together.

Because the occurrence of groups of problem areas is the aspect of interest in this study, it is necessary to analyse carefully the significant groupings which were identified. An example of a significant grouping is group **O** which consists of nine out of nineteen subjects (forty-seven percent)(*Figure 4.7*). In this group the subjects have a simultaneous occurrence of problems in language reception, auditory closure, verbal expression, auditory analysis, fine motor abilities, eye-hand co-ordination, auditory memory, concentration, visual motor integration, visual analysis and syntheses, figure-ground perception and visual closure.

Classification of both evaluation events into three basic groups of problem areas according to the professional domain (communication pathology and occupational therapy and those problems that fall into higher non-modality-specific problems) yields interesting information.

- ***A language disorder is the deficit with the highest incidence*** (for example, in group **A** of the multiple inheritance class structure)(*Figure 4.7*). According to all the

different analysis methods in the preceding sections, this fact is obvious. Although the subjects were selected only as children with learning disabilities they all have a language disorder. This suggests a close link between language abilities and learning disabilities as well as central auditory processing skills. This is significant in the sense that the assumption can be made that a language disorder may possibly be at the root of a learning disability. This is an accepted assumption in the findings of numerous authors (for example Keith, 1984; Lasky and Katz, 1983; Bernstein and Stark, 1985; Sanger, et al., 1987; Cline, 1988; Sloan, 1992; Riccio, et al., 1994; Campbell, 1993; Campbell, 1994; Gordon and Ward, 1995; Cacace and MacFarland, 1998 in the list of references in Appendix A). In this regard, Chase, (1996), suggests that the underlying neuro-physiological processes for children with learning disabilities are similar to those of children with language disorders.

- ***All the subjects have a deficit in their linguistic skills*** (*Table 4.1*; *Figure 4.6*). This interpretation must however be made with circumspection. The fact that the assessment tools used to evaluate central auditory processing skills in this study are all linguistically based assessments, should affect the outcome of these assessment results (Perez, Slate, Neeley, McDaniel, Baggs and Layton, 1995). Some authors even suggest that the linguistically based assessments and behavioural audiologic assessments are not testing the same ability (Sanger, et al., 1990).
- It is possible that several of ***the subjects could have problems in correctly interpreting the instructions*** for the activities required of them during the evaluation by the occupational therapist. This is the same reasoning as in the previous paragraph although to a lesser extent because of the nature of the activities. It is however also possible that the deficits in the concept forming abilities associated with relationships of the sensory systems and the outside world can influence the following of instructions (Gabbard, 1992).

- The ***presence of an attention deficit in a large percentage of subjects*** (*Table 4.1*; *Figure 4.6*) can also affect the assessment results. The ability to attend to an activity is a determining factor during assessment of a child. This fact suggests that attention skills are also important in academic performance and performing in skills important for language ability, central auditory processing and sensory integration. The question can be asked whether the deficit in attention influences the assessment results due to the inability to give attention to the activities and distractions present during the assessment procedures, or whether this attention deficit influences the development of these skills (Comings, 1990; Stach, 1992, Riccio, et al., 1994; McFarland and Cacace, 1995, ASHA, 1996 and Cacace and McFarland, 1998; Chermak, et al.,1999). These authors acknowledge a comorbidity of central auditory processing disorders and attention deficit disorder, but regard the two deficits as two distinct clinical disorders.
- In addition to the high incidence of language deficits, ***aspects of central auditory processing disorders present with a similar high incidence of occurrence*** (auditory closure and auditory analysis)(*Figure 4.6*). This can be due to the overlapping nature of central auditory processing and language processing. This assumption is also acknowledged in the literature (list of references in Appendix A). The assumption that central auditory processing disorders can be the underlying cause of many language disorders is suggested by a number of authors on neuro-physiologic (Chase, 1996; Cacace and McFarland, 1998) and behavioural evidence (Tallal, et al., 1996; Fitch, et al., 1997; Cacace and McFarland, 1998)
- According to the single inheritance hierarchy, ***only two subjects can be described as having a pure language and central auditory processing deficit*** (*Figure 4.5*). No subjects can be described as having a sensory deficit of only the visual modality or even a visual-motor deficit. This important finding leads to the conclusion that

language and central auditory processing skills should not be separated from skills involving the visual modality (Cacace and MacFarland, 1998; Chermak, et al., 1999).

- Additional groups in the grouping of problem areas in the multiple inheritance class analysis (*Figure 4.6*), suggest that there is a ***significant group of subjects which, in addition to the presence of high incidence problems, has a greater number of problems of the visual modality.*** The findings of the other analysis methods are thus endorsed by the multiple inheritance analysis and in addition provide a number of other groupings.
- Examination of the progress results as reflected in the analysis methods reveals that the ***order of incidence of problem areas changes*** (*Figure 4.3*; *Figure 4.5*; *Figure 4.6*) This progress may be due either to intervention or merely to the normal development of skills.
- ***The best improvement of problem areas is in central auditory processing skills*** (auditory analysis and auditory blending) (*Figure 4.3*). It is possible that these skills respond well to intervention, or that these are skills which develop more rapidly than in the other problem areas under investigation. Also of significance (*Figure 4.3*) is the high incidence of auditory closure and visual motor co-ordination problems. These results suggest a link between language abilities, central auditory processing, visual and motor skills, as well as integration skills.
- On the other hand, ***the poorest progress is in problems involving the visual modality and sensory integration skills*** (visual closure and bilateral integration) (*Figure 4.3*). One interpretation of this finding is that these are skills that require a basis of other skills which need to be developed before they can be refined.
- In the group context it becomes apparent that although ***emotional skills, eye movement and tactile defensive reactions*** progress slowly in individual subjects

(*Figure4.5*), they ***improve well as a group of problems*** (*Figure 4.6*). This suggests that in order to improve progress in therapy these problem areas should be treated together as a whole and not as individual problems.

- The group which exhibits problems with ***auditory memory, concentration skills and visual motor integration can possibly be seen as being part of a group of problems of higher level non-modality-specific factors*** (*Figure 4.6*). This group of problems also shows a large improvement in subjects responding well to intervention. This seems to endorse the holistic approach.

