Supervisor: Dr. Otfried Spreen

ABSTRACT

It is now commonly acknowledged that learning disabled children are not a homogeneous population, and current neuropsychological research in this area has focussed on attempts to identify subtypes of these disorders. Earlier subtyping studies adopted a subjective, clinical-inferential approach to classification, while recent research has emphasised a strictly objective, quantitative model which involves the use of multivariate statistical methods of classification. In the natural sciences, both objective quantification as well as the developmental, qualitative aspects of taxonomy are considered equally essential for a good classification (Adams,1985). Subtypes identified so far in various studies have had relatively little impact on either neuropsychological theory or clinical practice, and this has been attributed to a failure on the part of researchers to integrate the clinical-qualitative approach with the quantitative subtyping procedures (Wilson & Risucci,1986).

The present study attempted to address this problem by using a combination of these two generally accepted methods, in an attempt to identify reliable and meaningful subtypes within a sample of 275 clinic-referred and 26 normal control subjects. Two separate typologies of this subject sample were

generated: a) using clinical-inferential methods, based on clinical inspection of psychometric test data, and b) using multivariate statistical methods for the derivation of subtypes (cluster analysis). The two subtyping solutions were then compared, allowing each to be used to validate the other (Morris & Satz,1984).

The derived clusters and clinical typology groups identified all commonly found subtypes as well as most others reported by previous subtyping studies in the literature. The results of several internal validation procedures indicated that the clusters were relatively heterogeneous, and therefore somewhat unreliable, although the majority of clusters proved to be meaningful and interpretable. Comparison of the two classifications indicated approximately 58% correspondence in terms of individual case assignments to comparable subtypes between the typologies. Comparison of T-score ability profiles revealed generally satisfactory correspondence between the profiles of cluster analysis derived subtypes and those of comparable clinical subtypes.

Further analyses were performed on selected groups of subjects in order to explore specific hypotheses. Age effects on subtype patterns were examined, and the results suggested that subtypes do persist over the school age range. However, adolescent subjects were more prominent in the severe language disorder subtypes, and a large proportion of the younger subjects emerged in subtypes characterized by visual

perceptual problems. Reading disability subtypes were also analysed, indicating qualified support for Denckla's (1977) subtypes from the cluster analysis, but considerable confirmation of this typology from the clinical classification. Rourke and Finlayson's (1978) findings in regard to specific arithmetic disabilities were not replicated in this study. Subjects with specific profile patterns were also examined for evidence of characteristic social, emotional and behavioural difficulties, with mixed results. Finally, the obtained subtypes were examined in order to determine possible differences in terms of academic performance, in order to establish external validity for the two classifications.

It was concluded that, although there are definable as well as meaningful subtypes of learning disabilities, this population of children cannot be classified into discrete subtypes with clear boundaries and strictly defined criteria. In addition, it was deemed important to recognize that such disorders range, in degree of severity, from quite subtle to seriously impaired, so that diagnostic "cut off" points are inappropriate for this particular group of children.

Examiners:

Dr. O.Spreen

Dr. C.W Tolman

Dr. R. Hoppe

Dr. B. Simmons

Dr. J.F. Kess

Dr. D. Kendall

TABLE OF CONTENTS

APPENDICES page

LIST OF TABLES

LIST OF FIGURES

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CHAPTER I

INTRODUCTION

It is now generally accepted that children with learning disabilities do not constitute a homogeneous population. Over the last 20 years, there has been increasing recognition of the fallacy of the "unitary deficit" hypothesis as the underlying basis of such disorders, and the research strategy in relation to this topic has changed radically. Instead of the traditional contrasting group design model, which attempted to identify a single underlying variable that would discriminate between groups of learning disabled and normal children, current research in the neuropsychology of learning disabilities has focussed almost exclusively on attempts to identify relatively homogeneous subtypes of these disorders.

Methods of classification have involved two main approaches: a) the division into subtypes on the basis of subjective clinical interpretation of psychometric test profiles (Mattis, French & Rapin, 1975; Denckla, 1979) and b) the use of empirical and objective multivariate statistical classification procedures, such as Q-type factor analysis or cluster analysis of psy hometric data (Doehring & Hoschko, 1977; Fisk & Rourke,1979; Satz & Morris,1981). Many of the earlier studies adopted a clinical sorting approach to this question, based upon

visual inspection of the test data and clinical observations of learning disabled children. However, almost all recent neuropsychological research in this area has involved a quantitative, multivariate approach.

Another dimension relating to classification research in this area concerns the question of whether subjects are classified on the basis of academic performance measures (e.g. Boder,1973) or processing deficiencies based on cognitive and neuropsychological test performance.

Those studies in which subtypes have been determined on the basis of a number of cognitive and neuropsychological variables have been criticized as generally failing to examine the nature of the reading (or learning) disorder in detail. Similarly, studies in which subtypes have been determined on the basis of reading tests of various types have failed to integrate the results with either neuropsychological, medical or developmental information in order to validate the subtypes that have been identified.

A common problem is that, in studies using clinical data, there has been little consistency in the selection criteria for subject samples or in the choice of variables used for classification, which tends to limit comparisons of subtype solutions between studies.

In a discussion of theoretical issues in subtype research, Adams (1985) points out that, in the natural

sciences, taxonomic research has been conducted by the use of both "phyletic" and "phenetic" approaches. The phyletic component emphasizes the theoretical, phylogenetic, developmental and qualitative aspects of taxonomy; in contrast, the phenetic component emphasizes the objective quantification in classification through the use of empirical or derived mathematical models, based on a framework of measurement. These two ways of understanding the taxonomy are considered complementary and both are essential for a good classification system (Adams,1985). Such a concept is equally important in classification research pertaining to other disciplines, and Adams emphasises the importance of an adequate theoretical (phyletic) framework to guide the use of the mathematical procedures, when embarking upon neuropsychological subtyping research.

The process of forming a valid classification is directly involved in developing reliable diagnostic criteria from which theories and therapeutic plans can be generated (Kendell,1975). Thus a good, well-validated classification of learning disabled children should provide not only a greater understanding of learning disabilities as a whole, but also stimulate further research into the etiologies, prognoses and treatments of the various subtypes.

Morris and Satz (1984) have suggested that much of the

subtyping literature could be criticized for the failure to understand the underlying conceptual framework and purpose of classification. In particular, they criticize the failure of most subtype research to recognize the value and importance of relevant and reliable subtypes to the whole process of clinical diagnosis and treatment of learning disabilities in children. Although some definable subtypes have been identified in various studies using clinical or statistical approaches, many of them have had little impact on either neuropsychological theory or clinical practice. Wilson and Risucci (1986) attribute this to a failure on the part of researchers to integrate clinical-inferential and quantitative methods into the assessment and validation processes.

The present study attempted to address this problem by using a combination of the two generally accepted methods employed in subtyping research, namely: a)clinical inspection of test data and sorting techniques, and b) multivariate statistical methods. Both methods are oriented towards the same goal, and many psychiatric classification systems have used statistical techiques in conjunction with clinically derived methods, thus allowing each to be used to validate the classifications derived by the other (Morris and Satz, 1984). A recent classification study on language disordered children has also adopted this model (Wilson & Risucci, 1986).

The subject sample in the present study includes clinic referred children with learning, behavioural or social difficulties as well as a small group of normal children without any such problems. As the value of any typology to be used for explanatory purposes depends upon its validity, evaluations of the reliability, homogeneity and coverage of the subtyping solution were made susbsequent to the statistical classification. External validity of the typology will be evaluated by comparison with a number of external variables, including academic performance, behavioural, social, medical and developmental factors. This procedure is already in progress and will form the basis of a future study.

REVIEW OF THE LITERATURE

This review of the literature will begin by discussing the various issues relating to the definition and sampling of a population of learning disabled children. The literature which describes the search for subtypes in learning and reading disabilities will form the main focus of the review, and will include studies which involve various different population samples of learning disabled children, as well as a variety of methods used in the classification. Literature involving the theoretical aspects and problems of classification will also be reviewed.

Definition and Sampling Issues

Research into reading and general learning disabilities in children has been characterized by conflicting and confusing results. It is generally concluded that the reason for this is based upon the lack of agreement about terminology as well as definitions in regard to these disorders. This, in turn, has resulted in wide variation amongst subject samples between studies, which can obscure research findings and invalidate comparisons between studies.

A certain proportion of children within the regular school system have trouble acquiring academic skills, for reasons associated with mental retardation, gross

neurological impairment, severe emotional disturbance, cultural disadvantage or inadequate teaching. However, since the early fifties, it has been recognized that many children experience considerable difficulty in learning basic academic skills, although none of the above factors seem to account for their problems in learning.

Since the first case studies of children with such unexplained learning difficulties, some form of congenital defect with a neurological emphasis has been assumed. Morgan (1896) reported the earliest case of what came to be known as "congenital word blindness", and Hinshelwood subsequently published two monographs on this topic (1900,1917). He defined the condition as a "congenital defect occurring in children with otherwise normal undamaged brains, characterized by a disability in learning to read so great that it is manifestly due to a pathological condition, and where attempts to teach the child by ordinary methods have failed". Hinshelwood emphasised "the gravity of the defect" and the "purity" of the symptoms, which should be identical to those cases of acquired word-blindness with presumed lesions in the angular gyrus area of the brain. He also distinguished between this pure form and cases of children with milder disorders e.g. some slightly defective development of visual memory, and suggested the term "congenital dyslexia" for this latter group. This term was the one which survived

and became used for all forms of reading disability, whether mild or more severe.

The World Federation of Neurology agreed on a definition of developmental dyslexia, which reads as follows: "A disorder manifested by a difficulty in learning to read, despite conventional instruction, adequate intelligence, and socio-cultural opportunity. It is dependent upon fundamental cognitive difficulties which are frequently of a constitutional character" (Critchley,1970).

The work of Strauss and Werner (1938), Strauss and Lehtinen (1948), Strauss and Kephart (1955), and Cruickshank (1966) was influential in expanding the concept of dyslexia to encompass all forms of academic difficulty, including reading disorders. And Kirk (1963) is credited with coining the term "specific learning disability" to describe this group.

The first widely accepted definition of learning disabilties was the one put forth in 1975 by the 94th U.S. Congress, and reads as follows:

> Specific learning disability is a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in an imperfect ability to listen, think, speak, read, write, spell or to do mathematical calculations. The term includes such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. The term does not include children who have learning problems which are primarily the result of visual, hearing or motor handicaps, of mental retardation, of emotional disturbance, or of cultural,

environmental, or economic disadvantage.

Such definitions have become the source of much controversy and criticism over the years, both for the ambiguity in terminology as well as for the fact that diagnosis of dyslexia necessarily becomes one of exclusion. For example, Rutter (1978) suggested that the ambiguous wording of the definition could imply that a diagnosis of "learning disabled" was invalid if a child had visual or hearing problems, a lower than average IQ score, came from a poor family or had an unconventional background.

The research group associated with the Florida Longitudinal Project (Satz, Morris and colleagues) were amongst the critics of the World Federation definition, and were particularly concerned about the assumption in the and can be differentiated from other disabled readers. Using this definition, they selected a group of "dyslexic" disabled readers, who met the exclusionary criteria, and compared them to a matched group of "non-dyslexic" disabled readers, who had failed to meet one or more of the exclusionary criteria. Both groups as well as a normal control group received a number of neuropsychological, educational and personality tests, and the results showed that both groups differed from the control group, but there were no differences between the "dyslexic" and the non-dyslexic poor readers. This study (Taylor, Satz & Friel, 1979) was clearly designed to demonstrate the

worthlessness of the exclusionary criteria and the classic definition of dyslexia, particularly for the selection of subjects from a general school population. However, although the vigorous criticism levelled against the World Federation definition of dyslexia is, no doubt, justified, it should be mentioned that both Benton (1975) and Mattis (1978) have since proposed alternative definitions, which have positive defining criteria and avoid exclusionary clauses.

The medical concept of dyslexia as a syndrome of constitutional origin, with the assumption of a neurological basis, has also been the source of much controversy over the years. Although a neurological basis for specific learning disabilities has never been established, it remains a widely held premise, with broad acceptance by clinicians (Gaddes,1985; Hooper & Boyd,1986; Rourke,1975). However, although it is a likely presumption that dyslexia involves a developmental failure in neural integration, for which there is much circumstantial support, Benton (1975) has emphasised that it is still only a presumption, lacking any clear scientific evidence to this effect. Nevertheless, based on this premise, it has been assumed by physicians and many clinicians that children with constitutionally based reading or other learning disabilities can and should be conceptually separate from the larger population of below average learners.

Educators and other professionals object to this assumption, and prefer to use an operational definition of poor reading ability in children, namely: a "retarded reader" is one whose reading achievement is below what is normally expected for the child's age, ability and grade level; a "serious" reading deficit is defined as two or more years below grade level, and is termed a "disability", frequently attributed to cultural or emotional deprivation or other environmental factors.

Rutter (1978) also argued that the World Federation of Neurology's definition was impracticable for general use. He presented evidence from epidemiological studies in London and the Isle of Wight to show that, on statistical, medical and educational grounds, the distinction between two groups of underachieving readers (the "backward readers" and those with "specific reading retardation") was valid. Those whose reading level was well below that expected for their chronological age, but consonant with their IQ level were termed "backward readers"; children whose reading achievement was low, after taking both age and IQ level into account, belonged to the "specific reading retardation" group (Rutter, Tizard & Whitmore,1970; Rutter & Yule,1973,1975; Yule, Rutter, Berger, & Thompson, 1974). The findings of such studies are summarized as follows: a) The syndrome of "specific reading retardation" (SRR) occurred at a rate higher than would be expected on a

normal achievement distribution, forming a "hump" on the lower end of the distribution curve; b) There was a higher ratio of boys to girls in the SRR group (3.3 to 1), whereas sex distribution in the "general reading backwardness" (GRB) group was almost equal (1.3 to 1); c) Overt neurological disorder was more frequent in the GRB group (11.4%) as were wide range of "dubious" neurological deficits, including motor, praxic and speech abnormalities (25.3%). In contrast, there was no association with overt or "hard" neurological signs in the SRR group, although "dubious" (or "soft") neurological signs were evident to a lesser degree than in the GRB group (18.6%). ("Soft" signs can reflect either structural defects in the brain or developmental delay). d) However, the SRR was strongly associated with speech and language impairments. e) A greater proportion of the GRB group came from socially disadvantaged homes, and the familial incidence of reading difficulties and delayed speech acquisition in both retarded reading groups was about three times that of the control group. f) On follow-up at age 14, despite their generally higher IQ level, the SRR children made significantly less progress than the GRB group in reading and spelling, but sigificantly more progress in arithmetic, although both groups were still impaired in all three subjects.

Thus, although Rutter's subtyping of retarded readers

was based entirely upon a statistical definition, the concept of SRR is clearly meaningful both clinically as well as in terms of prognosis. The high male and familial incidence and the abnormalities in language development are characteristic of groups that could be diagnosed as "dyslexic" according to the World Federation of Neurology's definition. However, having been very critical of the term, "dyslexia", for not referring to any well-defined or easily diagnosed disorder, Rutter (1978) suggested the concept of SRR as an alternative, which could be easily defined by using the appropriate regression equation for the prediction of achievement, based upon the observed correlations between educational level, age and IQ in the general population. In so doing, it would also be possible to avoid any implications of an underlying neuropathological condition. Rutter (1978) also took care to emphasise that SRR was multifactorially determined, involving such factors as family size. SES, location of habitat, type of school and temperamental characteristics, presumably to avoid any suggestion of a unitary cause, such as dyslexia.

In discussing the relaticnship between neurological impairment and learning disabilities, Spreen (1989) cites the above series of epidemiological studies, pointing out the clear parallel to a study by Dingman and Tarjan (1960). Using actual prevalence estimates, these authors called

attention to the expected frequencies of varying degrees of intelligence under the Gaussian distribution curve, and concluded that there was an excess of cases at the lower end of the distribution (a result also found by Roberts, 1952). The authors postulated that the excess was due to pathological factors (e.g. brain damage of pre-or post-natal origin) and that this population could be viewed as having a separate distribution curve (with a mean of 32 and a standard deviation of 16), which extends well into the normal IQ range. Spreen suggests that the excess in the rate of the SRR group in Rutter and Yule (1974,1975) studies might also reflect a "pathological excess" of an otherwise normally distributed ability, i.e."that we can expect a certain proportion of people specifically disabled in intelligence, reading ability, and indeed musical or mathematical or any other abilities in any large population sample. However, the proportion at the low end of the distribution is higher than expected; this "excess" may be considered as resulting from pathological causes" (p. 393). Spreen tentatively concludes that a certain proportion of dyslexics should be expected on the basis of normal distribution of abilities alone, but the most likely explanation for the "excess" of cases is a genetic predisposition for neurological dysfunction, citing Regehr (1987) in support of this suggestion.

Research Strategies in the Study of Learning Disabilities

Traditionally, dyslexia was conceptualized as a unitary phenomenon, with many earlier researchers proposing theories concerning the basic underlying "cause" of the problem. For example, Orton (1937) proposed inadequate development of hemispheric dominance as the underlying problem; Kephart (1960) and Cruickshank (1968) both suggested perceptual-motor deficits; Smith and Carrigan (1959) proposed a theory of immature synaptic transmission to account for this condition, and Vellutino (1979) postulated that a verbal processing deficit was the single underlying factor in dyslexia. Similarly, some writers conceptualized a common basic deficit as underlying the broader category of specific learning disabilities (for example, Smith, Coleman, Dokecki and Davis,1971).

A substantial body of research was produced based upon this "unitary deficit" hypothesis, with predictable inconsistency in the findings. As Doehring (1978) pointed out, although such studies can often be criticized in terms of methodology as well as interpretation of results, the basic problem is the research paradigm employed.

This "single syndrome paradigm" in which groups of poor readers or poor learners were compared to groups of normal learners in relation to a single ability (e.g. visual perception), assumes that poor readers represent a homogeneous population deficient in a single ablity, which

is essential for learning to read (Applebee,1971; Wiener & Cromer, 1967). Such a model, as Doehring (1978) points out, has enjoyed a thriving existence in learning disabilities and dyslexia research over the years, and the numerous studies using this paradigm have, in effect, provided ample evidence to show that a very wide range of factors are associated with reading and learning disabilities. These include the following: pre-and perinatal factors (Kawi & Pasamanick,1959); finger localization and right-left discrimination problems (Kinsbourne & Warrington, 1963); temporal order recall and sequencing as well as serial positioning deficits (Bakker, 1967, 1972; Corking, 1974); bisensory memory (Senf,1969; Senf & Freundl,1971); perceptual-motor matching (Kephart, 1967; deficits in cerebral dominance (Orton,1928,1937; Satz, Rardin & Ross,1971; Yeni-Komshian, Isenberg & Goldstein,1975; Zurif & Carson,1970); crossmodal integration (Birch & Belmont, 1964,1965); and psycholinguistic deficiencies (Denckla,1972; Johnson & Myklebust,1967; Wiig, Semel & Crouse,1973, amongst many others). Rutter (1978) also mentions temperamental attributes, such as hyperactivity, poor concentration and impulsivity as associated factors (De Hirsh et al.,1966; Kagan,1965).

The evidence that a wide variety of deficits were associated with reading and learning disabilities prompted a further type of research strategy, which was essentially

an expanded version of the contrasting group model. It involved comparisons between groups of retarded readers and normal readers based on their scores from a large number of cognitive and neuropsychological measures (Doehring,1968). However, such a research design also had predictable problems related to the inconsistency of results between studies, largely due to the heterogeneity of the dyslexic groups.

Such research approaches eventually provided the impetus for conceptualizing learning disabilities in a multidimensional fashion, which resulted in the attempt to identify specific homogeneous subtypes within this population of children, based either on patterns of academic or reading skill deficits or neuropsychological variables (the "multiple syndrome" research paradigm, according to Doehring,1978). Such classification attempts, however, were not entirely new (particularly in relation to dyslexia), as is shown in the following section of this review, in which classifications based upon etiology are outlined. Where the current approaches break ground, however, is in attempting to find particular subtypes of the reading disability itself, which constitutes a multiple-syndrome model, with inferred multiple etiologies.

One further aspect of research strategy involves the selection of subject samples, which typically varies according to the theoretical stance of the investigators.

Thus, in earlier studies, subject selection was often based upon the exclusionary criteria of the classic definition of dyslexia, combined with a clinical examination which included a measure of reading skills. However, when discussing the study of dyslexia, Benton (1978) commented upon the danger of adopting too restrictive a definition, with criteria which may well exclude many cases which are relevant examples of a specific reading (or learning) disability. He emphasised the danger of excluding socially disadvantaged and emotionally disturbed children with severe reading (or learning) problems from consideration, because this may limit the diagnostic category of interest to a very select and "atypical" subgroup. Benton suggested that it may, therefore, be important to "cast a wide net" and study children with a wide variety of problems and deficits, including those with neurological, intellectual, social and emotional handicaps as well as those without any reading (or learning) problems at all.

The emergence of multivariate statistical classification techniques has, in fact, made such an approach to subject selection quite feasible, and is the method employed in such classification studies as Satz and Morris (1981) and Morris, Blashfield and Satz (1986), to be discussed later in this review. Important aspects of these studies are: a) the inclusion of normal readers in the total sample for cluster analysis, and b) the validation of

the subtypes on a large number of external variables, including birth data, neurological ratings, SES and parental education, teacher ratings of behaviour as well as personality test data. In this way, etiological factors have also been included into a classification of reading-disabled children.

The Search for Subtypes

Attempts to classify specific learning disabilities date from the 1960's and have involved several different approaches. A classic approach follows the single syndrome, multiple etiology model, in which dyslexia was still treated as an entity while many etiological causes were suggested (Bannatyne,1971; Keeney & Keeney,1968; Rabinowitch,1968). Most of these etiologically based classifications discriminated between a "specific (or primary) developmental dyslexia", and a type (or types) which were labelled as "secondary" or "symptomatic", i.e. reading retardation which was secondary to organic pathology of any sort, or resulting from emotional or motivational factors, cultural deprivation or other environmental circumstances, including overt brain damage. Quadfasel and Goodglass (1968) separated out the category of early brain damage into a distinct type of dyslexia (labelled symptomatic), in which the reading errors were similar to those of the primary dyslexic category. Bannatyne (1971) expanded the etiological classification to

include not only reading disabilities but all language disorders in children as well, using a hierarchical model. The groups in this classification included: intellectually retarded; emotionally disturbed; minimal neurological dysfunction; aphasic; dyslexic; autistic; as well as language deprivation; cultural or educational deprivation; and genetic dyslexia.

Arising out of the voluminous research of the sixties and seventies came the recognition of the heterogeneity of learning and reading disorders, leading to numerous studies which adopted the "multiple syndrome" method of classification. The two main approaches were: a) clinical-inferential, in which the division into subtypes was based upon clinical interpretation of psychometric assessment profiles (Boder,1979; Denckla,1977; Johnson & Myklebust, 1967; Kinsbourne & Warrington, 1963; and Mattis, French & Rapin, 1975), and 2) the use of empirical and objective multivariate statistical classification procedures such as Q-Type factor analysis or cluster analysis of psychometric data (Doehring & Hoshko, 1977; Fisk & Rourke,1979; Lyon, 1982; Petrauskas & Rourke,1979; Satz & Morris,1981). A further dimension of classification involved the actual performance variables used, such as whether subjects were classified a) on the basis of academic performance (Boder, 1973; Doehring & Hoshko,1977), or b) processing deficiencies, based on cognitive and neuropsychological

test performance (Petrauskas & Rourke 1979).

Almost all the early classifications were concerned with reading disabilities (dyslexia). This review will, therefore, begin by discussing the relevant research in relation to reading disabilities, and then go on to review the subtyping studies concerning other learning disabilities.

Clinical Inferential Classifications

As early as 1896, Charcot proposed the existence of two types of learners - visile and audile, according to Freud (1953). Also teachers through the years have assumed from observation that children with reading difficulties could be divided into those with "auditory channel deficits" and those with "visual channel deficits" (Mann & Suiter, 1974). Kinsbourne and Warrington (1963,1966) divided children (and one adult) on the basis of discrepancy scores on the WISC (VIQ/PIQ differences of 20 points or more). Judging from their performance on certain tasks, these authors suggested two different types of reading and writing retardation, namely a) a language deficit group, and b) a Gerstmann syndrome group, from which they drew analogies to two syndromes of cerebral cortical disorder in adults.

Smith (1970) also examined WISC profiles, from which were identified three subtypes of retarded readers: (1) Auditory sequencing and symbol manipulation were weak but

spatial ability was intact, (2) Spatial-perceptual skills were weak, whilst auditory sequencing and symbol manipulation were intact, and (3) Both spatial ability and auditory sequencing/symbol manipulation were deficient, suggesting a "mixed" subtype. Bateman (1968) also identified three groups of poor readers, based on examination of ITPA (Illinois Test of Psycholinguistic Abilities) profiles: Group 1 had good visual memory but poor auditory memory; Group 2 had good auditory memory but poor visual memory; and Group 3 had both poor visual and auditory memory. Similarly, Ingram, Mason and Blackburn (1970) examined 82 highly pre-selected children, with reading and spelling difficulties, employing an exclusionary definition for "dyslexia". They identified three subgroups of dyslexics: (1) an audiophonic type, with problems in sound discrimination and sound blending, as well as difficulties in phonic analysis, (2) a visuo-spatial type, with difficulties in visual discrimination and orientation (e.g. p,b, and d confusion) as well as in word recognition, and (3) a mixed type, who had both varieties of problems.

Although some of these studies lacked a control group of normal readers, and the selection of subjects was not clearly described in others, there is a great deal of agreement in results, which all suggest a fundamental dichotomy of visual processing and auditory processing

subtypes of dyslexia, with a third subtype which is a mixture of these two problems. Johnson and Myklebust (1967) also argue for two broad subtypes of dyslexia: the auditory and the visual subtypes, although these conclusions are based solely on observation and extensive clinical experience, and are not derived from any specific studies. However, they describe these particular types of reading problems in such detail, with specific examples of particular deficits and the associated academic difficulties, that their contribution to the field of learning disablities has been most influential.

The studies described above were amongst the first suggesting that there might be two or more subtypes of reading problems, and by the 1970's, there was increasing acceptance of the fact that dyslexia was not a homogeneous diagnostic entity. Among the notable researchers who attempted to demonstrate this heterogeneity are Boder (1973), Mattis, French and Rapin (1975), Denckla (1977, 1979), Myklebust (1978) and Bakker (1982), all of whom have adopted a clinical-inferential, theoretical or otherwise non-statistical approach to typology. Their contributions will be discussed separately below. While acknowledging that there are a number of others who have contributed to subtype research, including Pirozzolo (1979) and Aaron (1978,1982), the present review must necessarily be selective. Suffice it to say that both these investigators

reported two basic subtypes of reading disabilities, which involved the differing processing skills of the two hemispheres, based upon precise measurements of eye-movements (Pirozzolo) or difffering information processing strategies (Aaron).

Ingram, Mason and Blackburn (1970) had identified three subtypes of dyslexic children on the basis of their performance on reading and spelling tasks. Boder (1971, 1973), however, was the first to define specific diagnostic criteria for inclusion in each group of dyslexic subtypes, on the basis of their reading-spelling errors. Her research is noteworthy because of the careful qualitative as well as quantitative analysis of such errors, by which she was able to classify a pre-selected group of dyslexic children (who fitted the standard definition) into three subtypes: (1) a "dysphonetic" group, where the reading-spelling pattern reflected a primary deficit in phonetic word-analysis and synthesis skills, so that words were read as wholes, with substitution of semantically similar rather than phonetically similar words. The largest proportion (67%) of the sample belonged to this group; (2) 10% of the subjects were classified into a "dyseidetic" group, where the primary deficit involved the visual perception of whole words or the revisualization of words in spelling; (3) a mixed "dysphonetic-dyseidetic" group where both types of reading/ spelling problems were evident (23% of the sample). Of the

107 children, 100 could be classified into one of the three groups, only 7 falling into the "undetermined" category.

Boder's intention was to raise the level of diagnosis of developmental dyslexia from being one of exclusion to one of discrimination. Thus, her clearly defined diagnostic criteria would discriminate dyslexics from normal readers as well as from "non-specific" (secondary reading retardation) poor readers, using strict quantitative and qualitatve guidelines (Boder & Jarrico, 1982). There is much indirect support for Boder's subtyping in the literature (Bateman, 1968;Ingram, Mason & Blackburn, 1970; Johnson & Myklebust, 1967; Kinsbourne & Warrington, 1963; Smith,1970). Also, there have been several attempts to evaluate Boder's typology, using external criteria, which included language and non-linguistic tasks (Sweeney & Rourke,1978); electrophysiological measures (Fried, Tanguay et al.,1981; Leisman & Ashkenazi,1980; Rosenthal,Boder & Galloway,1982); dichotic listening and bi-sensory digit tasks (Obrzut, 1979); and experimental measures of hemispheric lateralization (Dalby & Gibson,1981). These studies produced some indirect support or else equivocal and mixed support for Boder's typology.

Mattis, French and Rapin (1975) approached the question of dyslexia from a theoretical viewpoint, derived in part from adult alexia literature, in which there were several causal deficits. Hence, these authors developed a

model of dyslexia (resembling Applebee's Model 2, 1971), which involved two major assumptions: a) that reading is a very complex process which requires the successful integration of several input, output and mediating processes, and b) that a deficit in any one of these critical processes will impair the learning of this complex skill. Theoretically, therefore, there should exist separate subgroups of dyslexic children, each cluster of deficits in higher cortical functioning representing a different defect in a critical process, necessary for learning to read.

Using a battery of neuropsychological measures as the basis of classification, Mattis, French and Rapin (1975) isolated three independent syndromes of dyslexia, which accounted for 90% of the 82 clinic-referred dyslexic subjects, aged 8 to 18. A unique feature of this study was the inclusion of a comparison group of brain damaged children who were normal readers. In this way, all those deficiencies in higher cortical functions which were found in this group could be disregarded as not causal to dyslexia. The authors were also particular about establishing strict and quantitatively defined criteria for each syndrome. The three syndromes, empirically defined, are described in Table 1. The 82 dyslexic subjects included both a brain damaged and a non-brain damaged group, who did not differ significantly in their level of measured

Table 1. Dyslexia Syndromes (Mattis et al. 1975)

I.	*Language Disorder*	
	(A)	Anomia (20% or greater proportion of errors on the Naming Test) and one of the following:
	(B)	Disorder of comprehension (performance on Token Test at least one standard deviation below the mean) or
	(C)	Disorder of imitative speech (performance greater than one standard deviation below the mean on the Sentence Repetition Test) or
	(D)	Disorder of speech sound discrimination (10% or greater proportion of errors on discrimination of 'e' rhyming letters).
II.	*Articulatory and Graphomotor Dyscoordination*	
	(A)	Performance on ITPA Sound Blending subtest greater than one standard deviation below the mean; and
	(B)	Performance on graphmotor test greater than one standard deviation below the mean; and
	(C)	Acoustosensory and receptive language processes within normal limits.
III.	*Visuospatial Perceptual Disorder*	
	(A)	Verbal IQ more than 10 points above performance IQ; and
	(B)	Raven's Coloured Progressive Matrices percentile *less than* equivalent performance IQ; and
	(B)	Benton Visual Retention Test (10-sec exposure, immediate reproduction) score at or below the borderline level.

intelligence. However, the brain damaged dyslexic group included a much greater proportion (43%) of the language disorder syndrome, compared with only 28% in the developmental dyslexia group. In contrast, the articulatory-graphomotor syndrome was observed in 48% of the developmental dyslexics and only 30% of the brain damaged dyslexics. In both groups, the proportion of children observed with visuo-perceptual disorder was relatively small (14 to 17%). It was emphasised in the study that no dyslexic child demonstrated findings consonant with more than one syndrome.

A cross-validation study on a sample of 163 black and Hispanic dyslexic children was reported by Mattis (1978) and provided support for the above subtyping. All three previously isolated dyslexic syndromes were again observed: 63% were classified as language disorder syndrome; 10% as articulatory-graphomotor syndrome, and 5% as visual perception disorder syndrome. All three syndromes were present in both primary (genetic) and secondary (brain-damaged) dyslexic children, but unlike the original study, mixtures of symptoms from all three syndromes emerged in 9% of the sample.

The reason for this, Mattis explained, was due to a greater number of subjects with multiple deficits and borderline or retarded intelligence in the subject sample.

The Mattis et al (1975) study has been criticized because they used a clinic-referred sample, limiting generalizability of the results (Rutter,1978); because they failed to validate the subgroups on measures of specific reading skills (Lyon,1983); and because the subgroups were independent and homogeneous, with exclusive membership, i.e. monothetic as opposed to polythetic groups are more appropriate for this population (Satz & Morris,1981). These critics also questioned the use of "a priori" decision rules for the classification, which may not reflect the true, hidden structure (natural groupings) of the data.

In a retrospective study of 52 dyslexic children (independent of etiology), selected from 297 patients (aged 7 to 14) seen in consultation, Denckla (1977) reported five types of dyslexia: 28 children with language disorder, involving prominent anomia; 6 subjects with articulatory-graphomotor dyscoordination syndrome; and 2 subjects with a visual-perceptual syndrome combined with anomia. This was evidently an attempt to replicate Mattis et al's (1975) findings on a different sample of children, also using a brain-damaged good reader group for control. Denckla also identified a "dysphonemic sequencing" difficulty in 7 cases, characterized by poor repetition scores, with phonemic substitutions and mis-sequences, as well as a "verbal memorization (learning) disorder" in 5 older children (13 to 15 years), where sentence repetition and

verbal paired associate learning were deficient, although language skills in general were intact (see Table 2). These last two subtypes were only suggested, as there was no brain-damaged good reader control group for this age range.

Later, in 1979, Denckla reported six types of dyslexia, with detailed clinical descriptions and characteristics which are listed in Table 3. Her subtypes, based upon clinical observation, include several that Mattis et al. (1975,1978) identified, although she had been unable to confirm the existence of a visual-perceptual disorder. She also identified a rare type of "correlational dyslexia", in which reading was normal but below expectations, given the intelligence level. The problems in these cases are subtle and mainly involve an imbalance of strategies, according to the author. It appears that Denckla strongly emphasises an impairment in language functioning as the primary problem in dyslexia. This is frequently not apparent in the verbal subtests of the intelligence scales, and may take a variety of different forms, including anomia, articulatory disorders, repetition and sequencing problems as well as verbal memory disturbances.

In 1978, Myklebust added several more subtypes to those originally described (Johnson & Myklebust,1967), in accordance with his newly developed conceptualization of dyslexia as a fundamental disturbance in cognitive and language functioning. This cognitive disturbance was

Table 2. Dyslexia Subtypes (Denckla, 1977)

1.	Language disorder with prominent anomia	(N = 28)
2.	Articulatory-graphomotor dyscoordination syndome	(N = 6)
3.	Visual-perceptual syndrome, combined with anomia	(N = 2)
4.	Dysphonemic sequencing disorder	(N = 7)
	poor repetition scores	
	phonemic substitutions and missequences	
5.	Verbal memorization (learning) disorder	(N = 5)
	Sentence repetition and Paired associate learning both poor	(13 to 15 years)
	although general language skills intact.	

Table 3. Dyslexia Subtypes (Denckla, 1979)

1. Global-mixed language disorder
   a. All tests of language fall below age expectations (comprehension, repetition, and naming tests)
   b. Verbal IQ is below 90 and performance IQ is at least 95

2. Articulatory-graphomotor disorder (Mattis et al., 1975)
   a. Fine motor coordination and pencil use deficient
   b. Language tests normal; articulation deficient

3. Anomic-repetition disorder
   a. Circumlocutory and paraphasic errors account for most excessive errors on confrontation naming
   b. Sentence and digit span shorter than, as well as qualitatively worse than, expected for age group (not true after ten years)
   c. Articulation and comprehension normal
   d. "Scatter" among subtests on verbal IQ

4. Dysphonemic-sequencing disorder
   a. Sentence and digit span "failed" by virtue of omissions, substitutions, errors of sequence
   b. Naming errors (not excessive in number) also characteristically phonemic and/or sequential details
   c. Complex synactical constructions misunderstood
   d. Articulation and verbal IQ at least average

5. Verbal learning (memorization) deficiency

6. Correlational (sequential-simultaneous?) deficiency

Note: numbers 1, 2, 3, and 4 also recognized by Mattis, 1977.

manifested, according to Myklebust, in a deficit in the ability to gain meaning from language symbols and the written word. The most severe form he termed "inner language dyslexia" or "word calling", which involved adequate decoding and mechanical reading skills, but there is no cognitive understanding of the meaning of what is read. This would seem to be the same condition that others term "hyperlexia" (Denckla,1979). Myklebust also describes "auditory dyslexia" and "visual dyslexia", which, unlike his previous notions of such types of reading difficulties, do not just involve either auditory or visual perceptual deficts. Instead, they represent basic cognitive disturbances in attaching meaning to what is heard or seen, i.e. auditory agnosia or visual-verbal agnosia. Myklebust also suggests a "cross-modal" dyslexia, which is an inter-neurosensory learning deficit, which again can be subdivided into "auditory intermodal dyslexia" and "visual intermodal dyslexia" depending upon the modality principally involved. While these concepts are interesting, Myklebust gives very little detailed information about the exact characteristics of each type of reading deficit, so that they cannot be easily compared to other typologies.

Based on the theory that each cerebral hemisphere plays a prominent but different role in the processing of reading material, Bakker (1982,1983) proposed two subtypes of specific reading disturbance. He cites evidence

suggesting that the right hemisphere is the primary processor of perceptually complex script, and suggests that in the early stages of learning to read, perceptual analysis and strategies are the most active and important. As these processes gradually become automatic, the need for semantic and syntactic strategies begins to assume greater importance in order to gain meaning from the text. Left hemisphere strategies are presumed to become more prominent during the later stages of learning to read. Therefore, in normal readers, perceptual strategies generated by the right hemisphere should gradually make way for the linguistic and assimilation processing of the left hemisphere, as children advance from single-word reading to fluent reading.

However, this shift from primarily right hemisphere to primarily left hemisphere processing of written language does not always occur, probably because of a functional supremacy of the right hemisphere. In other cases, possibly because of weakened right cerebral functioning or a functionally overdeveloped left hemisphere (expressed in a powerful right ear preference on dichotic listening tests), some children will tend to use left-hemisphere linguistic strategies from the very onset of reading, running into problems because they fail to pay attention to the spatial-perceptual features of the text. Thus, initially, perceptual strategies generated by the right hemisphere are

of fundamental importance. If these are not sufficiently represented, then such children usually read hastily and inaccurately, because of their linguistic approach to the reading material, and Bakker has labelled these types of reading disabled children L-type dyslexics. In other cases, where the young reader fails to reach the linguistic stage and clings to perceptual strategies, reading is relatively slow, with a letter by letter approach and many fragmentations and repetitions. Because they are sensitive to the perceptual aspect of the script, such children are labelled P-type dyslexics by Bakker. He cites evidence which indicates that L-type dyslexics show a strong left hemisphere lateralization (right ear advantage), while P-type dyslexics exhibit a right or bilateral representation of language on dichotic listening tests (left ear advantage).

Bakker's subtyping of dyslexia, based upon a hemisphere specific model, supports several other two-type classifications of dyslexia (e.g. Johnson & Myklebust, 1967; Kinsbourne & Warrington, 1963,1966). The difference is that Bakker provides a fairly plausible theoretical model to account for his two subtypes of dyslexia, with descriptions of the reading style which have clinical relevance. His theory is based upon much experimental research (Bakker,1973,1979,1981,1982,1983; Geschwind, 1979; Heir, le May, Rosenberger & Perlo,1978; Keefe & Swinney,

1979). Bakker has also recently produced some evidence to show that hemisphere-specific stimulation of the contralateral hemisphere in the two types of dyslexic children appears to have a positive effect on the their subsequent reading performance (Bakker, 1984; Bakker & Vinke, 1985). However, a recent dissertation (Gloria Grace, 1990, University of Victoria) did not confirm this.

Multivariate Statistical Classification Approaches

Because of rapid advances in high-speed computer technology, the use of empirical statistical techniques in subtype research has increased rapidly over the last 10 years and is now the universal method of choice in classification studies. Three of the earliest studies in which cluster analysis was used to find subtypes of dyslexic children were not particularly successful. Naidoo (1972) found two groups in her clinic referred sample: one with a language disorder and a family history of reading or speech problems, and one without such characteristics and no clear cognitive pattern. Also the percentage of unclassified subjects was quite high. Nor did the other two studies apparently obtain any clear clusters of reading disabled subjects in their attempts to use this method (Rutter,1969; Smith & Carrigan,1959).

In the first successful attempt to explore subtypes of reading problems in children using multivariate empirical techniques, Doehring and Hoshko (1977) identified three

subtypes by means of Q-type factor analytic methods. They described these subtypes as follows: (Type O) linguistic deficit; (Type A) poor intersensory integration; and (Type S) temporal ordering deficit. The findings of this study were replicated later by Doehring, Hoschko and Bryans (1979), who included a group of normal readers in the sample, and the same three subtypes emerged almost intact. Doehring, Trites, Patel and Fiedorowicz (1981) expanded this research by including tests of language and neuropsychological functioning in additon to the previously used measures of the reading process. While this ambitious study was not entirely successful in the attempts to add further measures for external validation, three reliable subtypes were, again, identifed, and remained stable through many manipulations of subject samples, additional variables, as well as a different method of statistical analysis (cluster analysis).