It is important to note that although subjects can be sorted into groups, careful further analysis of the results underline the heterogeneity of the group of children. Every single child should therefore be treated as an individual within the larger group and each individual seen as a whole entity in interaction with the world.

4.4 RESULTS MEASURED AGAINST RELEVANT RESEARCH

In support of the hypotheses and to satisfy the last sub-aim of this study, it is necessary to integrate and interpret these results in the context of information obtained from the literature as discussed in Chapter 2. In this light, two distinct approaches require elucidation, namely, neuro-physiology and human development.

4.4.1 Results viewed in the light of human neuro-physiology.

As discussed in Section 2.2, no sensory system functions in an isolated manner. The sensory systems as well as the motor system are inter-related throughout the central nervous system with numerous inter-connections on both sub-cortical and cortical levels.

The information of Section 2.2 in relation to the results this far discussed, give rise to a number of observations.

- The thalamus is one of the structures which plays a role in both language and memory mechanisms (*Figure 2.2*)(Comings, 1990; Akmajian, et al., 1992). In the results (*Table 4.1*), it seems that language tasks and memory tasks are inter-related and in this relationship auditory memory occurs in the problem areas with a high incidence. Auditory memory is also a problem area that does not show a large improvement in the intervention programme of the school, and presents in the group of problems with the highest occurrences (*Figure 4.3* and *Figure 4.5* and *Figure 4.6* respectively). In the single inheritance hierarchy tree (*Figure 4.5*), sixty-three percent of subjects inherited both language deficits and auditory memory problems. In the multiple inheritance class structures (*Figure 4.6*) problems with auditory memory are presented in the classes which have a large number of subjects. These groups of problem areas also show good improvement (*Figure 4.6*). Note that no other memory skills are included in the assessments under investigation.
- The reticular formation connects sensory modalities and motor systems and focuses attention (*Figure 2.2*)(Musiek and Lamb, 1992). Attention is thus important for perception and learning (Abravanel, 1981; Comings, 1990). Attention is also closely connected with sensory and cognitive processing (Musiek and Lamb, 1992) and can be described as being a higher level, non-modality-specific factor in the total picture of developmental learning disorders (Section 2.4.1)(Sanger, et al., 1990). In addition to the suggestion that attention skills can influence assessment results (Stach, 1992; ASHA, 1996; Cacace and McFarland, 1998), attention is also necessary for certain skills, for example, figure-ground perception (Kramer and Hinojosa, 1993). Furthermore concerning the results, concentration skills are of a high incidence in the admission assessments (*Table 4.1*), but as a single problem area progresses rapidly

(*Figure 4.3*). Fifty-three percent of subjects fall into the groups where concentration problems are evident according to the single inheritance phylogenetic analysis (*Figure 4.5*), but in the multiple-inheritance analysis, concentration problems present in groups of up to thirteen subjects (*Figure 4.6*). Concentration problems also present in groups together with auditory memory and figure-ground perception, which require attention skills (*Figure 4.5*; *Figure 4.6*). The finding that concentration problems are not of a similar high incidence as a number of auditory processing skills, suggests that central auditory processing disorders are not analogous to attention deficit disorder (Stach, 1992, Riccio, et al., 1994; McFarland and Cacace, 1995, ASHA, 1996 and Cacace and McFarland, 1998; Chermak, et al.,1999).

- According to ASHA (1996) to understand language efficiently, sensory detection and perceptual analysis should be present. This implies that language skills are dependent on perceptual skills. Authors also suggest that language is an interaction between a number of subsystems (Frederici, 1996; Frederici, et al., 1998). This assumption can be seen in *Table 4.1*, where no subject has only a language disorder, but each subject also has perceptual and processing problems in the other modalities under investigation.
- The situation also exists where the ability to learn and maintain skills is dependent on the connections between neural structures (Section 2.2.1.3)(Murray, 1991). It may therefore be suggested that sensory perceptual and processing skills are precursors to both language and learning skills. This suggestion is endorsed in the results of this study (*Table 4.1*).
- Learning disabilities are a dysfunction of primarily higher cortical processes, but involve both cortical and sub-cortical structures (Ayres, 1983; Murray, 1991). This can be seen in the large number of subjects (sixty three percent) who also have

balance skills problems (*Figure 4.1*), which can be described as skills involving lower neural structures.

- Finally, it is clear that the findings of numerous studies with persons with dyslexia (Section 2.2.2) also correlate with the findings of this study that dyslexia involves multiple sensory and association areas of the brain and thus involves auditory, visual, somato-sensory and motor skills (*Table 4.1*).

4.4.2 Results viewed in the light of human development.

A large percentage of children with developmental learning disorders do not present with a clear pathology or morphologic abnormality and could belong to the group of children presenting a maturational delay (Musiek, et al., 1984; Musiek, et al., 1990; Musiek and Chermak, 1994; De Conde-Johnson, et al.,1997; Chermak, 1998). It is therefore necessary to establish whether a number of subjects in this study fall into this category. The significant percentage and rate of progress of the subjects and problem area groups suggests that the majority of the subjects fall into the group of children with maturational delay (*Figure 4.6*). Only two of the subjects have a diagnosed pathology, namely, brain abnormalities due to haemolytic streptococcal septicaemia and Williams' syndrome.

As discussed in section 2.3 a number of skills are dependent on the development of other skills. An example is that balance (vestibular awareness) is important for development of all motor skills (Gabbard, 1992). It can thus be assumed that a deficit in balance should affect skills such as motor planning where motor and somato-sensory systems are involved. This developmental course is not clear from the results of this study. It is significant, however, that a large number of subjects do have problems with

body awareness (fourteen) and balance (twelve)(*Table 4.1*) and this can be a possible underlying cause for their problems in the other modalities and language skills.