Following Doehring's success with Q-factor analysis, Petrauskas and Rourke (1979) and Fisk and Rourke (1979) used the same multivariate approach to identify subtype patternsof performance on a battery of neuropsychological tests in reading disabled and learning disabled children. Petrauskas and Rourke (1979) identified three reliably replicated subtypes of reading disabled subjects: (1) A language disordered group with significant deficits in verbal fluency and auditory memory, as well as the largest

VIQ/PIQ discrepancy on the Wechsler Intelligence Scale for Children (lower VIQ); (2) A sequencing disorder group, with poor performance on the Wechsler sequencing tasks (the ACID pattern) as well as impaired visual memory and finger localization; (3) A group with poor conceptual development and poor eye-hand coordination, which the authors equated with the articulation graphomotor dyscoordination group described by Mattis et al.(1975). In this study, a group of normal readers was included in the subtyping analysis, for which the authors received credit in a review by Satz and Morris (1981). However, only 50% of the subjects were classified into replicable subtypes. In the second investigation, Fisk and Rourke (1979) attempted to verify the stability of these subtypes across three different age groups of children with general learning disabilities (not just reading problems). Using Q-factor analysis on the neuropsychological test scores at each age level, two of the previously identified subtypes emerged across all three age levels - a language disability group and a sequencing disorder group with poor finger localization. Eighty percent of the sample was successfully classified.

Lyon and Watson (1981) used hierarchical cluster analysis to identify subtypes on a sample of school verified 11 and 12 year old learning disabled poor readers. On the basis of 8 neuropsychological measures, chosen for their resemblance to the Mattis et al. (1975) battery,

cluster analysis yielded six homogeneous subtypes, which accounted for 89% of the subjects. Two of the subtypes identified had a mixed language and visual-perceptual disorder, in one of which the problems were more serious than in the other; the third subtype had both receptive and expressive language difficulties with very poor phonetic skills; and the fourth subtype showed a global language disorder, much more severe than subtype 3. The fifth subtype had deficits in visual-perceptual-motor skills; and subtype 6 showed a normal diagnostic profile. The surprising finding in this study was that the "visual perceptual" subtype included the largest number of subjects, which is unusual compared with previous studies, which have always suggested that the visual perceptual type of reading disability is quite rare. Further validation of these subtypes revealed significant differences among the groups in comprehension, spelling and reading performance (Lyon, Reitta, Watson, Porch & Rhodes,1981; Lyon, Stewart & Freedman,1982), as well as differential response to treatment (Lyon,1983). This research group is notable in its conscientious attempts at replication as well as the consistent evaluations against external criteria in order to validate their typology.

Using data from the Florida Longitudinal Project, Satz, Morris and Darby (1979) and Satz and Morris (1981) used cluster analysis to select a sample of 89 poor readers

from an unselected sample of 289 boys, on the basis of their reading. spelling and arithmetic scores on the WRAT. This totally objective, empirical approach to sample selection was consistent with the Satz research group's rejection of the concept of dyslexia as a specific group of disabled readers, for which the definition required them to be identified only by means of exclusionary criteria. Using four neuropsychological tests as the basis for cluster analysis on this subject sample, five subtypes of reading disabled boys were identified, as follows: a global language impairment; a naming disorder; a "mixed" language and visual-perceptual impairment; a visual-perceptual-motor disorder; and normal performance ("unexpected learning disability"). Ninety seven percent of the sample were classified. The cluster groups were examined against external variables, which included WRAT scores, neurological status, socioeconomic levels (SES) and parental reading levels.

The possibility of developmental changes with age in the patterns of deficit in learning disabled children has seldom been considered in subtype research. Opinions concerning this question vary: Satz et al. (1978), while conducting a longitudinal study of children from kindergarten to Grade 6, found some results which upheld the concept of age-related changes. Rourke (1977), on the other hand, maintained that subtypes should persist across

the school-age span. However, the previously mentioned study (Fisk & Rourke, 1979), which examined subtype patterns across three age-groups (9-10, 11-12 and 13-14) showed two of the subtypes emerging at all three age levels, but the third subtype was not present in the youngest age group.

Two fairly recent subtyping studies have addressed this question by adopting a longitudinal approach to the study of learning disabilities. The first of these was conducted by Morris, Blashfield and Satz (1986) on two pooled samples of reading disabled children combined with age-matched normal readers. All children were tested longitudinally at three age levels (kindergarten, Grade 2 and Grade 5), and 8 of these neuropsychological measures were selected for cluster analysis at each of the three age levels. The two best validated cluster solutions were chosen for description: 1) the two cluster solution represented a basic division between good readers and poor readers, and 2) further partition into five clusters revealed three subgroups of poor readers (Types A,B and C), and two subgroups of good readers (Types D and E). The subtypes were described as follows: Type A had deficient verbal skills and increasing improvement of visual perceptual skills with age; academic achievement was poor except for mathematics, and teachers rated them as being more active and emotionally reactive than their peers.

Type B children showed deficient visual-perceptual-motor skills and increasing deficits in verbal conceptual abilities as they grew older. Both the children and their parents had below average achievement scores, despite average parental education and SES levels. Neurological and birth history ratings showed more than normal problems. Type C children and their families were all below average on all tests and ratings. Type D subjects were shown to have above average performance on all tests and teacher ratings as well as family, birth and neurological data. Finally, Type E children were well above average on all tests as were their parents. They also had the least neurological and birth history problems. A unique feature of this study was that it was possible to examine developmental changes and follow the history of several subtypes over time. For instance, a comparison of the five subtypes shows that two basically different developmental patterns are in operation: the first includes the two normal reader subtypes (D and E) as well as the reading disabled group whose deficits were more general ("slow learner" group C), all of which show a consistent parallel development of abilities: Cluster E performed at above average levels across age-groups; Cluster D represented the normal development of the average child; and Cluster C consisted of generally slower functioning children, who made slower but consistent progress over time. (In some typologies, this group might be considered a "mixed"

subtype). In contrast, the second pattern group includes both the poor reader subtypes (A and B), whose development is remarkably inconsistent with various abilities developing at quite different rates.

The second study which examined developmental changes in subtypes of learning disabilities was conducted by Spreen and Haaf (1986). Subject samples were drawn from the Victoria longitudinal study of learning disabled (LD) children, and consisted of two groups of LD children (average age 10 years), some of whom (together with a matched control group) were followed up into adulthood and tested again at an average age of 24 years. Using a subset of neuropsychological and academic measures, cluster analyses were performed on all three groups with the following results: Group 1. Six clusters were identified in this 8-12 year old referral group of 63 children: a) a subtype with a specific reading disability, with deficits in sentence repetition, right-left orientation and coding, b) a subtype with a specific arithmetic disability, c) a linguistic deficit subtype with difficulties in similarities, vocabulary and coding subtests, d) a visuo-perceptual deficit subtype with difficulties in vocabulary, block design and coding (these last two subtypes were impaired in all areas of academic skill), e) a subtype in which scores were quite low in all areas, indicating pervasive and severe deficiency (Mean IQ=69), and f) a

subtype which was high in all performance areas, a minimally impaired type.

Cluster analysis on the second subject sample yielded eight subtypes, as follows: a) a minimally impaired subtype, b) a severely impaired subtype; c) a specific arithmetic disability subtype, d) a specific reading disability subtype with problems in graphomotor skills, e) a specific reading disability subtype with good verbal skills but poor scores in block design, coding and right-left orientation, f) a subtype with poor achievement in all academic skills, with generally severe impairment on other measures, but particularly block design, suggesting visuo-perceptual problems, g) a subtype with poor scores in all academic skills, but milder general impairment, except for right-left orientation which is weak, and h) a subtype with less impairment in academic skills that either subtypes (f) or (g), but has distinct problems in similarities and vocabulary subtests, suggesting a linguistically impaired subtype.

Finally, cluster analysis on the adult group (which included the normal control group) classified 100% of the subject sample and yielded nine clusters: Three of the clusters (Clusters 1,4 and 5) were composed mainly of control subjects together with a few of the highest performing LD subjects, although members of cluster 5 showed poorer scores in arithmetic. Cluster 2 also showed a

specific arithmetic disability; Clusters 9 and 3 represented the more generally impaired subtypes, with 9 the most severely impaired, while 3 showed good sentence repetition and right-left orientation. Cluster 7 members had a specific reading disability, but good performance on all other tests; Cluster 6 showed very poor reading comprehension, right-left orientation and motor skills, but good verbal fluency (suggested by the authors as a visuo-motor dyscoordination subtype); Cluster 8 was very similar, with poor block design and motor skill scores, although academic skills were better than in Cluster 6 and reading comprehension was adequate.

Although the cluster solutions for the two younger aged groups were not identical, there is a reasonable degree of concordance between groups. In both groups there are severely impaired and minimally impaired subtypes, a visual-perceptual subtype associated with general academic impairment, a linguistic deficit subtype, and a specific arithmetic subtype. The variations seem to be related to the specific reading disability subtypes, for which more information would be required in order to judge similarities. When the clusters from the group of subjects tested both in childhood and then later as adults are examined and compared, some similarity is evident. In both the referral age and adult groups, a reading disabled subtype with otherwise minimal impairment was identified;

also a specific arithmetic disabled subtype. Among the remaining adult clusters was a generally quite severely impaired subtype; a visuo-perceptual disorder subtype and a graphomotor subtype. However, at adult age, the linguistic subtype, which had been present in both the childhood groups was no longer present, and the subjects who had belonged to this subtype as children appeared in the adult clusters as members of the overall generally impaired group.

Classification Issues in Subtype Research

As previously discussed, the major shift in attitude and universal acknowledgement of the heterogeneity of learning disabilities has resulted in an increasing number of studies in which attempts have been made to develop a typology of this subject population. While forming a fundamental component of research in the natural sciences, classification research is still a fairly new approach in neuropsychology and is not well understood, according to Morris and Fletcher (1988). There exists an entire literature devoted to the theoretical and practical issues involved in forming classification systems (termed taxonomy), and a few selected issues which are relevant to the present study will be discussed in this review.

Blashfield and Draguns (1976) have reported two primary purposes for classification; communication and prediction. However, in psychiatric or other clinical

classifications these two purposes are in basic conflict. For good communication (with clients or colleagues), a classification should be simple in structure; the diagnostic rules for identifying cases into subtypes should be easy to use; and the characteristics on which the classification is based should be those most frequently used in standard practice. In general, the classification should be found useful and valuable by the clinicians, for whom it was originally designed. On the other hand, for predictive purposes, a classification needs to be highly complex, if it is to provide a basis for predicting responses to many forms of treatment; for the understanding of etiology; or to allow adequate predictions of prognosis.

Several writers stress the importance of having an overall theoretical orientation (concerning etiology or the nature of learning disabilities, for example) as a framework for planning the classification (Skinner,1981; Morris & Satz,1984, Adams,1985; Morris & Fletcher,1988). Such theoretical considerations will affect decisions about the selection of variables upon which the classification is based. They also dictate the choice of classification model used to specify subtypes and their interrelationships (e.g. categorical or hierarchical). And finally, they are also involved in the process of forming hypotheses concerning the final subtyping solution as well as relationships between the subtypes and external variables (external validation).

Sokal, writing in 1974, was critical of most classification research at that time, in which, he maintains, theory had frequently followed methodology and had generally only attempted to formalize the work in the field. These views are supported by authors of some of the subtyping studies discussed in the previous section of this review. What seemed most important was an overall theoretical model or "working hypothesis" on the part of the researcher as an essential element in the success of the final outcome. Mattis (1978) emphasized that research findings are determined to a large extent by the hypothetical constructs held by investigators before conducting the study, "A working hypothesis about the nature of dyslexia determines the selection of groups, the selection of measures, as well as the overall research design and method of analysis" (p.45). And the final outcome was that three distinct syndromes of dyslexia were isolated, which are still treated as a model and a guideline for comparison by other researchers in this field. Doehring (1981) also stated the need for a single unifying theoretical model as the basis for such research. The lack of such a model was one of the reasons why his comprehensive and ambitious study (Doehring et al.,1981) was not totally successful in producing interpretable results.

In discussing the scientific basis of subtype research,

Adams (1985) describes the difference between "phyletic" and "phenetic" approaches to taxonomic research, as mentioned in the introduction to this thesis. Since the advent of high-speed computer technology and the resulting availability of multivariate statistical software programmes for classification, Johnson (1970) has expressed concerns about the new completely empirical and objective methods of classification, which, he argues, have reduced the important phyletic component of taxonomic research. Adams (1985) is inclined to agree with this viewpoint, and stresses the importance of an underlying theoretical (phyletic) model, prior to embarking upon the research. In this, he says, the phenetic classification will have some chance of producing understandable and useful subtypes.

It seems to be generally agreed that classification research is seeking classifications which truly exist in nature (Sokal,1974). In order to reach this goal of finding "naturally occurring" groups, Blashfield and Draguns (1976) have described four major criteria which need to be met in any adequate classification system. These are reliability, coverage, descriptive validity and predictive validity. Examining these criteria, one by one: (1) Reliability involves the consistency of the classification over different conditions, in different subject samples, and using different methods. (2) Coverage refers to the extent to which subjects are able to be placed in the

classification - i.e. how many subjects are actually classified and how many remain undefined, as not fitting any particular category. (3) Descriptive validity refers to the homogeneity of the symptoms which are used to form a subtype.(4) Predictive validity refers to the value and accuracy of the classification to predict future behaviour or other consequences related to group membership.

In the development of a classification system, there are three possible models which have been used in classification research: a) a hierarchical model, which places subjects successively into specific non-overlapping subsets which can be further subdivided into subsets at lower levels in the hierarchy; b) a categorical model, which places subjects intodiscrete "classes"; and c) a dimensional model, in which subjects are ordered along dimensional axes in a multidimensional space. Recently, there have been hybrid combinations of these different models, which attempt to alleviate the limitations of the three basic models, for example the Diagnostic and Statistical Manual of Mental Disorders, 3rd edition (DSM III).

Related to the selection of a model is the debate about the nature of a "class" (Morris & Satz,1984). Theoretically, classes are mutually exclusive with clear boundaries, as well as a set of attributes by which they are defined. However, in the real world, class definitions

and assignment are necessarily inexact. Bailey (1973) distinguishes between a) a "monothetic" typology, in which groups possess a unique set of features that are both necessary and sufficient for membership to tha' particular class, and b) a "polythetic" typology, in which subjects are grouped together on the basis of the greatest number of shared features, and no single feature is either necessary or sufficient for membership in that group.

Although the ease of description is very important in any typology, one of the drawbacks about classification is that it creates an expectation that all subjects (patients, clients) should fit neatly into one of the categories, whether they actually do or not (Kendell, 1975). Kendell reports little or no evidence of any natural boundary between any one condition and others, in the psychiatric field, which leads to the conclusion that a "class" approach is very possibly inappropriate when considering developmental disabilities in children.

Morris and Satz (1984) discuss the importance of the choice of attributes on which to base the classification, a choice that is very dependent upon one's theoretical orientation, and might also involve consideration of the course of the particular disorder and possible changes over time.They also mention the different methods used to create a classification, which may involve a further decision for the researcher, namely: clinical experience and single-case

paradigms or clinical inspection of test data and rational sorting techniques of classification, as opposed to multivariate statistical techniques. Each method has its advantages and disadvantages, but both are oriented towards the same goal, albeit with different approaches. In many psychiatric classification systems, multivariate statistical techniques have been used in conjunction with clinically derived methods (Blashfield, 1980; Garside & Roth,1978; Kendell, 1975; Maxwell, 1971); Each can be used to validate the classification derived by the other, in a mutually supportive process (Morris & Satz,1984).

Several theorists (Hempel,1961; Fletcher, 1985; Sokal, 1974) have suggested that typologies are not in themselves an endpoint of the research, and that derivation of reasonably homogeneous subgroups explains nothing about the reasons for the disorder. Typologies should be treated as hypotheses concerning the particular classification of interest and, like all hypotheses, are subject to empirical evaluation. Fletcher stresses that the value of any typology for explanatory purposes must depend upon a systematic evaluation of its validity - i.e. its replicability (internal validity) as well as evaluation against external criteria which differ from those used to derive the typology (external validity).

Finally, Skinner (1981) has suggested a framework for classification research that combines the theoretical and

methodological components which are necessary for conducting such studies. It is based upon the principles of construct validation, and emphasizes the continual interaction of theory development and empirical analysis. Skinner also conceptualizes a typology as a dynamic system, which is open to modification from subsequent research. His proposal for the evaluation of classifications includes three interactive components: theory formulation, internal validation and external validation. The "theory formulation" component involves specifying the theoretical basis for all decisions involved in the classification process as well as, if possible, describing precisely the hypothesized "subtypes" one expects to emerge. Also included in this suggested framework are guidelines concerning the procedures of internal and external validation as well as a discussion of the issues involved in these two components.

CHAPTER 2

Objectives of the Study

1. The first objective is to identify reliable and meaningful subtypes within a sample of clinic-referred learning disabled children and to qualitatively describe the differential patterns of performance that characterize such subtypes on a number of cognitive and neuropsychological measures. This will be explored in two ways:
   a) Using a clinical-inferential approach, based upon the clinical inspection and interpretation of psychometric data, and
   b) Using multivariate statistical classification procedures (Cluster analysis techniques) in an attempt to confirm or validate these subtypes (Internal validation).
2. A second objective is to examine how the obtained subtypes differ in terms of academic performance. This involves comparison with Wide Range Achievement (WRAT) scores as well as with qualitative information about the precise nature of any problems, including phonic skills, oral reading, reading comprehension, arithmetic ability, spelling and writing skills. This procedure, which involves evaluation of the subtypes against an external criterion which differs from those used to derive the subtypes, is an attempt to establish external validity for the classification.

3. Further external validation might also be obtained by comparison of the subtypes in relation to data concerning medical and developmental history, behavioural, social and emotional factors.

Design of the Study and Theory Formulation

There are two separate parts to the study, involving two distinct classifications of the same subject sample, using different methods. These will be called Phase I and Phase II.

Phase I of the study involved an attempt to identify meaningful subtypes within a sample of clinic-referred and normal children by means of clinical-inferential or rational sorting techniques.

The approach to this classification followed an assessment model, which employed examination of psychometric test scores as well as qualitative clinical-observations noted during test administration. The theoretical principles and decisions which guided the process of classification include the following:

a) An acknowledgement that learning disabilities in children occur along a continuum of severity, ranging from quite subtle to very severe, i.e. that there exists no diagnostic "cut-off" point, beyond which a person is labelled as "learning disabled" or not, as the case may be.

b) In regard to the theoretical model used to specify the subtypes and their interrelationships, it was apparent that a typology of learning disabilities does not fit easily into a categorical model, which places children into discrete classes with clear boundaries and the expectation that all cases will fit neatly into each category (a "monothethic" typology). A hierarchical model, in which subjects are placed successively into non-overlapping subsets which can be further subdivided at various levels in the hierarchy, would appear to be a more appropriate model for learning disabled children. However, because the dimension of severity is taken into account to some degree in this typology, the dimensional model would also be applicable. Thus, the model chosen for this classification could be termed a composite or "hybrid" hierarchical model, according to Morris and Fletcher (1988).

c) While groups are usually conceptualized as mutually exclusive with clear boundaries, in most clinical sciences class definitions and assignments are inexact. Thus, in "monothetic" typologies, groups possess a unique set of features that are necessary and sufficient for each member of the class. But most classes in nature are "polythetic", developed by grouping together those individuals with the greatest number of shared features, and no one feature is either necessary or sufficient for group membership and may be shared across groups. Thus, a polythetic classification

based upon a composite hierarchical model would seem to be the most appropriate for this subject population (Morris & Satz,1984; Morris & Fletcher, 1988).

d) The selection of a subject sample is another matter to be considered in relation to theoretical principles. Morris and Fletcher (1988) emphasise the importance of an appropriate sampling strategy, which a) reflects the population of interest, with a broad enough representation to include subtypes that may occur infrequently, and b) which is not so general as to include "artificial" groups, which include cases that do not fit the definition of the population of interest. In the present study, the population sample was drawn from cases referred to a community clinic for assessment and consultation in regard to learning, social and behavioural problems. All those cases referred for assessment because of suspected learning disabilities, who met the selection criteria, were included. Approximately one third of this group had initially been referred to the clinic because of social, emotional or behavioural difficulties, and the clinicians assigned to these cases had subsequently requested assessment, in order to explore possible underlying reasons for the presenting problems. Many of these children had no reported academic difficulties, although they often displayed signs of resistance towards performing their school work.

Consequently, the population sample in the present study was not restricted to those cases who necessarily complied with the official educational definition of a "learning disability". Such an approach to the selection of a subject sample is consistent with the underlying theoretical premise of the current study, namely: that the concept of a "learning disability" encompasses more than just difficulties in acquiring academic skills or in learning new material, but can include problems in performance, behaviour, social interaction as well as emotional disturbance. This approach is also consistent with Benton's (1978) comments in regard to the study of dyslexia, and the danger of excluding emotionally disturbed or socially disadvantaged children from consideration, which might otherwise result in a very "atypical" subject sample. Thus, Benton advocated the importance of "casting a wide net" and studying children with a wide variety of problems, including those without any obvious academic difficulties.

Phase II of the study involved an attempt to identify reliable and meaningful subtypes within the same sample of clinic-referred and normal children by means of multivariate statistical classification procedures.

The theoretical principles and decisions which guided the process of this classification include all those relevant to the first phase (listed above). In addition, an

important decision to be made for Phase II related to the selection of variables (psychometric test scores) for the statistical analyses. This involved consideration of a) the reliability and validity of the test measures; b) their possible value in being able to discriminate differences in subtypes, and c) ensuring a reasonable balance between measures of different constructs e.g. language, visual perceptual, memory, motor etc. Such factors also had to be weighed in relation to one another when the selection was made (e.g. a test in which reliability and validity were questionable, but which might prove to be a valuable discriminant variable). In the present study, another factor became an important selection criterion, namely: the frequency of a variable's occurrence in the data set, due to an unforeseen problem relating to missing values.

HYPOTHESES

The following hypotheses are the same for both Phase I and Phase II. They are derived from the literature relating to subtype analysis in learning disabilities and are partly exploratory due to inconsistencies in the findings of previous studies. Hypotheses relating to various specific topics are listed as follows:

Learning Disability Subtypes

Hypothesis 1. There is a certain degree of convergence amongst the several typologies proposed in the literature, which suggest two or three main subtypes. It is expected that the classifications will identify a) a language disorder subtype; b) a visuo-perceptual disorder subtype, and c) a mixed language/perceptual disorder group (Boder, 1973; Denckla,1977; Ingram et al.,1970; Johnson & Myklebust, 1967; Ingram et al.,1970; Lyon & Watson,1981; Mattis,1978; Morris et al.,1986; Satz & Morris,1981; Spreen & Haaf,1986).

Hypothesis 2. In order to provide convergent validation for several subtypes identified and reported independently in the literature by a number of investigators, the two typologies are expected to demonstrate the existence of: a) a global language impairment; b) a visual-perceptual disorder; c) a sequencing finger-localization disorder; d) a specific naming or other linguistic disorder; e) an articulatory-graphomotor disorder f) a severe generally

impaired type; g) a minimally impaired type - which is likely the same as h) a normal pattern of test performance ("unexpected learning disabled subtype", Fisk & Rourke, 1979; Lyon et al.,1982; Lyon & Watson,1981; Mattis et al., 1975; Petrauskas & Rourke,1981; Satz & Morris,1981; Spreen & Haaf,1986).

Reading Disability Subtypes

The majority of subtyping studies are concerned with reading disabilities, and several of the subtypes listed in hypotheses 1 and 2 have been identified in classification studies of reading disorders. Denckla (1977;1979), however, suggested a typology which was similar to others in some respects but emphasised the importance of various different types of language problems that are associated with reading disabilities. As this hypothesis is exploratory, it will take the form of a question:

Hypothesis 3. Can either of the subtyping solutions verify the existence of Denckla's (1977 or 1979) division of reading disabled children into five (six) subtypes as follows:

a) Global mixed language disorder, with prominent anomia; b) Articulatory-grapho-motor disorder; c) Anomic-repetition disorder; d) Dysphonemic-sequencing disorder; e) Verbal learning (memorization) deficiency; f) Visual-perceptual syndrome, combined with anomia, and g) Correlational (sequential-simultaneous) deficiency?

Academic Performance

Hypothesis 4. It is expected that subjects whose WRAT scores reveal a poor performance in arithmetic relative to reading and spelling will be those whose profiles indicate deficiencies in visual-spatial organization, non-verbal problem-solving and logical reasoning, while auditory perceptual, language skills and verbal memory are satisfactory (Rourke & Finlayson,1978).

Hypothesis 5.It is expected that subjects whose WRAT scores indicate poor reading and spelling skills in relation to their arithmetic, will prove to be deficient in auditory perceptual, verbal memory and language skills, while visual perceptual abilities are intact (Rourke & Finlayson,1978).

Developmental Aspects-The Effects of Age

Although, theoretically, subtypes should persist across the school-age span, there is evidence in the literature of developmental variations and age-related patterns (Satz et al.,1978; Satz & Morris,1981; Spreen & Haaf,1986). In order to examine this question, subjects will be divided into three groups, according to age, as follows: a) subjects between 6 and 8 years; b) subjects between 8 and 12 years, and c) subjects between 12 and 17 years. Separate cluster analyses will be performed on each group, and the resulting subtypes compared, in order to answer the following question:

Hypothesis 6. Is there evidence to show that subtypes persist across the age span of the total subject sample? or do the subtyping solutions for the three age-groups reveal any evidence to suggest developmental variations or specifically age-related patterns?

Social,Emotional or Behavioural Factors

Hypothesis 7. It is expected that subjects with profiles indicating differentially poor psycholinguistic skills (e.g. a language disability) would prove to be fairly shy and quiet in social or group situations, a "loner" by choice, as well as emotionally vulnerable, with a tendency towards emotional outbursts of temper (Denckla, 1979).

Hypothesis 8. Subjects with non-verbal learning disabilities (i.e. profiles showing marked difficulties in visual-spatial organization and non-verbal problem solving) would be expected to experience fairly severe social problems due to "social imperception" - an inability to profit from non-verbal experiences or interpret the behaviour of others (Johnson & Myklebust,1967; Ozols & Rourke,1985; Rourke,1988; Wiener, 1980).

Hypothesis 9

This hypothesis relates to the validation of the 11 broad subtypes of learning disabilities derived from the clinical-inferential sorting technique in Phase I. As this was an exploratory procedure, the hypothesis will be

expressed in question form:

Is there any indication of concordance or qualitative similarity between the clinical subgrouping of Phase I and the statistical subtyping solutions of Phase II, which could indicate some degree of mutual validation? Also, will external validation procedures provide any evidence to support the validity of either the clinical or the statistical typologies?

CHAPTER 3

METHOD

Subjects

Subjects for this study were selected from the files of children who had been referred to a Children's Community Mental Health clinic for assessment and consultation in regard to learning, behavioural and social problems. Because of suspected "learning disabilities" (based upon central processing disorders) which might be contributing to their problems, all cases received comprehensive neuropsychological and educational assessment.

Subjects were selected according to the following criteria: a) a Verbal or Performance IQ of at least 80 on the WISC-R; b) the absence of any primary psychiatric or emotional disturbance; c) the absence of any major sensory deficit in vision or hearing at the time of the assessment; and d) age at the time of assessment between 6 years and 17 years. In addition, subjects who met the above criteria were included only if most of the relevant data were available in their file, namely: the cognitive and neuropsychological test scores; the measures of academic performance and qualitative analysis of this material; data relating to behavioural, social and emotional problems; as well as information about developmental and medical history. All name-identifying information was removed from the files for reasons of confidentiality.

The above selection criteria yielded 323 cases. However, although most cases performed a large number of the same tests, assessments varied according to individual needs in the clinical situation and a uniform test battery was not administered. Consequently, the data contained a number of missing values, which proved to be a problem for the planned cluster analysis of the data. None of the relevant computer programmes allowed for missing values, so that it was necessary to re-organize the data set for analysis. This procedure involved elimination of some test variables as well as cases in order to ensure a complete data set, which reduced the total number of clinic-referred subjects to 275. It should be noted that the process which resulted in the exclusion of cases from the data set was strictly related to the choice of retaining or rejecting certain variables. This decision depended mainly upon how frequently they occurred in the data set. If the variable was retained, then any case who lacked a score on this variable was automatically dropped from the subject sample.

Of the total sample of 275 subjects, 215 were males (78%) and 60 were females (22%). The subject sample was divided into two groups for analysis, according to age as follows: Sample A ranged from 8 years, 0 months to 17 years, 0 months, with a mean age of 10.82 years. Sample B ranged from 6 years, 0 months to 7 years, 11 months, with a mean age of 7.07 years. Intelligence levels (Full Scale IQ)

for Sample A ranged from 72 to 138, with a mean IQ of 99. For Sample B, Full Scale IQ levels ranged from 74 to 138, with a mean IQ of 102. In Sample A, there were 159 males and 52 females, while in Sample B there were 56 males and 8 females. Table 4 gives summary statistics for these clinic-referred groups.

This division into two age groups for analysis was necessary because of minor differences in the tests administered to the two age groups, specifically those tests designed for children younger than 8 years old with suitable normative data (e.g. the McCarthy Scales). A comment about the inclusion of 6 year olds in a sample of learning disabled children might be pertinent at this point. For many years, the educational criterion of a "learning disability" required a level of reading or general academic retardation which was at least two years behind chronological age, and this generally precluded children younger than 8 years old from qualifying for inclusion in this category. However, with the more recent acceptance of a neurodevelopmental basis for such disorders and the presumption of central processing deficiencies as accounting for the learning difficulties as well as the associated behavioural or social problems, there is no age limit for this population. The present study therefore included subjects who spanned the whole school-age range, if the assessment findings and presenting problems

Table 4:Verbal IQ, Performance IQ, Full Scale IQ, Sex and Socioeconomic rating of two Clinic-referred groups (Sample A and Sample B) and Control group.

Variable		Sample A	Sample B	Control group
Age in years	Mean	10.8	7.1	10.8
	S.D.	2.4	0.6	2.4
Verbal IQ	Mean	98.8	103.1	118.6
	S.D.	13.2	15.1	12.2
Performance IQ	Mean	99.5	102.5	113.0
	S.D.	13.1	14.0	9.5
Full Scale IQ	Mean	99.0	102.9	117.4
	S.D.	11.8	14.6	10.8
SES	Mean	3.4	3.4	2.8
	S.D.	1.3	1.3	1.0
Sex	Male	159 (75%)	61 (86%)	18 (69%)
	Female	52 (25%)	10 (14%)	8 (31%)
N of subjects		211	71	26

suggested that a central processing disorder could be contributing to the child's difficulties.

Socio Economic Level

The socioeconomic status of each subject was calculated according to the Blishen Scales (Blishen,1976). These scales provide a socioeconomic index of occupations in Canada based on income level, educational status of the father and prestige ranking of the father's occupation. Examples of the six scales are:

1. Administrators, physicians, veterinarians, university professors, architects, dentists, judges, magistrates.
2. Accountants, civil engineers, economists, elementary school teachers, social workers, psychologists, pilots, officers in the armed forces, writers and editors.
3. Laboratory technicians, surveyors, secretaries, insurance or real estate salesmen, radio or TV announcers.
4. Boilermakers, cinema projectionists, railway brakemen, clerical workers, mail carriers, electrical repairmen, daycare workers.
5. Car mechanics, plumbers, fishermen, house painters, cooks, bus drivers, hotel clerks, sales clerks.
6. Sawmill workers, ship's crewmen, farmers, watchmen, janitors.

In the present study, the socioeconomic rating was based upon the occupation of the primary bread-winner in the family (either mother or father) or, if both parents

worked, upon the occupation with the highest rating. In the sample of clinic-referred subjects, the average socioeconomic status (SES) rating was 3.4, with a standard deviation of 1.26 (Table 4). The frequency distributions for each socioeconomic level are listed in Tables 5 and 6.

Control Group

In addition to the clinic-referred sample, a small group of normal control subjects was drawn from three local public schools. Classroom teachers from all grades were asked to select children a) who were average or above average learners and b) about whom there were no concerns in regard to any behavioural, social or emotional problems. A letter was sent to parents of these selected children, explaining the project and asking those who were interested in participating in the study to phone and make an appointment for assessment. Such procedures yielded 31 volunteers, five of whom either failed to follow through on their appointments, moved to another province before testing was completed, or changed their minds about participating. The final sample of 26 control subjects included 18 males (69%) and 8 females (30%). Ages of this group ranged from 6 years, 2 months to 16 years, 2 months with a mean age of 10.77 years. Intelligence levels ranged from a Full Scale IQ of 96 to 141 with a mean IQ of 117. The average socioeconomic status (SES) rating for this group was 2.85, with a standard deviation of 1.0. Table 4

Table 5. Frequency Distribution of SES Rating in Sample A.

Value	Frequency	Percent
1	13	6.2
2	26	12.3
3	60	28.4
4	52	24.6
5	17	8.1
6	13	6.2
No information	30	14.2

Table 6. Frequency Distribution of SES rating in Sample B.

Value	Frequency	Percent
1	6	8.5
2	8	11.3
3	17	23.9
4	23	32.4
5	7	9.9
6	4	5.6
No information	6	8.5

gives summary statistics for this group of normal control subjects. The frequency distribution for each socioeconomic level is listed in Table 7.

As Table 4 indicates, the average SES rating for the normal control group was slightly higher than that for the clinic referred subjects. A possible explanation is that parents of higher SES ratings might be more interested in responding to a request for their children to volunteer as research subjects. Nor was there a similar proportion of males to females in the control group as compared to the clinic-referred group, although males still outnumbered the females by more than 2:1.

At this point, a comment about the presence of a normal control group in a subtyping study might be appropriate. Satz and Morris (1981) have suggested that most subype research would benefit from including a comparison group of subjects who are functioning normally, particularly with respect to the specific problem area of the population under study (e.g. a group of normal readers in a subtyping study of dyslexics). The reasons for doing so are as follows: a) In order to ensure that the derived subtypes are specific to the target group under study, i.e. that the same subtypes emerge consistently, regardless of the presence of a control group; b) Also in order to determine whether, in fact, the subjects identified as normal by their teachers did, in fact, differ from the

Table 7. Frequency Distribition of SES Rating in Normal Control Group.

Value	Frequency	Percent
1	1	3.8
2	10	38.5
3	9	34.6
4	4	15.4
5	2	7.7
6	0	0.0
No information	-	-

clinic-referred cases in the present study, particularly given the unusually broad guidelines for selection of a "learning disabled" sample. Hence it was anticipated that the control group subjects might emerge together on a single cluster in Phase II of the study, thus demonstrating genuine differences between this group and the target population. Finally, c) the use of a control group with normal reading, spelling and arithmetic performance becomes essential when interpretations of qualitative differences between subtypes in terms of academic performance are planned (as in the external validation stage of the present study). For example, the use of control group allows one to make appropriate interpretations of group performance in, say, spelling, which may suggest distinctive performance differences between certain LD subtypes and children without any such problems.

Test Measures

Dependent measures were selected from an eclectic battery of cognitive, neuropsychological and language tests which reflected performance on a wide range of cognitive and adaptive abilities. In the original choice, measures were selected because of their possible value in discriminating between subtypes as well as their theoretical relevance for use in the present analysis. However, as explained earlier, it became necessary to eliminate a number of test variables in order to avoid

missing values in the data set. Those which were eliminated included: Raven's Matrices (Raven,1977); Token Test (Spreen & Benton,1969); Finger Localization Test (Benton,1969); Stereognosis Test (Benton,1969); Boston Naming Test (Kaplan et al.,1978); Auditory Closure, Sound Blending and Visual Sequencing tests from the ITPA (Kirk et al.,1968); Goldman-Fristoe Test of Articulation (1969); and the Grooved Pegboard Test (Klove, 1963). The remaining variables were, by default, those in which scores were obtained from the greatest number of subjects, and so do not include all tests considered relevant for this study.

The remaining group of 19 test scores represented a pool of variables from which different subsets could be selected for analysis. For Sample A (8 to 17 years), the measures available were as follows:

1. Eleven of the 12 subtests of the Wechsler Intelligence Scale for Children-Revised (WISC-R), namely: Information, Similarities, Arithmetic, Vocabulary, Comprehension, Digit Span, Picture Completion, Picture Arrangement, Block Design, Object Assembly and Coding.

12. Word Fluency Test (Spreen & Benton,1969)
13. Sentence Repetition Test (Spreen & Benton,1969)
14. Embedded Figures Test (Spreen & Benton,1969)
15. Developmental Test of Visual-motor Integration (Beery,1967)
16. Right-Left Orientation Test (Benton,1956)

17. Finger Tapping Test (Reitan,1974)

18. Hand Dynamometer (Halstead-Reitan,1947)

19. Speech Perception Test (Halstead-Reitan 1947)

For Sample B (6 to 8 years), the majority of test measures were identical to those for Sample A, except for the Right-Left Orientation and Speech Perception tests, for which the following tests were substituted, as being more appropriate for this age group (19 variables):

20. Right-Left Orientation subtest from the McCarthy Scales of Children's Abilities (McCarthy,1970)

21. Goldman-Fristoe-Woodcock Test of Auditory Discrimination (American Guidance Service,1970)

PROCEDURES

Phase I

This phase of the study involved an attempt to identify meaningful subtypes within the sample of clinic-referred and normal children by using clinical-inferential or rational sorting procedures. The subjects for this clinical classification included all 323 cases who had originally met the selection criteria for inclusion in the study. The sorting decisions were based upon scores from all the tests administered to each subject as well as observations and comments about test performance and behaviour noted during the assessment, for example: Inclined to give up easily, if does not see solution immediately; tends to nod or gesture, when possible,

instead of talking; very slow paced response and performance; easily distractible, has great difficulty staying on task; quite talkative but has trouble finding words.

Reliability of Clinical Typology

The idea for the present study developed over 16 years of clinical experience while working in a local Children's Community Mental Health clinic from 1971 to 1987. During this time I dealt specifically with children referred for assessment and consultation in regard to learning, behavioural, social or emotional problems, where a learning disability, neurological impairment, or developmental delay was suspected as the basis of the child's problems. Each case received a thorough neuropsychological and educational assessment, and over the years of testing, various patterns of similarity in test results had been noticed, suggesting the existence of different "types" of disorder. Inevitably, one began to form hypotheses and make predictions about test profile patterns from referral information and initial parent interviews.

All subjects used in the present study had been cases whom I had seen, personally, for clinical service. I had also done all the testing, parent interviews (see Appendix C) and consultation for each case, and was thus responsible for the total data collection used in the study, except for that in the Parent Information Form (see Appendix D). The

research plan also involved clinical decision-making in order to create the clinical typology of learning disabled (LD) children, a process which was quite similar to the diagnostic decisions required every day in clinical practice. However, the fact that the clinical typology was developed entirely by the experimenter working alone necessarily introduces the question of reliability.

The initial plan to involve one or two other clinicians to examine and interpret the test profiles independently during the clinical sorting procedures proved to be unfeasible. The clinic had closed down, the assessment services had been discontinued, and colleagues with clinical experience in this particular field had long since departed. Therefore, a set of objective decision rules for classifying cases according to the clinical typology was developed. Using such rules as a guideline, trained research assistants could classify a sample of the cases in order to determine inter-judge reliability, as follows:

The objective decision rules for classifying cases into subtypes according to the clinical typology can be found in Appendix B. At least one other judge (and possibly two) could be trained in the procedures and decision-making process, following which they would each be given 40 cases to classify from the total sample of 323 (12%). The selection of cases for determining reliability would not be

random. Instead, it would involve a representative sample, with some cases from each group in the typology, so as to ensure representation from the whole range of subtypes. Once 90% agreement with the primary judge was reached during practice trials, reliability measures would be obtained from the sample of 40 representative cases.

Phase II of the study involved the multivariate statistical classification of both samples (A and B). Because of the broad age range of the subjects, the raw scores of the 21 test measures were standardized by converting them to age appropriate T-scores with a mean of 50 and a standard deviation of 10. This procedure allowed for comparisons between measures. For variables 12,13,16,18,20,21 and 22, this conversion was based upon regional norms (Spreen & Gaddes, 1969; Gaddes & Crockett, 1975). For the remaining variables, the conversion was based upon test manual norms.

Several texts on cluster analysis (Lorr, 1983; Maxwell,1971) recommend standardization of the variables as the best solution to the problem of diverse sources of raw scores or diversity in age which would otherwise produce misleading results. However, this procedure can apparently dilute differences between groups on the variables which are the best discriminators, and may thus give spurious results (Everitt, 1980). An alternative approach to this problem is to factor analyse the test score data to produce

factor-related composite scores, which are, it seems, equally inappropriate for this purpose, because they tend to force homogeneity on the data set. However, as raw scores were standardized individually on the basis of age-norms and not from standard deviations derived from the complete set of cases, standardization was considered to be the most appropriate course of action. It also proved to be a necessary preliminary step prior to the use of the Euclidean distance measure in the cluster analyses, which is otherwise badly affected by the changing scale of a variable, a common problem when raw scores are the measures. (Everitt,1980).