The results of this study do not lend themselves to more assumptions concerning the development of sensory and motor skills. However, it is important is to note that perception precedes language and speech skills (Akmajian et al., 1992), and language skills are closely linked to development of cognitive processes, socialisation and academic learning skills (Bukatko and Daehler, 1995). The assumption that the different skills cannot be viewed as isolated entities is thus endorsed by this fact as seen in the mixed occurrence of the different problem areas.

4.4.3 Interpretation of the grouping patterns

From the interpretation of the groups discussed in the foregoing text it is possible to integrate the suggestions and information from the literature to obtain an understanding of the nature of the groupings. A possible interpretation of the grouping patterns is outlined in *Figure 4.8*.

A number of aspects of *Figure 4.8* require interpretation.

- Group CA, consisting of language reception, auditory closure and verbal expression problems may be described as language processing problems. Auditory skills are necessary for the development of language skills (ASHA, 1996).
- Group CB consists of auditory analysis, fine motor abilities and eye-hand co-ordination problems and may be interpreted as problems in fine co-ordination in eye-hand, motor and auditory-semantic skills. These skills may be described as requiring refinement of higher order skills.

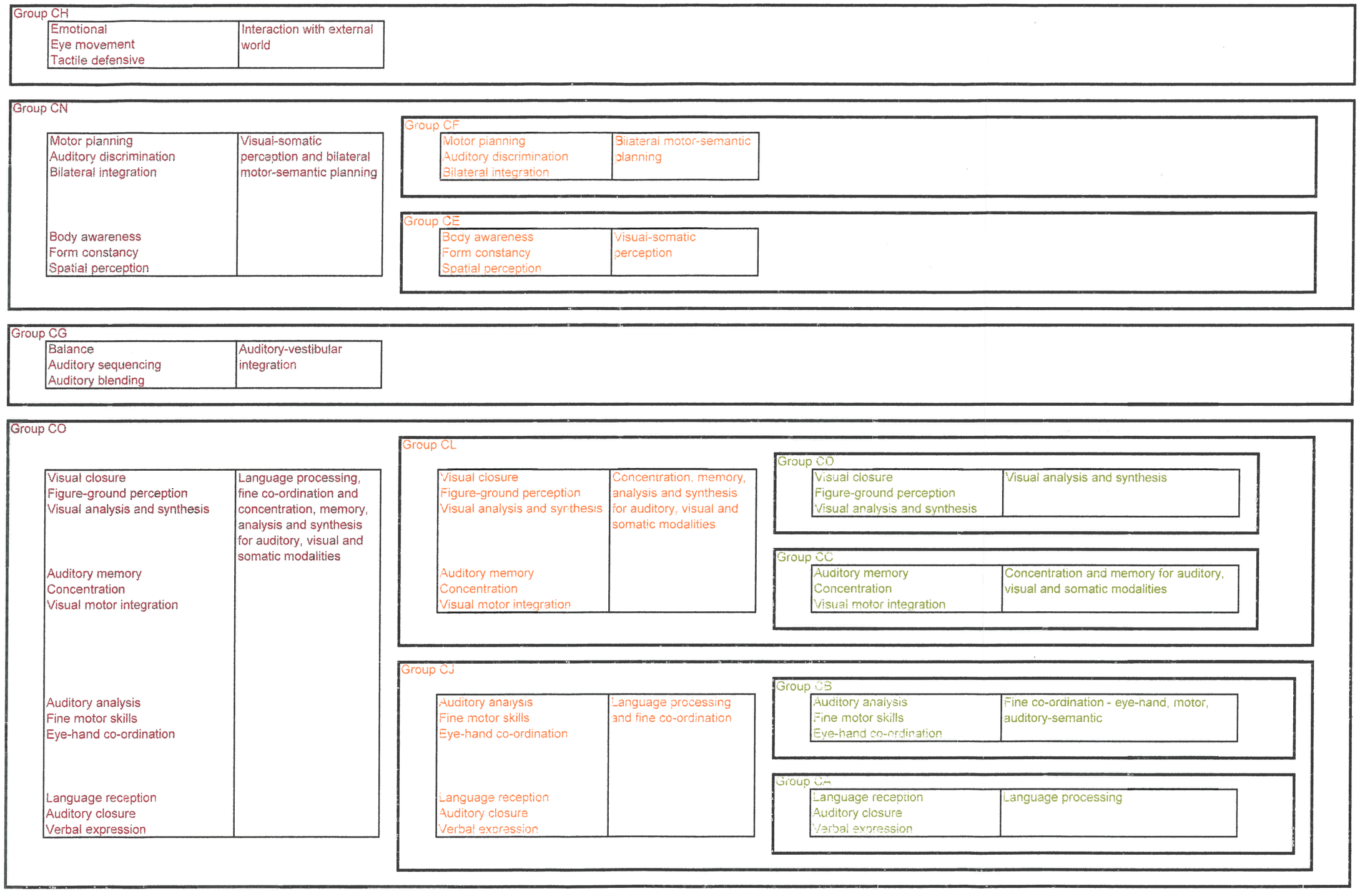


Figure 4.8: A possible interpretation of the grouping patterns

- Group CJ consists of the problems in group CA and group CB. This group may be described as subjects having problems in language processing and fine co-ordination. All these skills may also be described as higher order processing skills.
- Group CL consists of the problem groups in group CC and CD. This group may be described as having problems with concentration, memory, analysis and synthesis for auditory, visual and somato-sensory modalities. This may be seen as a supra-modal group and the possible root of the problems may be found in the underlying lack of sufficient concentration (Cacace and McFarland, 1995).
- Group CO consists of the problems of group CJ and CL. This group may be described as having problems in language processing, fine co-ordination, concentration, memory, analysis and synthesis for auditory, visual and somato-sensory modalities. This may also be seen as a supra-modal group with an underlying concentration problem being the cause of the problems (Cacace and McFarland, 1995).
- Group CG consists of balance, auditory sequencing and auditory blending problems. This can be described as an auditory-vestibular integration problem. The relationship between auditory and vestibular skills is a phenomenon observed by occupational therapists (Fisher and Murray, 1991).
- Group CE consists of body awareness, form constancy and spatial perception problems. This may be described as a visual somato-sensory perception problem. The integration of modalities needed for these skills is also a known phenomenon in the field of sensory integration therapy (Fisher and Murray, 1991).
- Group CF consists of motor planning, auditory discrimination and bilateral integration problems. This group may be described as having a bilateral motor-

semantic planning problem. These skills may be described as being processed on a pre-attention level (Fisher and Murray, 1991, Kraus, et al., 1996)

- Group CN consists of group CE and CF and may be described as a group of problems in visual-somato-sensory perception and bilateral motor-semantic planning. This may be seen as a group acknowledged by the sensory integration therapy view (Fisher and Murray, 1991).
- Group CH consists of emotional, eye movement and tactile defensive problems and may be described as a group of problems involved in interaction with the external world.