CHAPTER 4

ANALYSES AND RESULTS

Phase I

Phase I involved the clinical-inferential classification based upon visual inspection of the test profiles combined with qualitative observations noted during test administration.

This clinical sorting procedure on the sample of clinic referred cases, produced an initial division into three broad categories, namely: 1)Language Disorders; 2) Visual perceptual/Non-verbal Disorders; and 3) Mixed Language and Visual Perceptual Disorders. However, these category titles should be clarified: the 'Language Disorders' group included cases whose primary problem involved verbal and language skills although there might also be subtle or more pronounced deficits in various aspects of perceptual-motor functioning (e.g. visual-motor or visual memory problems). Likewise, the 'Visual Perceptual Disorders' group included cases whose primary problems involved perceptual/non-verbal difficulties, but who might also have subtle problems in verbal expression or comprehension. When language or perceptual deficits were both represented almost equally or to a fairly serious degree, then cases were classified under the 'Mixed' category.

Each of the three categories was further subdivided, in accordance with the planned hierarchical subtyping approach, and most of the resulting groups were again partitioned into even more specific classes. Beginning with the language disorder group, the cases were sorted according to the degree of perceptual deficiency that was evident in their test profiles. Starting with those cases of "pure" or almost pure language disorder, without any evidence of perceptual deficit, the process of placing cases in the order of increasing perceptual deficiency continued, until they became severe enough to warrant placement in the "mixed" category. A similar process was then employed with the large group whose primary problem involved visual perceptual disorders. Starting with those cases who were very articulate and apparently without any language difficulties at all, this sorting procedure continued, according to the degree of associated language difficulty that was evident.

At this point, it became necessary to consider another important discriminating factor, namely: the level of severity of the major problem area within each of the two large groupings. It was not enough, for example, to order the perceptually impaired cases only in relation to their additional language deficits; one also had take into account the degree of severity in their perceptual impairment. For instance, there existed a whole group of

cases with good language abilities in the presence of very severe perceptual deficiency. Likewise, in the language disordered groups, the type and severity of the language disorder also became a necessary grouping factor, resulting in groups with mainly expressive language problems; with receptive and expressive difficulties; and with severe, global language disorders.

Following these ordering and grouping procedures, cases from all groups were then carefully re-examined with respect to other possible grouping factors. It had been observed during all these procedures that numerous other similarities between cases assigned to the same subgroup existed, quite apart from the original grouping determinant, which was encouraging and also indicated naturally occurring factors. It was also important to consider clinically relevant factors as group discriminators, so that the list of other possible grouping factors included the following: verbal memory, auditory discrimination, gross motor problems, naming, rote repetition skills, spatial abilities, visual memory, tactile perception and other sensorimotor attributes, articulation, printing and writing skills, as well as comprehension and concept formation abilities. Obviously, it was not possible to take all such factors into account in the final classification, so that it became necessary to decide which were the most important to consider. The final

decision emphasised the inclusion of the naturally occurring factors as grouping variables, which meant that many symptoms, mainly relating to sensorimotor or motor functioning, could not be taken into account for group assignment.

Thus, throughout this whole process, an attempt was made to classify cases and develop groupings which, as far as possible, seemed to be naturally occurring, since this also appeared to be more clinically relevant. Such an approach is also consistent with the views of Satz and Morris (1981), who caution against developing a group of subtypes that conform to a set of a priori decision rules, which may not reflect the true hidden structure of the data, especially complex data sets.

The resulting assignments were then reviewed and checked repeatedly, until all changes and decisions proved to be stable. During this process, data based rules were developed for inclusion into the various subtypes. However, in line with the theoretical decision to avoid a categorical classification model as being unsuitable for this population of children, the inclusion rules for class assignment were gradually modified, so that only the major defining and discriminating characteristics were retained for each group. While realising that this increase in "coverage" would inevitably reduce homogeneity and consequently reliability, it was felt that the alternative

approach would produce a comparatively useless classification of this quite complex group of disorders, labelled "learning disabilities".

Of the 325 cases, 320 were classified. Five cases proved to be unclassifiable into any particular group, due to limited test results in some cases, or because the results were evidently invalid due to resistance and lack of cooperation.

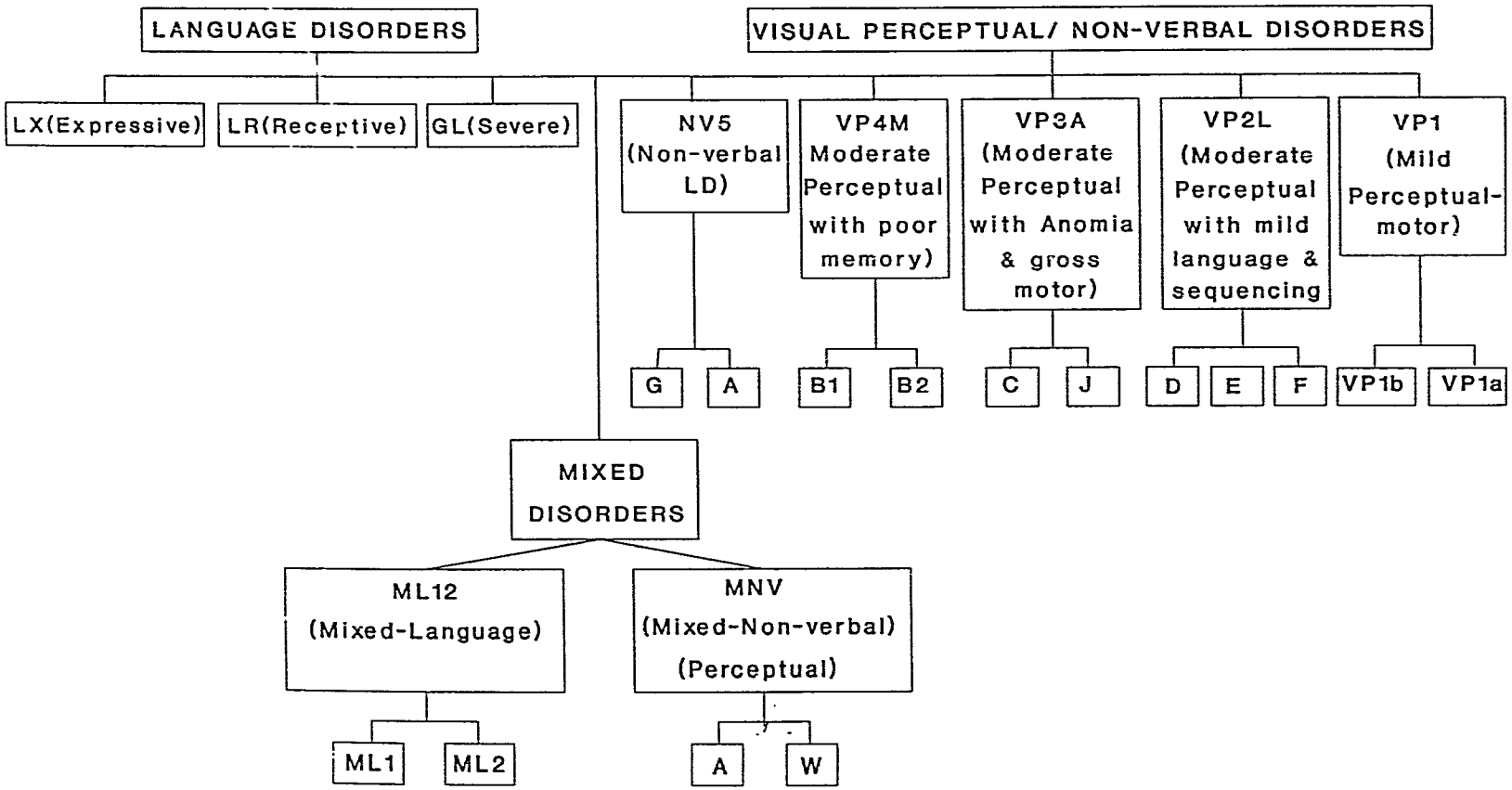
Clinical Inferential Typology of Learning Disabilities

The hierarchical classification identified 11 broad subtypes, which could each be divided further into two or more subgroups, with a more precise differentiation between groups. Figure 1 shows a diagram which displays the hierarchical groupings of the typology. The main categories and the 11 broad subtypes are described briefly below. A more detailed description of the classification and the subtype characteristics can be found in Appendix A.

I. LANGUAGE DISORDERS

1. Group LX (Expressive Language Disorder): Language impairment in this group is mainly expressive (word-finding, naming, sentence construction difficulties and fluency in general); verbal responses are either limited or circumlocutory, and vocabulary is weak. General sequencing problems are evident; visual perceptual skills and visual memory are good, but there may be some problems in visual-

Figure 1: Hierarchical Classification of Learning Disabilities



motor copying. VIQ is within average range and less than PIQ. Cases in this group tend to be fairly quiet (not spontaneously talkative) and shy by nature. This subtype is divided into two subgroups: one in which verbal memory is deficient and one in which verbal memory is intact (See Appendix A).

2.Group LR(Receptive-Expressive Language Disorder). Language impairment in this group involves both verbal expression and comprehension. There are difficulties in naming, grammatical construction and verbal fluency. General sequencing problems are evident. VIQ is less than PIQ, and is generally lower than in Group LX (74 to 103 in this sample). Cases in this group tend to be slow in thinking, processing, response and performance. This group is also divided into two subgroups: one in which verbal memory is intact, and one in which verbal memory and verbal learning are weak (See Appendix A).

3.Group GL (Global Language Disorder): Language impairment is quite severe in this group, with very low scores on all the verbal subtests of the WISC-R as well as on other language measures. There are problems in both expressive and receptive language abilities, including naming, vocabulary and reasoning skills. Auditory discrimination is weak; visual perceptual deficits may include visual-motor copying, visual figure-ground skills, and visual memory, but there are average scores on WISC-R performance

subtests. VIQ is very low (55 to 78), while PIQ is average to above average (92 to 117). Sensorimotor and motor deficits may include right-left orientation, finger praxis, eye-tracking, handgrip strength and fine-motor skills. Verbal memory is poor, and speech is indistinct with minor articulation problems in some cases. Some talk quite freely, but tend to ramble irrelevantly; others are quiet and very slow to respond.

VISUAL PERCEPTUAL/NON-VERBAL DISORDERS

As with the "Language Disorder" groups, the presence or absence of a verbal memory deficit proved to be an important factor in the classification process, mainly related to the degree of severity, i.e. those with verbal memory deficits generally had more severe disorders. In the first three subtypes listed below (Subtypes 4,5 and 6), verbal memory is intact, but in Subtype 7, verbal memory is poor.

4.Group VP1 (Mild Perceptual-Motor Disorder):Cases in this group show evident problems in visual perceptual, spatial and visual-motor abilities. Language skills are essentially good, ranging from extremely articulate and without any problems to mild word-finding problems or difficulty in following directions. Comprehension is good; there are no problems with auditory discrimination or articulation; visual memory is good; sensorimotor deficits range from none at all to problems in all areas; and handgrip strength

is also variable. Verbal memory is good. This group can be divided into two subgroups: one in which gross motor skills are poor and one in which gross motor skills are intact (See Appendix A).

5.Group VP2L (Moderate Perceptual-Motor Disorder with Mild Language and Sequencing Problems): Cases in this group show evident problems in visual perceptual, spatial and visual-motor abilities. However, there are also mild language weaknesses, ranging from naming and fluency problems to difficulties in organizing thoughts and understanding verbal instructions. General problems in sequencing are also evident, and sensorimotor deficits vary. Verbal memory is good. This group can be divided into three subgroups, in two of which there are problems in articulation and speech pronunciation, as well as marked difficulties in printing, writing and pencil work in general. (These two groups could together could be labelled as an "Articulatory-Graphomotor" subtype. In the third subgroup, there are problems in motor planning or constructional tasks, and writing is difficult for some cases (See Appendix A).

6.Group VP3A (Moderate Visual Perceptual Disorder with Anomia and Gross Motor deficits: In this group, VIQ>PIQ but the split is not more than 6 to 10 points; visual perceptual problems are numerous and varied. Language is basically adequate, although there are pronounced difficulties in naming and verbal expression, with immature

grammatical patterns. Some cases are fairly quiet and reluctant to expand responses; in others, speech is rambling and circumlocutory; all have some difficulty in understanding directions and questions. Visual memory is good in most cases; gross motor skills are poor and verbal memory is intact. This group can be divided into two subgroups: one in which auditory discrimination is poor and articulation is normal; and one in which auditory discrimination is intact, but there are problems with articulation; printing and written work are also very difficult, and speech rate can be very slow (Articulatory-graphomotor type).

7.Group VP4M (Moderately Serious Perceptual-Disorder with Poor Verbal Memory): These cases have a mixture of fairly serious visual perceptual deficits and weaknesses in expressive language. There are also problems in sequencing as well as in understanding directions. Many cases in this group gave articulation problems combined with graphomotor difficulties. Their perceptual/non-verbal deficits range from moderate to serious (PIQ's are 100 to 69), while language abilities are within average range; all have problems with verbal memory. There are two subgroups: one in which gross motor skills are good; and one in which gross motor skills are weak.

8.Group NV5:(Moderately Serious Non-verbal Disorder): This group includes two subgroups with similar profiles of

strengths and weaknesses, namely: Deficits in non-verbal, visual/spatial perception and organization, while language skills are good in comparison; auditory discrimination is poor; verbal memory is good. The two subgroups differ in the following ways:

Type A: Visual-spatial/non-verbal deficits are serious, and VIQ/PIQ split is between 12 and 20 points. Language is articulate and these cases are talkative, although repetitive, with characteristic problems in logical reasoning. They are often described as clumsy and are slow in pencil work. Gross motor skills are deficient and they are usually poor in arithmetic.

Type G: This group is similar to Type A, with average language ability combined with relatively low performance scores on the WISC-R (74 to 92). There are some difficulties in verbal expression in this group (poor naming and limited vocabulary) as well as weaknesses in sequencing skills. Gross motor ability is good. But the main differences include deficits in concept formation as well as articulation and graphomotor problems in many of the cases.

III. MIXED LANGUAGE AND VISUAL PERCEPTUAL DISORDERS

In all the following "mixed" subtypes, low scores were recorded on either or both the Similarities or Comprehension subtests of the WISC-R.

Mixed Subtypes with Weaker Language Abilities

9.Group ML1:(Mild Mixed-Language Disorder): In this group, intelligence is within average range, with VIQ slightly less than PIQ. All cases have comprehension and reasoning difficulties, and also frequently have problems in conceptual thinking. Language expression is difficult, verbal responses are limited, and speech rate is often quite slow. Verbal fluency is poor at younger ages, and improves at older ages. Visual perceptual deficits may include poor visual-motor copying, low scores on several WISC-R performance tests, as well as problems with visual figure-ground and spatial perception. Visual memory is adequate in most cases. Articulation is immature in many of these children, and printing or writing is extremely difficult for them. Verbal memory is average and gross motor skills are intact. The children in this group are particularly strong-willed by nature: some are active and restless, whilst others are merely stubborn, resistant and inclined to be disruptive in class.

10.Group ML2:(Moderately Severe Mixed-Language Disorder): Reasoning and comprehension problems characterize this group, in which language impairment is more severe than visual perceptual deficits, although the latter are significantly present. Language deficits include problems in verbal expression, naming, word-finding and fluency; thought patterns tend to be disorganized. Auditory

discrimination is poor, and many cases have minor articulation problems. These children tend to talk a lot, but their speech is circumlocutory, perseverative and long-winded. Verbal memory is poor. Sensorimotor and motor deficits may include right-left orientation, finger localization, finger praxis, eye-tracking, stereognosis, finger tapping and handgrip strength. In most cases, gross motor functioning is affected to some degree. This group comprises three different subtypes, which include a lower functioning group, one slightly higher functioning group, and a subtype with articulation and graphomotor deficits (See Appendix A).

Mixed Subtypes with Weaker Visual Perceptual Skills

11/12.Group MNV:(Severe Mixed Non-verbal Disorder

There are two main groups under this heading: one in which verbal memory is deficient and one in which verbal memory is intact.

11.Group(W):(Moderately Severe Mixed Non-verbal Disorder): In this group, verbal memory is intact but there are marked problems in comprehension, non-verbal problem-solving, and logical reasoning. Language deficits include both receptive and expressive difficulties. These children are talkative and perseverative in their speech, but their talk tends to be rambling and lacking in substance. They have difficulty in following directions. Auditory discrimination is

average, and handgrip strength is poor in many (but not all) these cases. VIQ's range from 80 to 95; PIQ's range from 74 to 88.

12.Group(H):(Severe Mixed Non-verbal Disorder): In this group, verbal memory is poor, and there are pronounced problems in reasoning, non-verbal problem-solving as well as abstract thinking. These children can be quite talkative and frequently use verbal mediation when performing non-verbal tasks. But, they have some difficulties in word retrieval and verbal expression, and can be reticent at times. Also, although vocabulary use may be sophisticated, comprehension is often lacking. Auditory discrimination is weak in many of these cases, and gross motor skills are below average.

Means and standard deviations of 16 variables for each of the clinical typology groupings in both samples (A and B) can be found in Tables 9 and 10. Table 8 lists the abbreviation codes for the clinical typology groups. Profiles of the 11 groups as well as the normal control group (Sample A) are shown in Figure 2. Because of the small size of Sample B, some of these clinical typology groups contained very few subjects. Thus, some fairly similar clinical groupings were combined to produce seven clinical subtypes for Sample B, for which T-score profiles were plotted (see Figure 3). The seven group clinical typology for Sample B is shown in Table 11.

Table 8. Abbreviation Codes for Subtypes in Clinical Typology.

Code	Brief Description of Subtype
LX	Expressive Language Disorder: visual perceptual skills and visual memory are good.
LR	Receptive-Expressive Language Disorder: processing slow and both verbal expression and comprehension affected.
GL	Global Language Disorder: severe language impairment and poor verbal memory. Visual perception is within average range, but verbal scores between 55 to 78.
VP1	Mild Perceptual-Motor Disorder: visual spatial and visuomotor deficits; language is essentially good.
VP2L	Moderate Perceptual-Motor Disorder with mild language and sequencing problems (verbal expressive weaknesses and understanding directions).
VP3A	Moderate Visual Perceptual Disorder with Anomia and Gross Motor Deficits. Language is generally adequate, although pronounced problems with naming. Work pace very slow in many cases.
VP4M	Moderately serious Visual Perceptual Disorder, with Expressive Language and Verbal Memory Problems.
NV5	Moderately Severe Perceptual-Spatial Disorder, with good language abilities; talkative; clumsy; gross motor deficits; reasoning poor. (Typical non-verbal learning disability subtype).
ML1	Mild Mixed-Language Disorder; intelligence in average range; comprehension and reasoning problems. Language deficits greater than perceptual deficits, although both present.
ML2	Moderately severe Mixed-Language Disorder, with Poor Verbal Memory. More impaired than ML1.
MNV	Severe Mixed-Perceptual/Non-verbal Disorder. Perceptual deficits greater than language deficits, although both are present.

Table 9. Means and Standard Deviations of 16 Variables (S.D's in brackets) - Clinical Typology Groups - Sample A.

VARIABLES	GROUPS Normal Controls	VP1	VP2L	VP3A
Similarities	64.1 (7.5)	55.5 (8.7)	61.5 (7.0)	60.1 (8.8)
Vocabulary	59.8 (8.0)	62.9 (7.1)	56.1 (8.4)	55.8 (7.9)
Comprehension	60.3 (9.4)	61.8 (7.4)	56.5 (7.0)	53.4 (7.6)
Block Design	60.7 (6.0)	55.4 (10.3)	48.8 (9.8)	52.2 (6.0)
Object Assembly	56.6 (8.2)	54.5 (8.3)	49.4 (5.4)	54.8 (8.2)
Coding	53.8 (8.6)	42.7 (9.9)	44.2 (12.2)	43.0 (8.6)
Digit Span	55.6 (9.1)	48.4 (7.4)	46.1 (9.7)	45.3 (5.9)
Picture Arrangement	56.8 (7.3)	55.3 (6.4)	54.0 (4.6)	52.1 (7.3)
Word Fluency	56.4 (8.8)	53.7 (8.4)	47.7 (9.1)	44.6 (7.7)
Sentence Repetition	57.6 (11.2)	55.5 (6.4)	52.5 (7.3)	51.9 (6.1)
Embedded Figures	57.2 (10.1)	49.0 (10.4)	45.6 (8.9)	51.3 (11.7)
Beery V.M.I.	57.9 (8.2)	48.3 (13.5)	45.4 (9.1)	49.1 (10.1)
Right-Left Orientation	53.3 (7.8)	43.5 (14.8)	44.3 (13.4)	44.3 (16.4)
Finger Tapping	44.6 (10.1)	44.4 (7.4)	39.4 (9.4)	38.8 (11.2)
Dynamomometer	48.8 (12.6)	41.6 (16.5)	61.2 (12.4)	31.6 (11.7)
Auditory Discrimination	52.7 (9.6)	47.7 (13.1)	43.1 (13.3)	46.6 (10.6)

Table 9 cont'd

VARIABLES	GL	ML1	ML2	VP4M
Similarities	36.0 (8.9)	48.1 (7.2)	47.1 (7.4)	55.6 (6.6)
Vocabulary	32.0 (7.7)	49.3 (6.8)	42.6 (6.6)	51.0 (7.4)
Comprehension	34.0 (9.2)	43.1 (5.6)	42.8 (6.4)	53.1 (5.8)
Block Design	48.0 (4.9)	51.4 (12.8)	48.2 (9.5)	49.8 (6.3)
Object Assembly	56.6 (13.7)	52.9 (10.9)	50.3 (8.2)	49.4 (8.8)
Coding	32.0 (7.0)	43.6 (8.6)	40.8 (10.4)	39.9 (8.0)
Digit Span	36.0 (7.0)	47.7 (7.5)	39.8 (6.5)	42.8 (9.1)
Picture Arrangement	52.4 (7.2)	53.0 (4.1)	51.8 (7.3)	50.1 (8.8)
Word Fluency	35.4 (10.7)	43.1 (7.3)	41.8 (8.5)	42.4 (8.6)
Sentence Repetition	28.6 (3.6)	52.5 (5.4)	37.6 (7.4)	40.9 (6.2)
Embedded Figures	37.4 (13.7)	44.4 (8.2)	41.7 (13.0)	43.8 (10.5)
Beery V.M.I.	39.8 (17.0)	42.5 (9.5)	41.2 (10.7)	46.1 (11.2)
Right-Left Orientation	34.5 (19.9)	45.0 (16.5)	35.7 (17.9)	39.8 (17.2)
Finger Tapping	35.6 (12.2)	41.4 (10.0)	36.8 (6.9)	39.9 (7.6)
Dynamometer	31.2 (18.7)	43.8 (22.4)	32.8 (17.3)	42.3 (17.2)
Auditory Discrimination	25.8 (13.4)	45.6 (7.8)	39.0 (13.7)	44.4 (11.7)

Table 9 cont'd

VARIABLES	NV5	MNV	LX	LN
Similarities	50.7 (11.6)	50.3 (7.9)	54.1 (7.8)	49.3 (7.5)
Vocab ılary	54.0 (5.7)	46.6 (5.6)	53.1 (7.2)	43.6 (6.5)
Comprehension	52.7 (6.6)	41.5 (7.8)	52.3 (3.6)	47.6 (6.4)
Block Design	42.2 (10.0)	35.8 (7.9)	59.2 (6.9)	56.4 (10.8)
Object Assembly	43.3 (5.9)	40.8 (6.8)	59.4 (8.0)	54.9 (8.3)
Coding	37.7 (6.8)	39.1 (9.6)	48.9 (6.1)	48.4 (8.2)
Digit Span	47.5 (7.7)	42.8 (8.3)	47.1 (6.7)	42.0 (6.9)
Picture Arrangement	46.5 (5.2)	42.9 (9.5)	58.0 (7.8)	53.1 (7.5)
Word Fluency	48.3 (11.9)	44.1 (10.3)	42.6 (10.3)	41.8 (9.9)
Sentence Repetition	53.3 (4.7)	39.8 (11.7)	47.2 (10.2)	42.0 (10.4)
Embedded Figures	39.1 (13.5)	27.2 (15.4)	54.6 (5.4)	48.0 (9.8)
Beery V.M.I.	38.1 (12.1)	36.9 (11.8)	52.8 (8.1)	51.0 (6.1)
Right-Left Orientation	41.1 (15.2)	35.7 (15.4)	47.5 (18.7)	42.7 (16.0)
Finger Tapping	40.1 (7.9)	36.8 (13.3)	40.3 (10.7)	41.3 (8.9)
Dynamometer	38.5 (13.0)	35.9 (17.6)	42.4 (20.7)	52.9 (17.2)
Auditory Discrimination	48.8 (5.1)	42.5 (11.2)	44.8 (14.0)	42.9 (12.4)