The discussion of *Figure 4.8* can thus serve as a summary of the interpretations of the results obtained from the phylogenetic inheritance analysis as well as assumptions made by the author to interpret the results in the light of the neuro-physiologic functioning of the human sensory and motor systems as a holistic unit.

4.5 PROPOSED MODEL FOR EVALUATION AND INTERVENTION

To explain the holistic approach suggested from the results of the study, a model for evaluation and intervention may be developed to complete the last sub-aim of the study. *Figure 4.9* is a presentation of the different professional fields which were investigated and shows the overlap which exists.

Key for *Figure 4.9*: Each professional field is in a block with a different border to facilitate visibility. The small block on the right hand side of the problem group block indicates the number of subjects in the group.

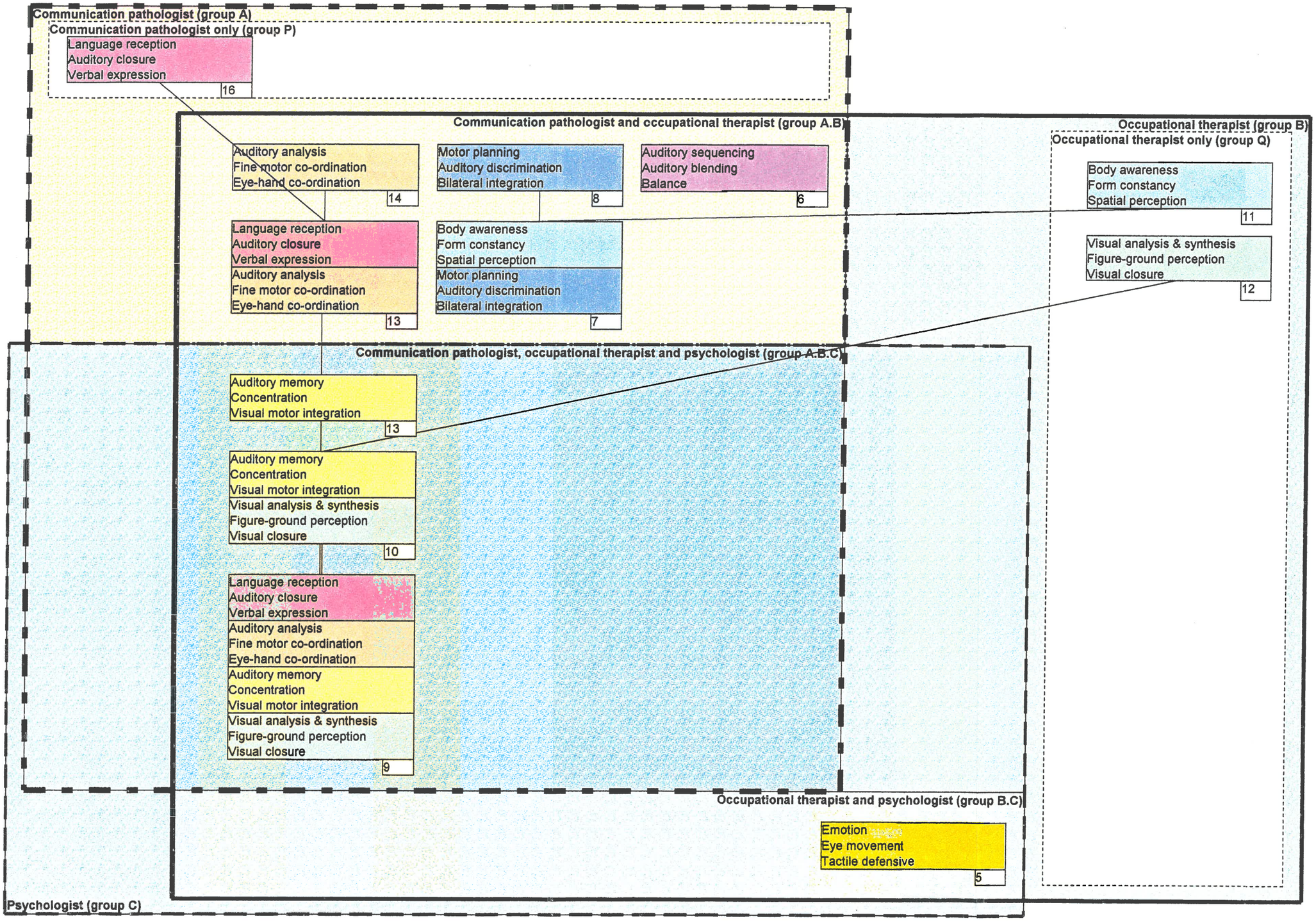


Figure 4.9: Overlapping of respective professional fields working on problem areas

In *Figure 4.9* the different groups from the results in the foregoing sections of Chapter 4 are arranged according to the current professional responsible for intervention of that particular problem. Three professional fields are used, namely, those of the communication pathologist, the occupational therapist and the psychologist. For example, the group of problems consisting of language reception, auditory closure and verbal expression falls into the field of the communication therapist alone (group A). Several of the problem groups, however, fall into the area where the fields of the communication therapist and the occupational therapist overlap (group A.B). To establish whether a model will be feasible the work areas and the problem areas were combined. This presents with a model (*Figure 4.10*) to show how the current diagnosis and intervention programmes are approached.

In *Figure 4.10*, describing the suggested model, five main groups may be formed.

- Group P consists of subjects (sixteen subjects) who would benefit from intervention from the communication pathologist alone.
- Group A.B consists of subjects (fourteen subjects) who may receive intervention from the communication pathologist and the occupational therapist.
- Group A.B.C consists of subjects (thirteen subjects) who may receive intervention from the communication pathologist and the occupational therapist, as well as from the psychologist.
- Group Q consists of subjects (twelve subjects) who may receive intervention from the occupational therapist only.
- Group B.C consists of subjects (five subjects) who may receive intervention from the occupational therapist and the psychologist.

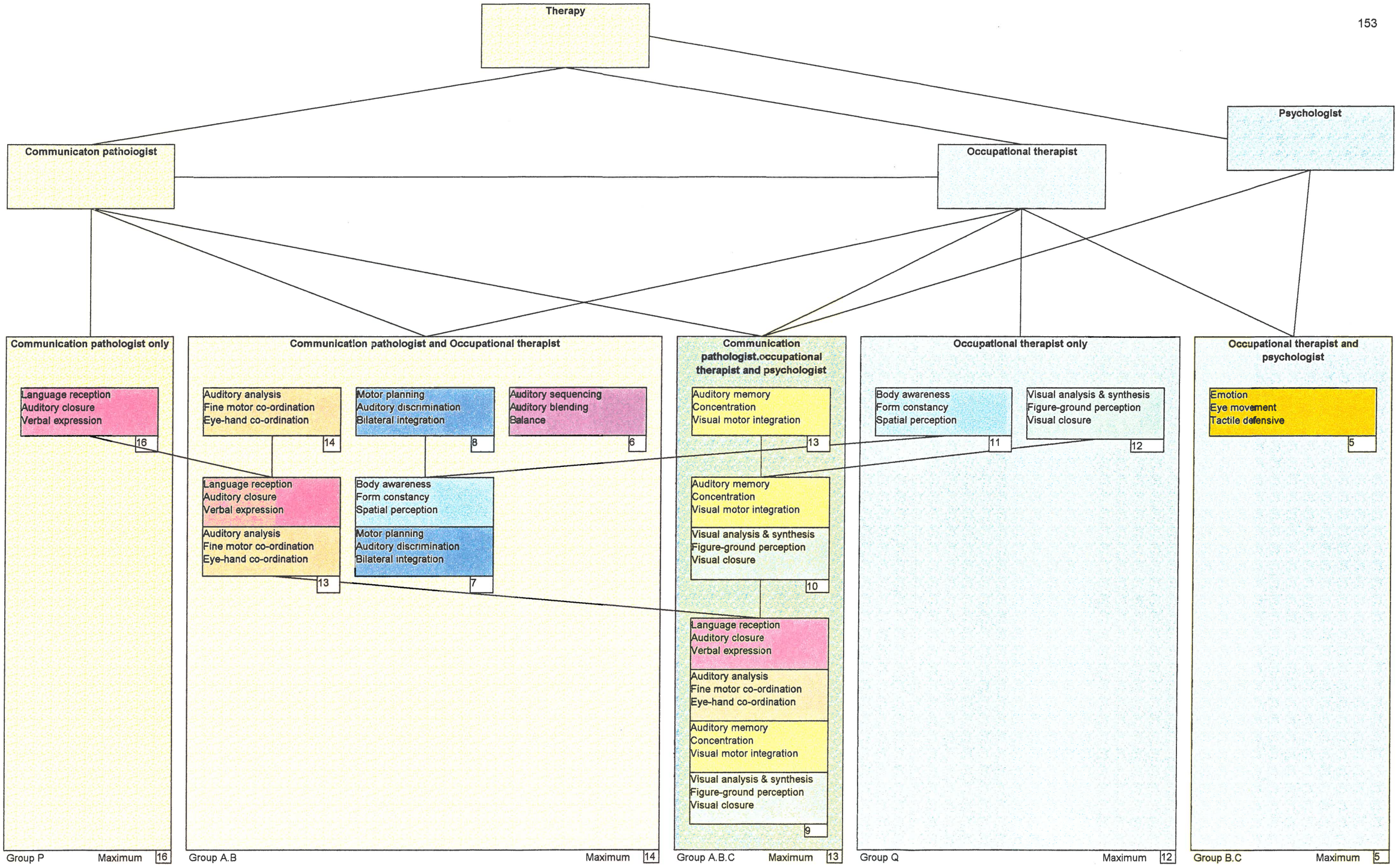


Figure 4.10: Overlapping of respective intervention programmes

The lines connecting the specialist therapist with the groups of problem areas cross each other. This indicates the overlap which exists.

The overlap between the groups covered by the communication pathologist and the occupational therapist may be removed when the concept of a single trans-disciplinary orientated ("new") therapist is introduced, as depicted in *Figure 4.11*.

This model (*Figure 4.11*) suggests a trans-disciplinary orientated therapist ("new" therapist) who can handle all the problems of the five groups, or a trans-disciplinary team approach where these children may receive therapy in a group involving more than one professional. For example, the children in group A.B may benefit from group interaction in the therapy session due to the nature of the problems and may thus receive group therapy from one therapist. On the other hand, the nature of the problems in the group of children in group Q may suggest that one-to-one therapy sessions may be beneficial. This model differs from the trans-disciplinary team approach as described by Du Plessis (1998) in the sense that the person responsible for intervention should be a knowledgeable professional, an educated and trained clinician and not merely a manager.