Figure 2. Clinical Profiles - Sample A

Variable List

SI - Similarities Test from WISC-R

VO - Vocabulary Test from WISC-R

CP - Comprehension Test from WISC-R

WF - Word Fluency

SR - Sentence Repetition

BD - Block Design Test from WISC-R

CO - Coding Test from WISC-R

EF - Embedded Figures Test

BE - Beery Test of Visual-motor Integration

RL - Right-left Orientation Test

FT - Finger Tapping

DY - Dynamometer

AD - Auditory Discrimination

Fig 2. Clinical Profiles-Sample A

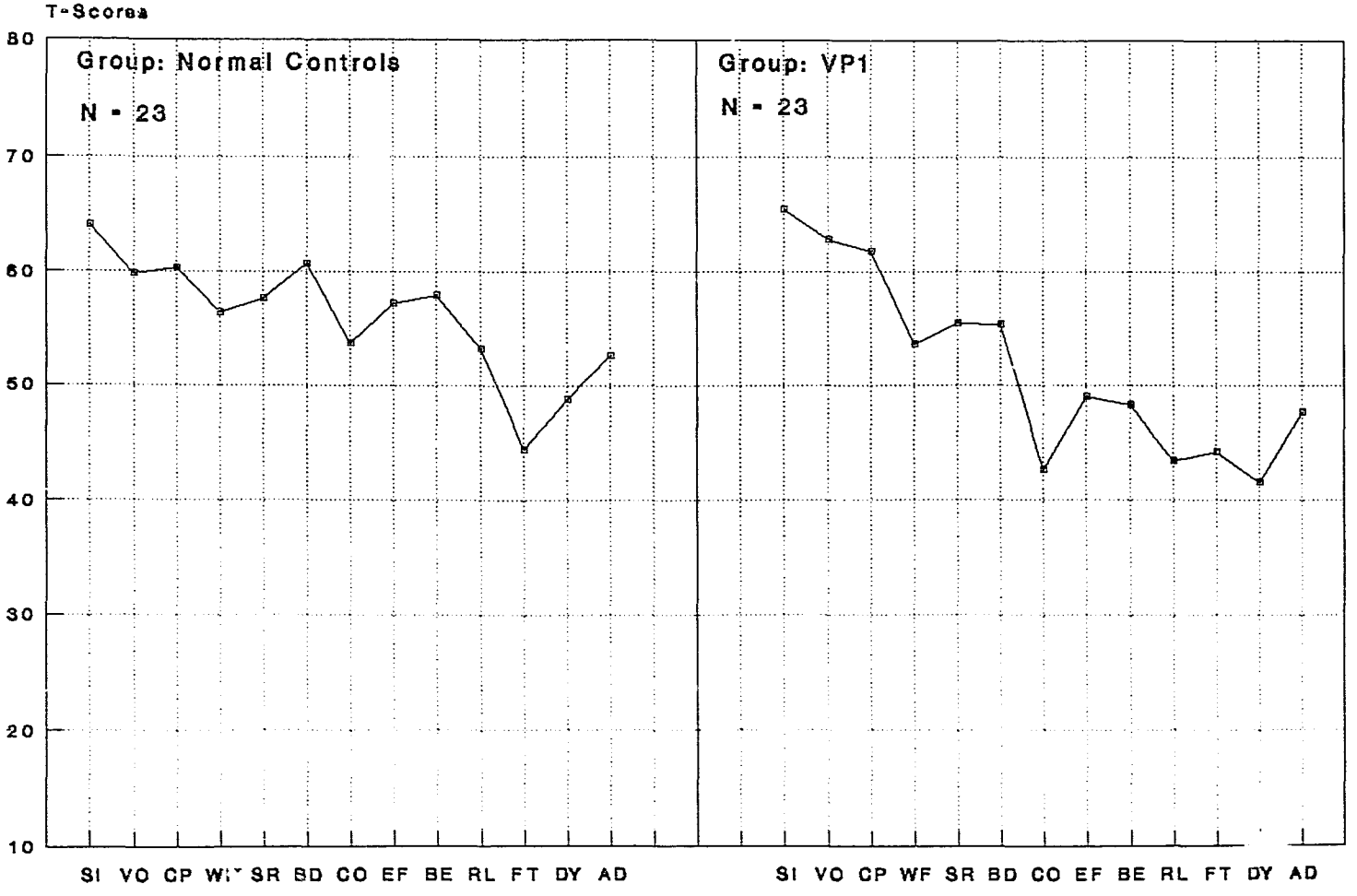


Fig 2 (cont.) Clinical Profiles-Sample A

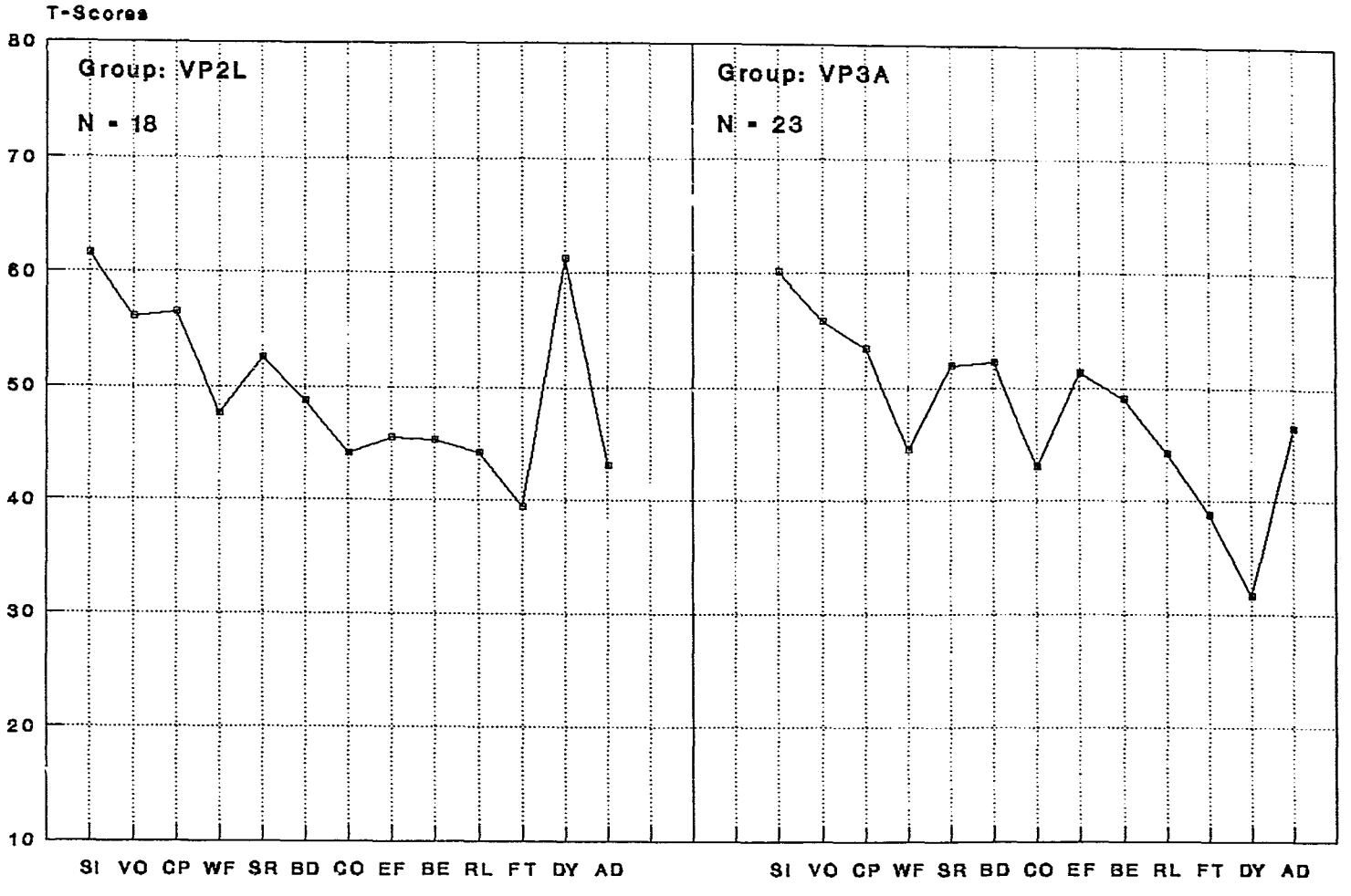


Fig 2 (cont.) Clinical Profiles-Sample A

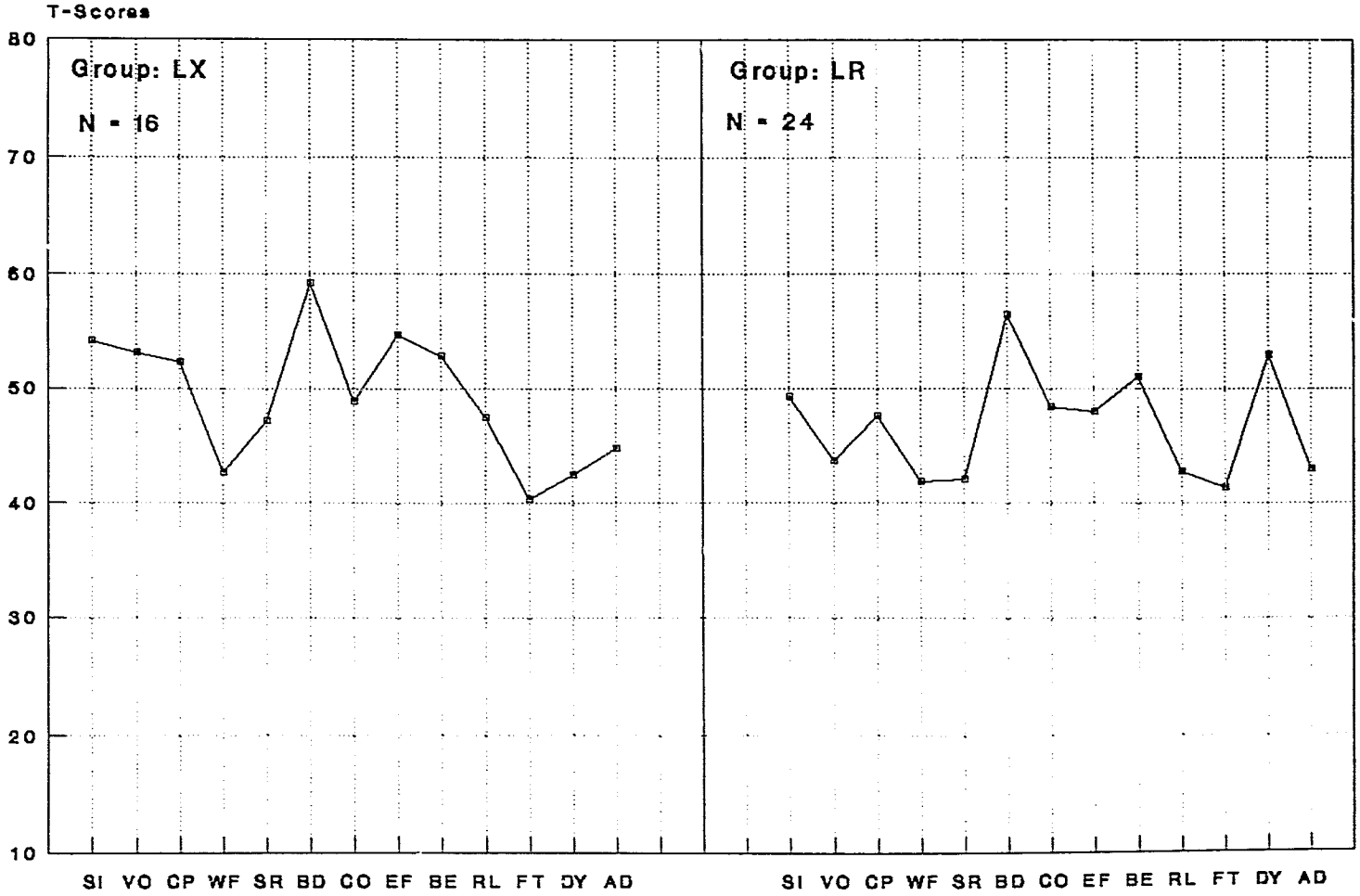


Fig 2 (cont.) Clinical Profiles-Sample A

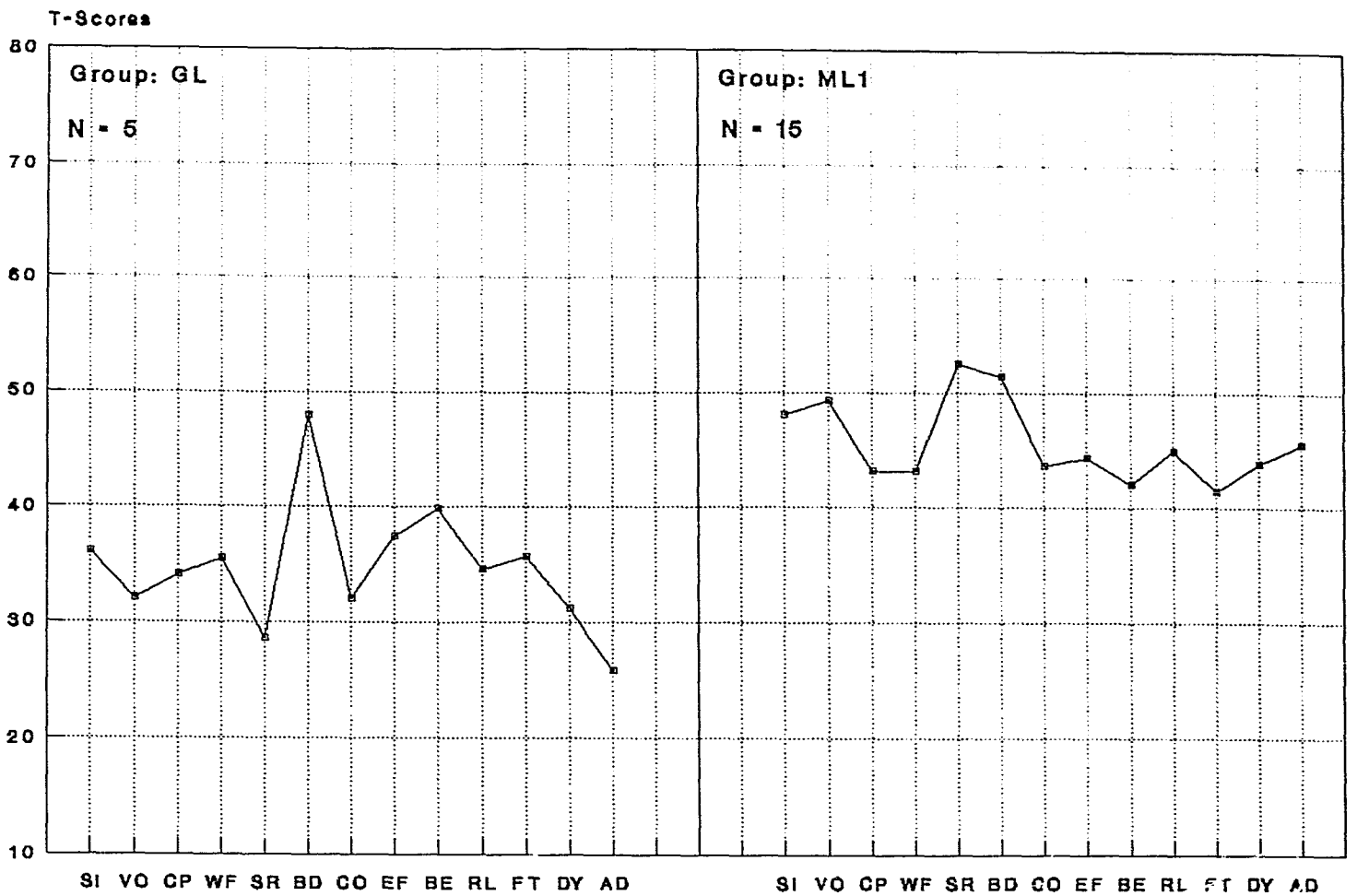


Fig 2 (cont.) Clinical Profiles-Sample A

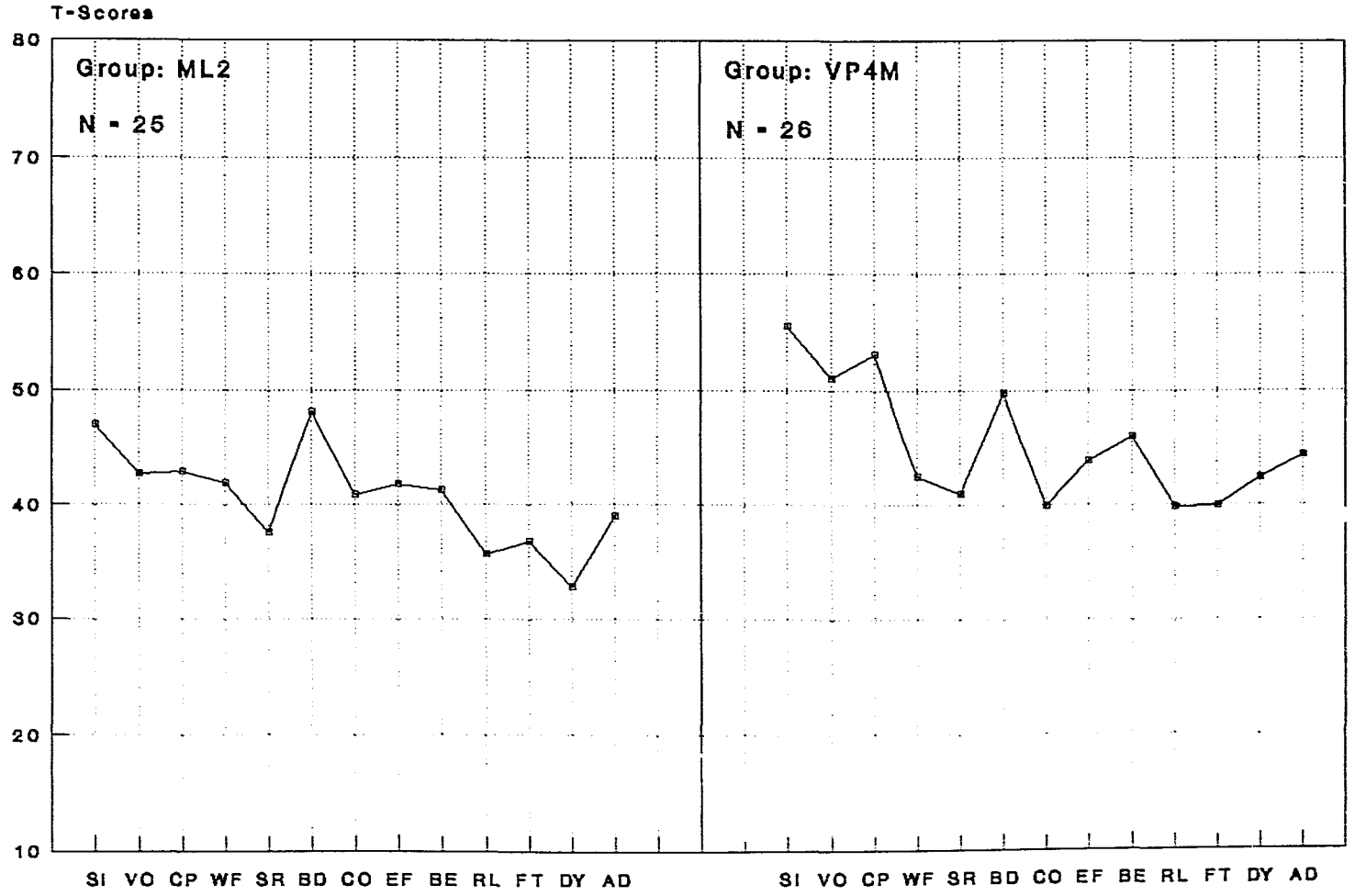


Fig 2 (cont.) Clinical Profiles-Sample A

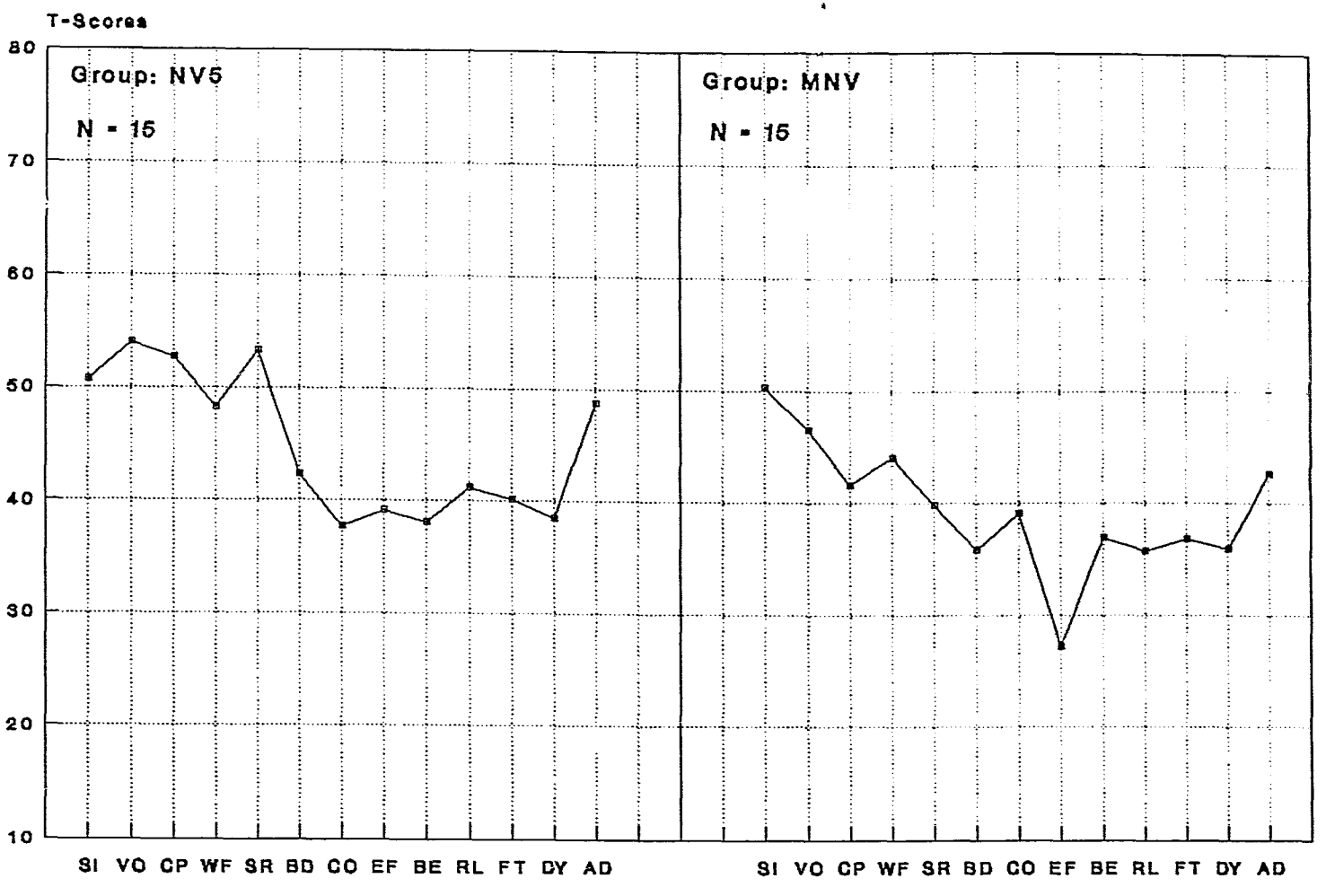


Table 10. Means and Standard Deviations of 16 Variables (S.D's in Brackets) - Clinical Typology Groups - Sample B.

	GROUPS			
VARIABLES	Normal Controls	VP1	VP2L	VP34
Similarities	72.3 (13.3)	68.4 (5.4)	61.4 (8.9)	56.0 (4.4)
Vocabulary	71.0 (10.1)	62.9 (4.8)	61.4 (10.1)	54.0 (7.4)
Comprehension	58.6 (12.5)	62.9 (6.9)	59.1 (5.9)	53.4 (5.2)
Digit Span	59.0 (8.5)	49.9 (8.5)	50.2 (9.9)	43.2 (11.9)
Picture Arrangement	63.3 (11.9)	59.1 (7.9)	53.6 (8.7)	50.6 (14.2)
Block Design	64.3 (7.5)	58.3 (7.1)	52.7 (9.9)	46.6 (9.9)
Object Assembly	63.3 (8.5)	52.4 (12.4)	52.4 (7.4)	51.8 (7.3)
Coding	58.0 (11.5)	42.9 (12.6)	47.9 (9.9)	44.8 (14.5)
Word Fluency	66.6 (5.7)	55.9 (8.8)	50.3 (8.9)	46.4 (4.7)
Sentence Repetition	66.0 (5.3)	59.4 (10.3)	54.2 (5.7)	45.8 (4.3)
Embedded Figures	66.7 (14.2)	46.4 (4.7)	45.2 (10.5)	49.8 (13.1)
Beery V.M.I.	57.7 (12.9)	51.8 (9.6)	45.1 (8.5)	43.2 (14.2)
Right-Left Orientation	51.7 (10.1)	44.3 (11.5)	38.2 (10.8)	31.6 (13.2)
Finger Tapping	39.7 (6.7)	36.5 (7.2)	40.8 (11.1)	41.4 (9.6)
Dynamometer	56.0 (2.7)	45.8 (13.1)	56.4 (8.1)	33.6 (7.9)
Auditory Discrimination	42.3 (2.1)	42.5 (13.5)	44.1 (9.4)	51.6 (4.8)

Table 10 cont'd

VARIABLES	NV5	MNV	LXLR	ML12
Similarities	44.8 (5.7)	52.3 (7.5)	51.2 (7.6)	46.2 (7.3)
Vocabulary	50.8 (8.3)	45.[illegible] (3.7)	46.9 (7.6)	45.9 (10.3)
Comprehension	50.8 (7.4)	42.7 (2.6)	48.7 (7.8)	42.3 (6.0)
Digit Span	45.0 (8.5)	40.0 (12.4)	42.5 (9.8)	45.2 (9.2)
Picture Arrangement	39.0 (4.9)	40.0 (8.9)	55.7 (9.8)	48.1 (11.4)
Block Design	43.3 (9.4)	42.8 (4.9)	53.2 (10.3)	49.2 (10.8)
Object Assembly	50.8 (1.5)	42.8 (3.4)	55.7 (7.5)	55.5 (7.6)
Coding	41.8 (8.1)	35.7 (3.6)	45.5 (9.9)	45. (9.6)
Word Fluency	49.3 (11.2)	44.8 (10.9)	42.3 (7.4)	43.3 (5.2)
Sentence Repetition	50.3 (2.9)	45.7 (7.9)	43.5 (5.9)	45.4 (8.4)
Embedded Figures	35.0 (5.8)	35.5 (7.2)	50.1 (10.4)	43.8 (9.1)
Beery V.M.I.	37.8 (8.3)	38.3 (6.9)	52.4 (8.7)	45.2 (9.7)
Right-Left Orientation	37.3 (16.1)	33.2 (12.4)	46.0 (6.4)	36.5 (10.1)
Finger Tapping	40.3 (2.8)	36.7 (8.8)	39.8 (6.6)	38.8 (10.3)
Dynamometer	49.5 (8.1)	40.7 (10.1)	50.7 (10.7)	49.6 (7.3)
Auditory Discrimination	35.0 (9.1)	38.7 (9.5)	43.5 (9.1)	38.0 (9.4)

Figure 3: Clinical Profiles - Sample B

Variable List

SI - Similarities (WISC-R)
VO - Vocabulary (WISC-R)
CP - Comprehension (WISC-R)
BD - Block Design (WISC-R)
CO - Coding Test (WISC-R)
AD - Auditory Discrimination
BE - Beery Test of Visual-motor Integration
WF - Word Fluency
SR - Sentence Repetition
FT - Finger Tapping
EF - Embedded Figures
RL - Right-Left Orientation
DY - Dynamometer

TABLE 11

Abbreviated Codes for Clinical Typology Subtypes: Sample B

Code	Title of Subtype
VP1	Mild Perceptual-motor Disorder
VP2L	Moderate Perceptual Disorder with mild language and sequencing problems
VP34	Moderate Visual Perceptual Disorder with anomia, gross motor deficits, and verbal memory problems
NV5	Moderate Perceptual/Non-verbal Disorder with good language abilities and poor reasoning
MNV	Severe Mixed-Perceptual/Non-verbal Disorder
LXR	Language Disorders: Expressive and Receptive
ML12	Mixed-Language Disorders (mild to moderate) with perceptual deficits and poor reasoning