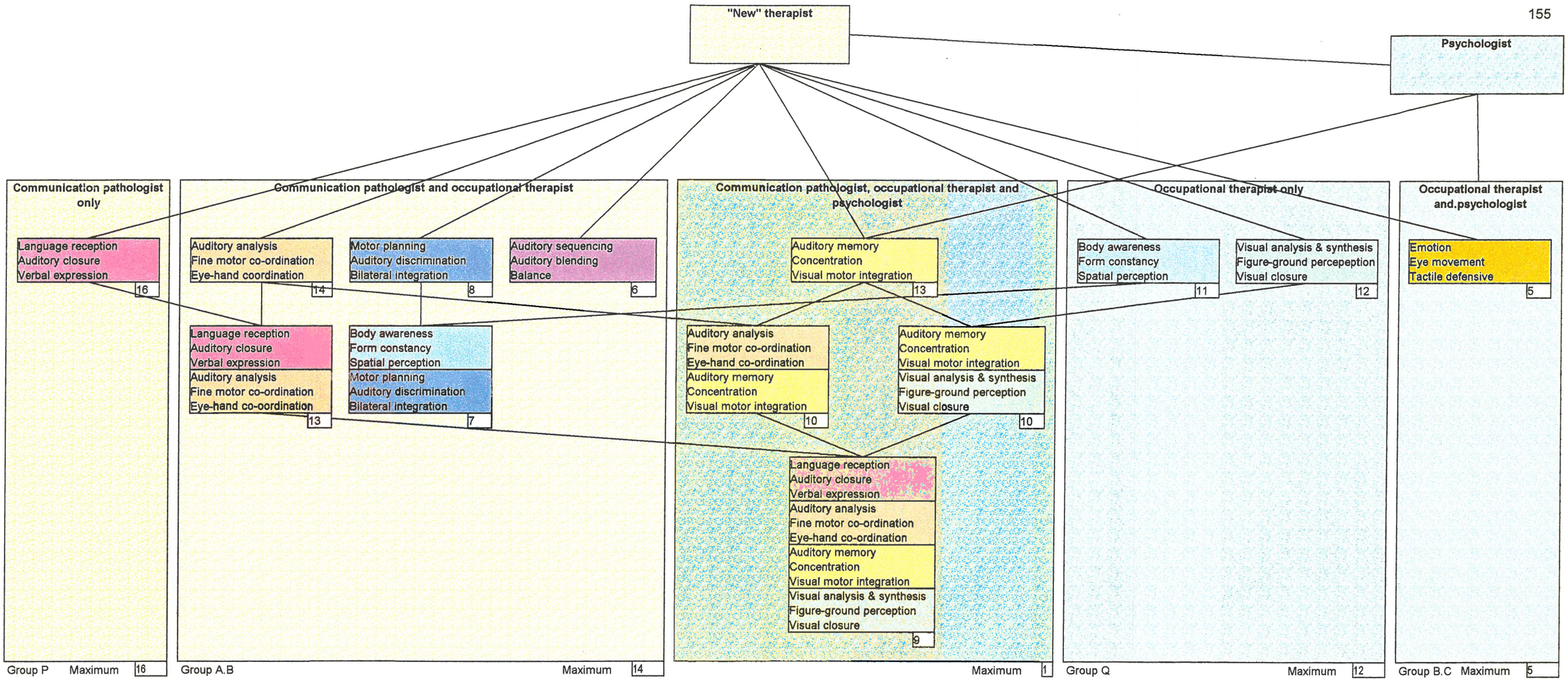


Figure 4.11: Proposed consolidation of intervention programmes

4.6 SUMMARY

From the analysis of the data obtained by using conventional frequency incidence correlation statistics and phylogenetic inheritance analysis it becomes evident that no deficit in the context of children with learning disabilities is isolated from any other deficit.

Significant groupings become apparent, which indicate that the subjects all present with deficits in more than one modality or skill. Because language seems to be the primary deficit, the assumption can be made that the interrelationship between auditory, visual, somato-sensory motor and language skills should be acknowledged. Although language disorders and learning disabilities are the deficits present in all the subjects, no subject has a pure language disorder or only academic learning problems without any involvement of sensory systems, either auditory, visual or somato-sensory or all of these systems together.

Most inheritance groupings obtained from the single and multi inheritance class hierarchy analysis consist of problem areas grouped in a mixed manner from auditory, visual and somato-sensory systems. Motor skill problems and supra-modality problems also play a role in a number of problem areas under investigation and also occurs in a mixed manner together with sensory perceptual and processing deficits. Recent research (Chapter 2) provides background information to explain these groupings and endorse the findings.

From the results of this study it is evident that neuro-physiological integration of the sensory and motor systems, as are investigated in this study, weigh heavily in the development of academic skills.

It is thus apparent from the results that learning disabilities, central auditory processing, language disorders and sensory integration dysfunction cannot be viewed and treated in an isolated manner, but should be seen as aspects (symptoms) of an umbrella syndrome condition, that can be described as a developmental learning disorder. A holistic approach in the clinical situation using the integrative nature of these disabilities can thus be an inter- or trans-disciplinary team approach with emphasis on the integration of the individual involvement of different professionals as suggested in the model proposed in this chapter. The consequences of this statement will be discussed in Chapter 5.

CHAPTER 5: CONCLUSIONS, EVALUATION AND CLINICAL IMPLICATIONS OF THE STUDY

5.1 INTRODUCTION

Although the relationship between central auditory processing disorders, learning disabilities, language disability and sensory integration dysfunction are frequently mentioned in the literature (Katz and Wilde, 1994; Gordon and Ward, 1995; Welsh, et al., 1996; McSporran, 1997; Cacace and McFarland, 1998; Chermak, 1998; Sloan, 1998; Bellis and Ferre, 1999; Chermak, et al., 1999 and others in the list of references in Appendix A), the nature of this relationship is not clear. Awareness of this fact prompted a number of authors (Riccio, et al., 1994; Cacace and McFarland, 1998, Chermak, 1998) to ask the whether these disabilities could share a common aetiology (neurological or neuro-maturational) or are they the result of common genetic, neurological and psychological factors. This approach to the disorders has implications for intervention. Many authors suggest a multi-, inter- or trans-disciplinary (Matkin and Hook, 1983; Young and Protti-Patterson, 1984; Sanger, et al., 1985; Young, 1985; Koay, 1992; ASHA, 1996; Chermak, 1998; Bellis and Ferre, 1999) approach to children with central auditory processing. Currently the most favoured approach in South Africa is the inter-disciplinary approach (Graz, 1998; Fourie, 1998). This approach, however, requires still more skilled manpower and funds than are presently available in the education community. An effective resource-efficient model to approach these problems will aid in providing an evaluation and intervention programme which may be easily implemented with existing resources. This may be achieved without losing the professional skills of the different fields involved with children who have a developmental disorder, by

consolidating the knowledge of all the professionals into a holistically viewed clinical approach.

Whether this study has succeeded in providing answers to the nature of the relationship of central auditory processing disorders, learning disabilities, language disability and sensory integration dysfunction will be discussed in this chapter. The proposed model for approaching children with a developmental learning disorder will be discussed to provide a possible solution in the clinical situation.

5.2 SUMMARY OF THE STUDY

The aim of this study is to determine whether assessment results currently used in a school for remedial teaching can be used to establish the nature of the relationship between central auditory processing disorders, language disorders, learning disabilities, and sensory integration dysfunction, in order to facilitate the diagnosis and intervention programmes on the basis of a holistic approach. This was determined in terms of three sub-aims.

The first sub-aim was to determine the statistical patterns of existing assessment results used by the professionals at the school for remedial teaching in order to determine correlation. Conventional graphical presentations provided a presentation of the patterns indicating the incidence of the different problems. These results could be used to make assumptions regarding the incidence of problems and the progress of the subjects in the school programme, namely, that each individual subject presented with a number of problems which were not limited to one sensory system. The conclusion from these results is that language problems together with learning disabilities can be described as

the common factor between the children at the school, but are not isolated from problems related to other modalities. This also endorses the current trend in the literature that central auditory processing disorders should be viewed as a disorder influenced not only by the auditory modality (Welsh, et al.,1996; Cacace and McFarland, 1998; Sloan, 1998; Bellis and Ferre, 1999; Chermak, 1998).

The next sub-aim was to use phylogenetic analysis results to determine the problem sub-groups on the assumption that this grouping of problem areas could assist in the establishment of the nature of the relationship between central auditory processing disorders, learning disabilities, language disorders and sensory integration dysfunction. The single inheritance hierarchies provided information which led to the assumption that the groups of problem areas which suggest the existence of a disability group containing problems of auditory, visual, somato-sensory, motor and supra-modal factors which influence the processing of information. Although the multiple inheritance groupings enhanced the basic suggestion from the single inheritance groupings, additional information emerged, namely, that these groupings may be explained on terms of the functioning of the central nervous system. These results endorse the multi-sensory manner of functioning of the central nervous system with interconnections between a number of systems found by researchers in the field of neuro-physiology (for example, Gabbard, 1992; Jordaan and Jordaan, 1994; Bukatko and Daehler, 1995; Nolte, 1999).

The last sub-aim was to endorse the results achieved and assumptions made during the process of reinforcing the first and second sub-aims with infprmation from the literature. These results were then used to develop a model for the diagnosis of and intervention into the problems of children who can be described as having developmental learning disorders. This study proposes a change in the manner of approach to children with

developmental learning disorder from an isolated discipline-specific approach to a holistic approach in evaluation and intervention, to incorporate skills from the different professional fields to form one umbrella approach. A possible consequence of this approach is that it may affect the education and training of professionals working with children with a developmental learning disorder.

5.3 EVALUATION OF THE STUDY

The use of phylogenetic analysis in the field of communication pathology has not - to the author's knowledge - been used previously. This method, however, provides a means to re-establish patterns of correlation which have been lost with conventional statistical methods. Several factors could however have influenced the results of the study and these will be briefly discussed.

- It was necessary to use a series of research designs in order to pursue the objectives of the study (*Table* 3.1 in Section 3.3). This provided a thorough and logical analysis of all the aspects of the research question. A prospective longitudinal study spanning all the evaluations of the subjects, however, may provide the information needed to establish the influence of developmental patterns and the nature of these relationships in relation to the development of the child as a whole. The main aim of this study was, however, supported by the data used.
- The tests most frequently used in the literature from the audiological perspective to determine central auditory processing disorders, are behavioural audiologic tests (for example, Katz, 1992; Stach, 1992; Stach and Loiselle, 1993, Katz and Wilde, 1994, ASHA, 1996, Jerger, 1998; Bellis and Ferre, 1999). The tests used by the professionals at the school to determine central auditory processing abilities are however, linguistically based assessments. The question is whether these

assessments provide a sufficient diagnosis to determine central auditory processing disorders? (Sanger, et al., 1990). From the audiologic point of view, the exclusion of behavioural audiologic tests to determine central auditory processing abilities may be a limitation in this study, because only language based auditory processing was assessed by the professionals at the school. As suggested by Sanger, et al., in 1990, both these approaches (audiologic and linguistic) should be included because the different assessments may assess different aspects of auditory processing. A prospective study which includes both audiologic and linguistic measures to determine central auditory processing skills may provide valuable information to determine the nature of the relationship between central auditory processing disorders and language disorders. The inclusion of audiologic tests in a similar study could thus examine this aspect in further research. Nevertheless, the aim of the study was to determine the possible use of existing low technology measures to determine central auditory processing disorders, and as such the assessments used did provide sufficient evidence to support this aim.

- Although the filing system of the school used in the study was sufficient, it lacked uniformity in the report structures. It was not always possible to determine which assessment tools or measures were used and the scores obtained in these assessments were not always noted. The lack of uniformity of the assessment reports also influenced the choice of data which could be used, because only data which was consistent in all the files was used. These factors can provoke criticism regarding the validity and reliability of the study, because of the lack of control over the conducting of the various assessments. Different professionals with different views used different measures to assess the same abilities under different environmental conditions. The aim of the study was however to establish whether existing assessment results could be used to determine the relationship between the

problem areas. The use of "0" or "1", which indicated the presence or not of a problem, meant that the analysis was not to be sensitive to exact scores of the evaluation measures. The issue was thus the presence or absence of a problem, which compensates for the above-mentioned lack of control.

- The time difference between the admission assessment results and the most recent evaluation results may have influenced the interpretation of the progress due to the difference in the quantity of intervention. The amount of intervention received by the different subjects was thus not the same. The progress of the children was, however, not covered as a central issue of this study; the focus was rather on the *nature* of the development of the problem areas.
- Another factor which may have influenced the results of the study was the inclusion of children with a mother tongue other than English (Nelson, 1993). Limitation of these variables in the selection of the subjects would aid the specificity of the study. It should, however, be noted that this aspect plays a valid role in the case of what is perceived to be a learning disability and/or central auditory processing disorder. The unfamiliar language use may cause normal children to present with an image similar to that of a true disorder. From the observations made in this study it is possible that a large proportion of children with a mother tongue other than English might have made rapid progress in the intervention programme once they had mastered English sufficiently. Because of the frequency of children receiving instruction in a second language in the South African situation, this could be a topic for further investigation.
- Although nineteen subjects provided sufficient data for a phylogenetic analysis, more subjects could have influenced the conventional statistical data analysis. It is not expected that significant additional groupings will be added if more subjects are included in the study; the core of the patterns is already evident. This fact became

clear when the analysis of the data of ten subjects were compared with the analysis of the data of nineteen subjects (discussed in section 3.6.2).

5.4 CLINICAL IMPLICATIONS

Far-reaching implications arise from the results of this study. The study postulates a change in view of different professionals from a specialised view and consequently the isolated treatment of children with central auditory processing disorders, learning disabilities, language disorders and sensory integration dysfunction, to a holistic approach to these children. This may be achieved by means of a very strong inter-disciplinary team, or, possibly more appropriately, by introducing a "new" type of trans-disciplinary therapist as proposed in the model for assessment of and intervention into children with a developmental learning disorder. The implications of this approach to children with central auditory processing disorders, language disorders, learning disabilities and sensory integration dysfunction will be discussed in the following three sections.

5.4.1 Developmental learning disorder as a syndrome

The interrelationship between academic, central auditory processing, language processing, sensory integration abilities is clearly illustrated in this study. There is thus an indication that children with auditory processing disorder, language disorders, learning disabilities and sensory integration dysfunction may belong to a syndrome condition that can be called a developmental learning disorder as advocated in the medical field (DMS-IV). These children thus present with a number of problem areas (symptoms) which are commonly found in all of these disabilities.

5.4.2 Holistic approach

This study proposes an approach to children with auditory processing disorders, learning disabilities, language disorders and sensory integration dysfunction, which consists of a cross-disciplinary approach in both diagnosis and intervention. Analysis of the results as presented in Chapter 4 suggest that a holistic approach, namely a strong inter-disciplinary or trans-disciplinary team approach as proposed in Section 4.2.3.4 to intervention in the case of the children with developmental learning disorders may be adopted to provide a solution which would reduce the manpower and funds needed for diagnosis and intervention. This approach will also result in effective diagnosis and intervention, because of the clinical consolidation of the various issues currently handled in isolation.

5.4.3 Proposed model for evaluation and intervention

To implement the holistic approach suggested from the results of the study a model for evaluation and intervention was developed (Section 4.2.3.4). This model shows that the overlap between the groups covered by the communication pathologist and the occupational therapist may be removed if the concept of a single "new" therapist is introduced, as depicted in *Figure 4.11*. This model expands the concept of the trans-disciplinary team approach as described by Du Plessis (1998) in the sense that the person responsible for intervention should be a knowledgeable professional, an educated and trained clinician.

This model thus implies that the education and training of professionals working with children with developmental disorders may benefit from a broader approach and

incorporation of education and training which overlaps and integrates the different fields. A suggestion is that the "education" of students rather than the "training" be significantly emphasised in order to provide an open-mindedness in accepting views from other professional fields which can be incorporated in the intervention programme. This also implies continued education for the qualified professional, starting, possibly, from a specialised therapist in one traditional professional field and evolving into the holistic propounded ("new") trans-disciplinary therapist.

5.5 SUGGESTIONS FOR FURTHER RESEARCH

The topic of the relationship between different abilities/disabilities and the functioning of a human being as a holistic entity still needs further research. The approach to this phenomenon in assessment and intervention programmes can also benefit from further research. A few suggestions are as follows:

- regarding the holistic approach:
  - ♦ re-organisation and consolidation of teams working with children with developmental learning disorder,
  - ♦ determining a strategy for an effective low technology holistic assessment, thus developing an effective assessment battery,
  - ♦ determining an intervention strategy to optimise the use of resources.
- regarding the nature of the relationships:
  - ♦ the analysis methods used to obtain the groups as discussed in Chapter 4 may be used in longitudinal studies to determine the influence of normal neuro-development of the sensory, motor and cognitive systems on each other and to see if the patterns of relationship alter with age,

development of the sensory, motor and cognitive systems on each other and to see if the patterns of relationship alter with age,

- research to determine whether the neuro-physiological basis of the relationships as seen in the dominant groups could provide knowledge of the functioning of the central nervous system as a holistic entity,
- inclusion of attention deficit disorder, cognition and social influences to determine the relationship between these factors and central auditory processing disorders, learning disabilities, language disorders and sensory integration dysfunction,
- research into the influence of intervention (and school education) in English, rather than in the mother tongue of children with learning problems.

5.6 SUMMARY

In overview of this study it can be concluded that the results of the study are endorsed by the information from the literature (and vice versa) regarding the nature of the relationship between central auditory processing disorders, language disorders, learning disabilities and sensory integration dysfunction. Although limitations exist in the study, the findings provide sufficient valuable information regarding the nature of the relationship between central auditory processing disorders, language disorders, learning disabilities and sensory integration dysfunction, which can aid in the development of a model for evaluation of and intervention into children with a developmental learning disorder.

The most important suggestion of the study is a change of approach from the isolated approach of each professional involved with children with a developmental learning disorder to a holistic approach, involving a tightly coupled professional team, and/or a

"new" holistic trans-disciplinary therapist who incorporates a range of traditional professional skills in a single person.

"It is not essential to understand the nature of these complex difficulties fully before taking steps to help individuals with these problems. By working together as a team in our various work settings and by listening carefully and with an open mind to individuals who have these difficulties, we will find many solutions as well as further understanding." (Sloan, 1998: 376).