Fig 3 Clinical Profiles-Sample B

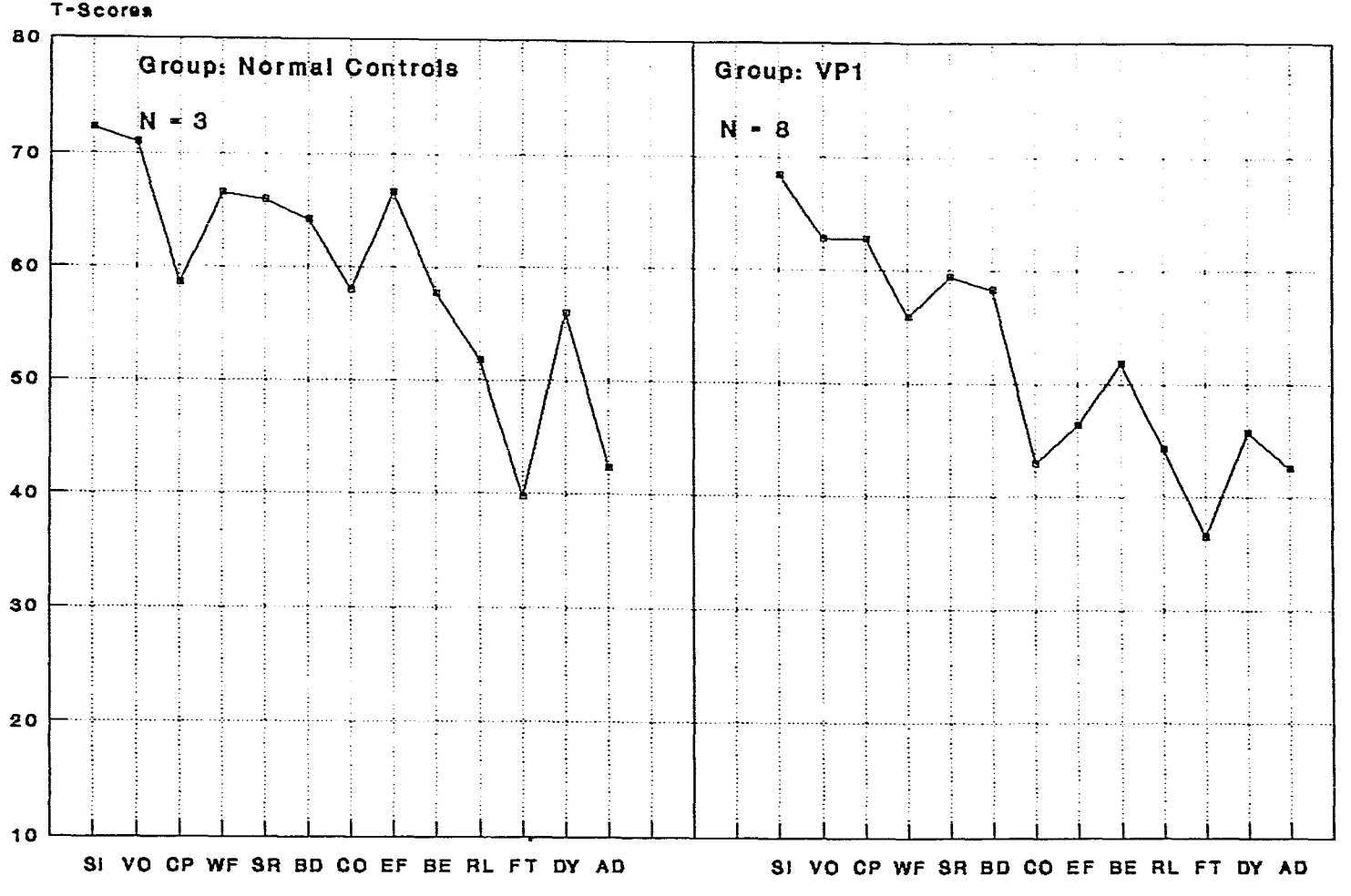


Fig 3 (cont.) Clinical Profiles-Sample B

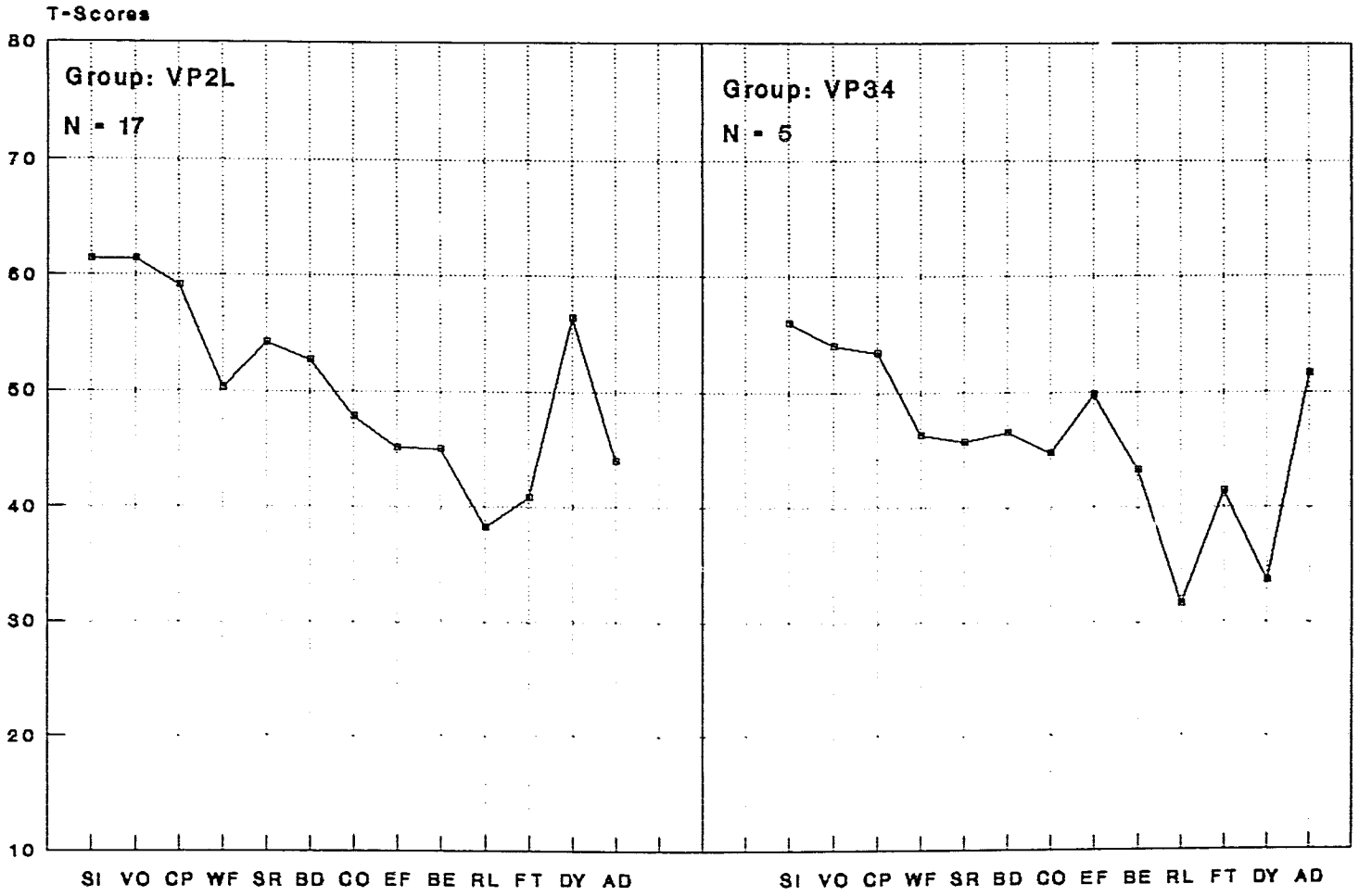


Fig 3 (cont.) Clinical Profiles-Sample B

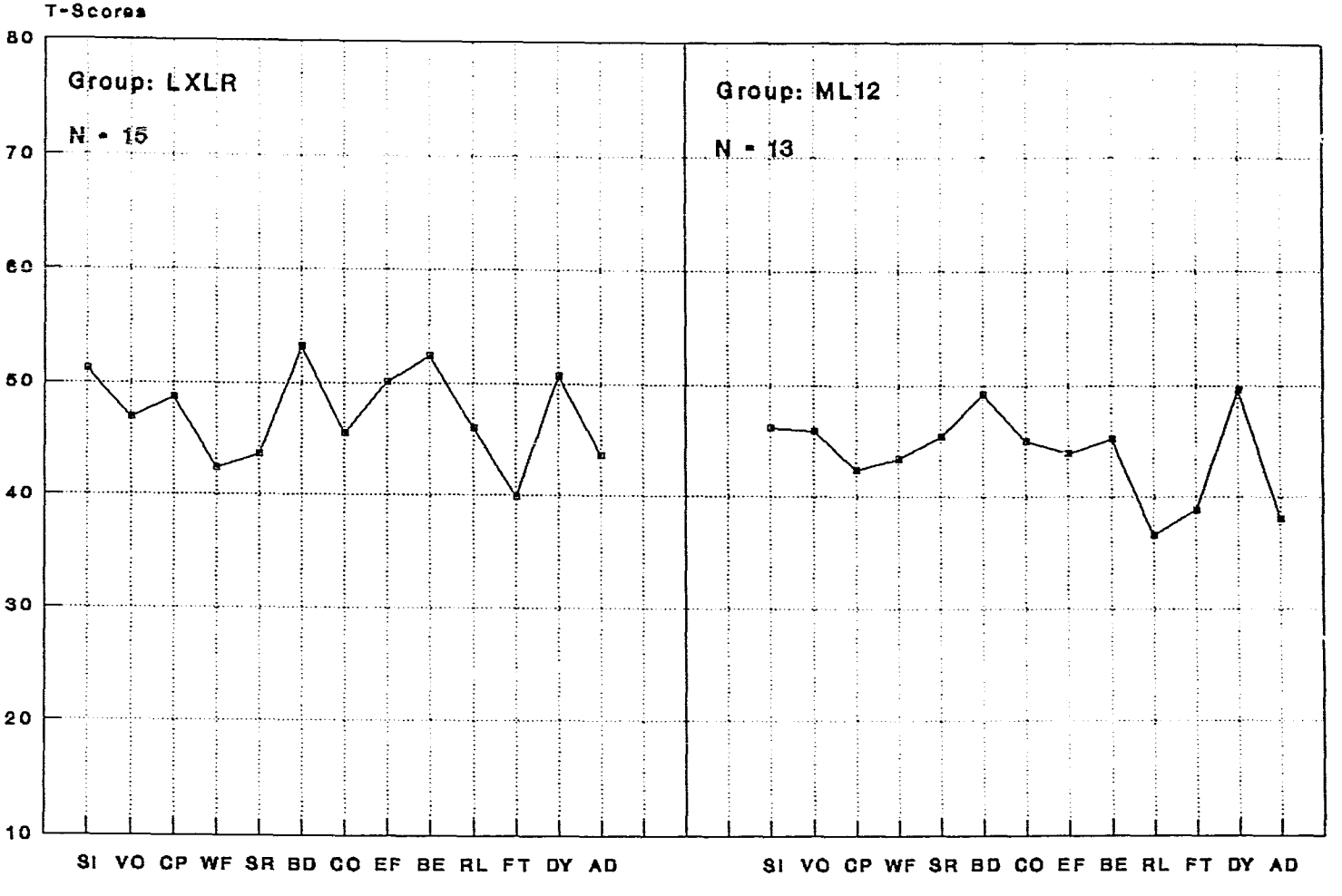
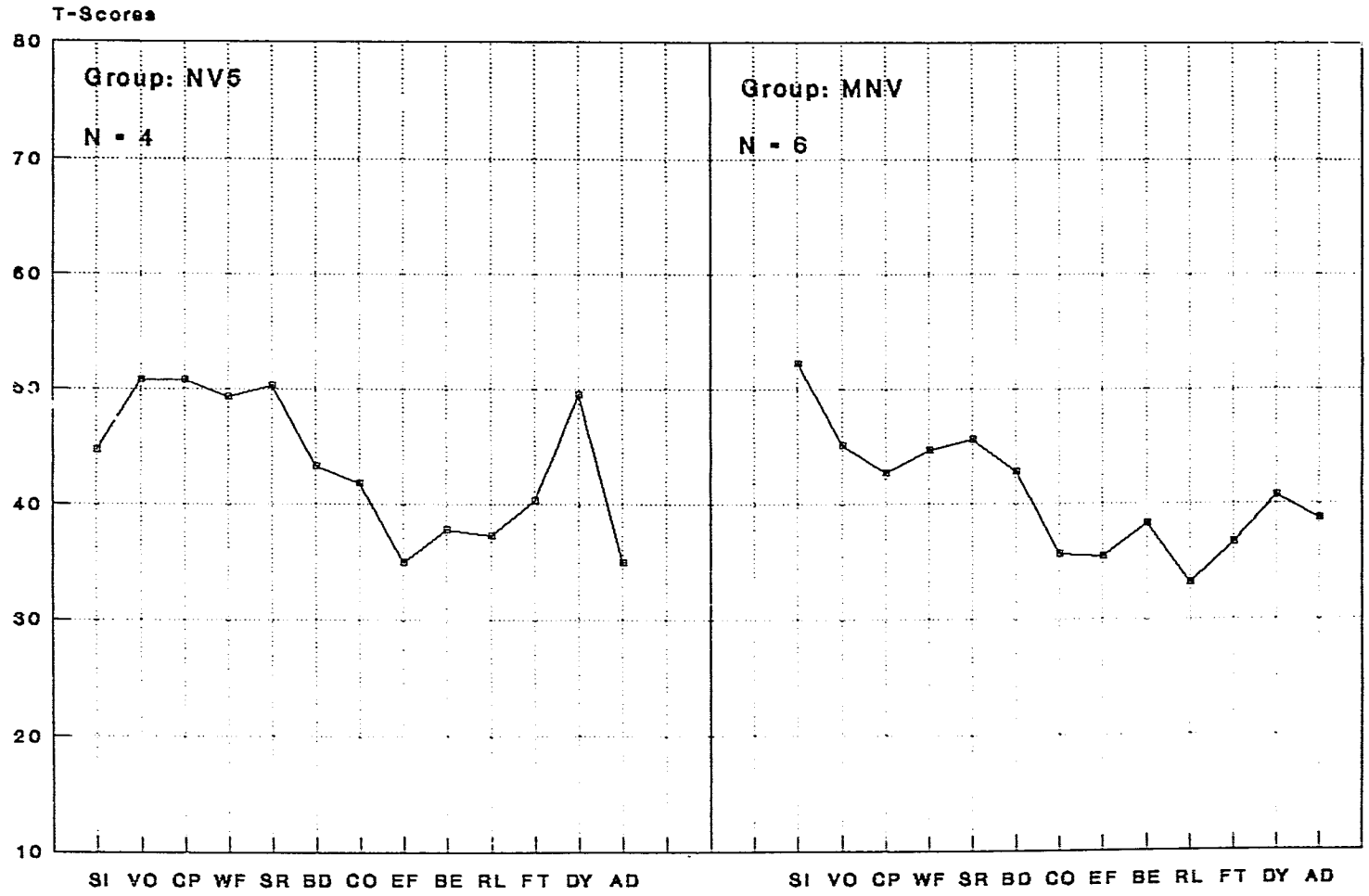


Fig 3 (cont.) Clinical Profiles-Sample B



Phase II

Phase II involved an attempt to identify reliable and meaningful subtypes within the same sample of clinic-referred and normal children by means of multivariate statistical classification procedures.

Cluster Analytic Methods for Samples A and B

For these analyses, the following 11 variables were selected: the Similarities, Vocabulary, Comprehension, Block Design and Coding subtests from the WISC-R; Sentence Repetition, Word Fluency, Embedded Figures, Right-Left Orientation, Dynamometer and The Beery Test of Visual Motor Integration.

Because a hierarchical agglomerative clustering technique had been chosen, the choice of a similarity measure was the first decision to be made. This step involved consideration of the relative importance of both pattern and elevation in the planned analysis. Although the product moment correlation coefficient is usually suggested when the similarity of profile shapes is an important consideration, a distance based measure, such as the squared Euclidean distance, can take both elevation and shape into account. The latter was, therefore, selected as the most appropriate similarity/dissimilarity measure (Fleiss & Zubin,1969; Morris et al., 1981). The second decision involved the choice of method for defining the

similarity between groups of subjects, as different algorithms can result in quite different cluster solutions. Several different methods were selected and tried, and Ward's (1963) minimum variance method used with the squared Euclidean distance measure, provided the best solution in the present cluster analysis. Ward's algorithm considers all possible combinations of clusters and combines clusters which minimize the increase in the error sum of squares (Everitt, 1980).

The Cluster analysis programme from the SPSSx Advanced Statistics Guide (SPSS Inc.,Chicago,USA,1985) was used for the initial hierarchical grouping analyses on both samples (A and B) separately. This was followed by the Cluster programme (SAS/STAT Guide,SAS Institute Inc.,Cary,N.C.,USA, 1987) in order to determine the optimal grouping level. The resulting hierarchical tree and the clustering coefficients are generally used to provide this information. The optimal solution (i.e.the level that best reproduces the underlying natural group structure) is determined by observing a significant change from one stage to the next in the value of the cubic clustering criterion (CCC), and stopping at the level before a large jump in the value, which would imply that the combining of the previous two clusters had created a heterogeneous cluster with extensive variance (Lorr,1983; Mojena,1977; Morris, Blashfield & Satz,1981). There was no evidence of a sudden jump in value in the CCC,

but the hierarchical tree indicated 10 to 12 clusters as the optimal solution. Although there were only very few deep divisions between clusters on the hierarchical tree, several more minor divisions within each major cluster proved to be relevant and interpretable. However, this type of configuration suggested heterogeneity within clusters, which was confirmed by the negative values of the CCC, indicating that clusters should be interpreted with caution.

Although this information applies equally to other cluster analysis routines on the same data set, the cluster solutions derived from the SPSSx Cluster programme proved to be very similar to those that emerged from the SAS cluster analysis. Thus, the choice of an optimal grouping level was made from both these sources, according to the most meaningful division into clusters that were as homogeneous as possible. This proved to be a 10 cluster solution for Sample A and a 6 or 7 cluster solution for Sample B, which emerged as optimal through numerous analyses, using different sets of variables as well as different methods.

A problem with hierarchical methods is that an ineffectual grouping at an early stage of the clustering process cannot later be corrected. In contrast, the iterative partitioning methods are able to check cluster groups and relocate any misassigned subjects to a more

appropriate cluster (Morris et al.,1981). Therefore, the selected grouping for each data set was submitted as an initial starting point for a K-means iterative partitioning procedure (BMDP Statistical Software Inc., University of California Press, Berkeley, Calif. USA,1988). K-means procedures begin with an initial cluster solution and iteratively re-assign individuals until the within-cluster sum of squares is minimized. They also search for "outliers", which are cases who show extremely deviant results in comparison to others in the sample. These subjects may represent unique and rarely encountered individuals; others whose scores are unusually low or high in comparison with the sample; or they may be the result of measurement error. The presence of outliers, whatever the reason, can significantly influence variable distributions and disrupt classification (Morris et al.,1981). For Sample A, outliers were defined as subjects appearing in clusters of $n<5$, and 11 outliers were identified by the Fastclus K-means procedure (SAS/STAT Guide, SAS Institute Inc.,Cary, N.C., USA, 1987). The BMDP K-means partitioning was eventually chosen as the most plausible subtyping solution. Outliers were also removed from the data set prior to a second hierarchical cluster analysis using the SAS Cluster programme (1987), but the results were identical to those in the previous analysis. In Sample B, small clusters of $n<5$ were not treated as outliers, because of the comparatively small sample ($N = 67$).

Results for Samples A and B

The SPSSx clustering routine classified 97% of the cases in Sample A, omitting seven due to missing data. Overall, 17% of the subjects in Sample A were reclassified by the K-means partitioning procedure. Examination of the reclustering revealed that almost all the changes involved the five clusters which were the most heterogeneous. However, although some of the reallocations corrected this situation, a number of the changes merely added to the heterogeneity of these clusters, which confirms the need for caution in interpreting the subtypes (Morris et al., 1981).

The clustering routines classified 100% of the cases in Sample B, and overall, 15% of the subjects were reclassified by the K-means partitioning procedure.

Internal Validation Procedures

Sample A

In order to test the reliability of the cluster solution several procedures were employed. The first of these involved a split-sample design, in which the subject sample was randomly divided into two subsamples (N = 114 and N = 115). Each subsample was submitted to the identical hierarchical cluster analysis routine as used on the complete sample. The results were then compared with those from the total sample with the expectation that the same subjects would cluster together and that the

subsamples should yield similar results. Overall, 30% of the cases were reclustered, which indicates heterogeneity within clusters. However, examination of the cluster descriptions revealed considerable homogeneity within five of the 10 clusters.

The second procedure involved a comparison of the iterated clusters with the results obtained by using an alternative algorithm on the squared Euclidean distance method, as suggested by Morris, Blashfield and Satz(1981). The above procedures were repeated using the average linkage method for defining the similarity between groups of subjects. In this method, the distance between two clusters is the average distance between all pairs of individuals in the two groups (Everitt,1980). This comparison showed 32% of the initially grouped subjects reclustered, which again suggests limited generalizability of the grouping results.

A third procedure involved examining the effect upon the obtained cluster solution of adding more variables as well as reducing the number of variables used in the clustering routines, as follows: a) Four additional variables were included in the analysis, namely: the Picture Arrangement, Digit Span, and Object Assembly subtests from the WISC-R and the Finger Tapping test, and the cluster analysis routines were repeated as before; and b) Five variables were removed from the original eleven leaving only the Similarities, Vocabulary, Coding and Block

Design subtests from the WISC-R as well as Embedded Figures and Sentence Repetition tests, and again the clustering procedures were repeated. The results of the 15 variable analyses revealed that 31.8% of the cases were reclustered; the 6 variable analyses showed 35.6% of the initially grouped subjects in different clusters. Again, examination of the cluster groupings in both these analyses showed fairly stable and homogeneous clusters in five of the clusters. Also, these cluster groupings usually included those cases at the extreme ends of the severity scale, namely the most impaired and the least impaired subjects.

Sample B

Reliability testing of the cluster solution in Sample B did not include the split-sample replication, since the resulting split samples would be too small to assure valid results. However, the iterated cluster solution of Sample B was compared with the results obtained by repeating the above procedures using the average linkage method. This comparison showed 12% of the cases classified into different groupings.

The cluster analyses procedures were also repeated using both a reduced and an additional number of variables, as described above. The results of the 6 variable analysis revealed reclustering in 18% of the cases; in the 15 variable analysis, only 6% of the cases were reclassified into other groupings. Thus, the clusters that emerged from

Sample B data proved to be considerably more stable and homogeneous than those from Sample A, presumably because of the smaller sample size and consequently less variability.

Interpretation of the Clusters (Sample A)

The hypotheses in this study are dependent in part upon the qualitative and descriptive characteristics of the cluster groupings derived from the statistical procedures described above. Profiles of the 10 clusters that emerged from Sample A data are shown in Figure 4. Means and standard deviations of the clustering variables for each subtype can be found in Table 12. The 10 clusters can be described as follows:

1)Visuomotor-Praxis Deficit In this cluster, language skills are quite competent, but performance on tasks involving visual processing and analysis is somewhat slow and less efficient, although scores may not be below average. Weaknesses may include: short-term memory for unrelated material (e.g. Digit Span); fine-motor skills (finger tapping) and frequently handgrip strength; eye-tracking, finger-localization or finger-praxis difficulties; as well as problems in written work, printing and other visual-motor tasks (e.g.coding). However, verbal memory is good. These subjects could be described as having mild perceptual-motor problems. Fourteen of the normal control subjects were assigned to this cluster, as well as 24 clinic referred subjects (N = 38, 16.6% of total group).

Table 12: Means of Clustering Variables. Sample A

VARIABLES	GROUPS				
	CL1	CL2	CL3	CL4	CL5
Similarities	66.8 (7.6)	60.7 (8.9)	50.2 (6.3)	56.7 (6.9)	56.9 (8.2)
Vocabulary	63.0 (7.2)	57.3 (7.6)	49.1 (6.2)	53.3 (7.9)	52.9 (7.2)
Comprehension	63.0 (7.9)	54.1 (8.3)	45.3 (9.9)	52.9 (5.3)	54.1 (6.1)
Block Design	55.6 (9.9)	56.0 (8.9)	36.6 (8.8)	59.2 (7.6)	47.9 (4.8)
Object Assembly	53.7 (7.4)	53.8 (9.0)	43.6 (8.3)	57.6 (8.1)	47.5 (7.6)
Coding	44.9 (10.1)	44.2 (6.9)	35.2 (7.3)	54.1 (8.1)	37.9 (6.9)
Digit Span	52.2 (9.1)	48.1 (7.9)	41.9 (8.6)	47.1 (8.6)	41.9 (7.1)
Picture Arrangement	55.4 (7.3)	54.5 (8.5)	44.6 (10.1)	55.7 (6.5)	50.0 (7.2)
Word Fluency	56.4 (9.2)	43.9 (9.3)	42.6 (8.5)	49.4 (8.0)	41.1 (8.8)
Sentence Repetition	60.2 (7.7)	51.6 (6.7)	47.3 (8.4)	46.0 (9.1)	43.1 (7.0)
Embedded Figures	51.9 (10.6)	51.8 (11.8)	27.4 (13.1)	53.4 (8.7)	39.9 (9.6)
Beery V.M.I.	53.6 (9.5)	45.6 (11.5)	34.5 (8.9)	55.5 (8.1)	44.5 (7.9)
Right-Left Orientation	50.2 (9.0)	21.9 (6.4)	32.2 (15.1)	55.3 (6.7)	44.3 (13.5)
Finger Tapping	43.2 (8.5)	41.4 (8.6)	33.0 (9.5)	43.2 (10.3)	36.9 (9.5)
Dynamometer	46.3 (13.5)	37.2 (9.8)	32.6 (11.4)	47.4 (10.8)	49.0 (12.3)

Table 12:Means of Clustering Variables (contd.) Sample A

VARIABLES	GROUPS				
	CL6	CL7	CL8	CL9	CL10
Similarities	42.8 (9.2)	52.3 (7.5)	46.7 (6.6)	44.3 (7.2)	55.5 (7.3)
Vocabulary	42.1 (6.1)	46.4 (6.8)	43.9 (10.6)	43.8 (4.9)	50.6 (8.6)
Comprehension	44.5 (8.1)	45.9 (6.1)	41.7 (8.9)	44.0 (5.6)	52.6 (6.8)
Block Design	38.3 (10.1)	56.2 (9.8)	46.0 (9.8)	47.9 (6.6)	51.1 (9.7)
Object Assembly	46.7 (10.5)	55.2 (10.6)	49.3 (9.4)	48.5 (8.9)	54.3 (7.9)
Coding	44.6 (9.2)	46.1 (9.9)	38.6 (7.6)	41.1 (10.2)	40.8 (8.1)
Digit Span	40.6 (6.8)	44.7 (8.2)	38.2 (5.6)	45.9 (9.4)	44.4 (6.3)
Picture Arrangement	52.1 (5.8)	52.0 (6.6)	51.8 (8.0)	49.8 (9.0)	50.6 (5.5)
Word Fluency	37.1 (9.9)	45.2 (7.8)	45.6 (10.5)	42.1 (10.5)	43.1 (5.9)
Sentence Repetition	38.3 (10.4)	48.8 (8.2)	33.1 (9.3)	42.8 (9.3)	45.6 (6.7)
Embedded Figures	26.6 (13.1)	48.5 (8.1)	39.6 (12.2)	45.5 (6.3)	51.9 (10.4)
Beery V.M.I.	34.7 (11.9)	49.6 (8.2)	42.8 (9.9)	37.8 (11.8)	50.2 (8.7)
Right-Left Orientation	32.9 (11.4)	48.9 (11.0)	15.3 (7.2)	52.9 (5.9)	50.2 (10.5)
Finger Tapping	43.9 (10.3)	41.7 (9.4)	37.4 (8.1)	39.4 (9.6)	37.1 (8.4)
Dynamometer	46.1 (21.6)	72.8 (8.8)	29.1 (14.5)	28.8 (11.5)	21.3 (9.3)

Note: Beery V.M.I. is Beery Test of Visual Motor Integration.

Figure 4: Cluster Profiles - Sample A

Variable List:

SI - Similarities Test (WISC-R)

VO - Vocabulary (WISC-R)

CP - Comprehension Test (WISC-R)

WF - Word Fluency

SR - Sentence Repetition

BD - Block Design Test (WISC-R)

CO - Coding Test (WISC-R)

EF - Embedded Figures

BE - Beery Test of Visual-motor Integration

RL - Right-Left Orientation

FT - Finger Tapping

DY - Dynanometer

Fig 4. Cluster Subtype Profiles-Sample A

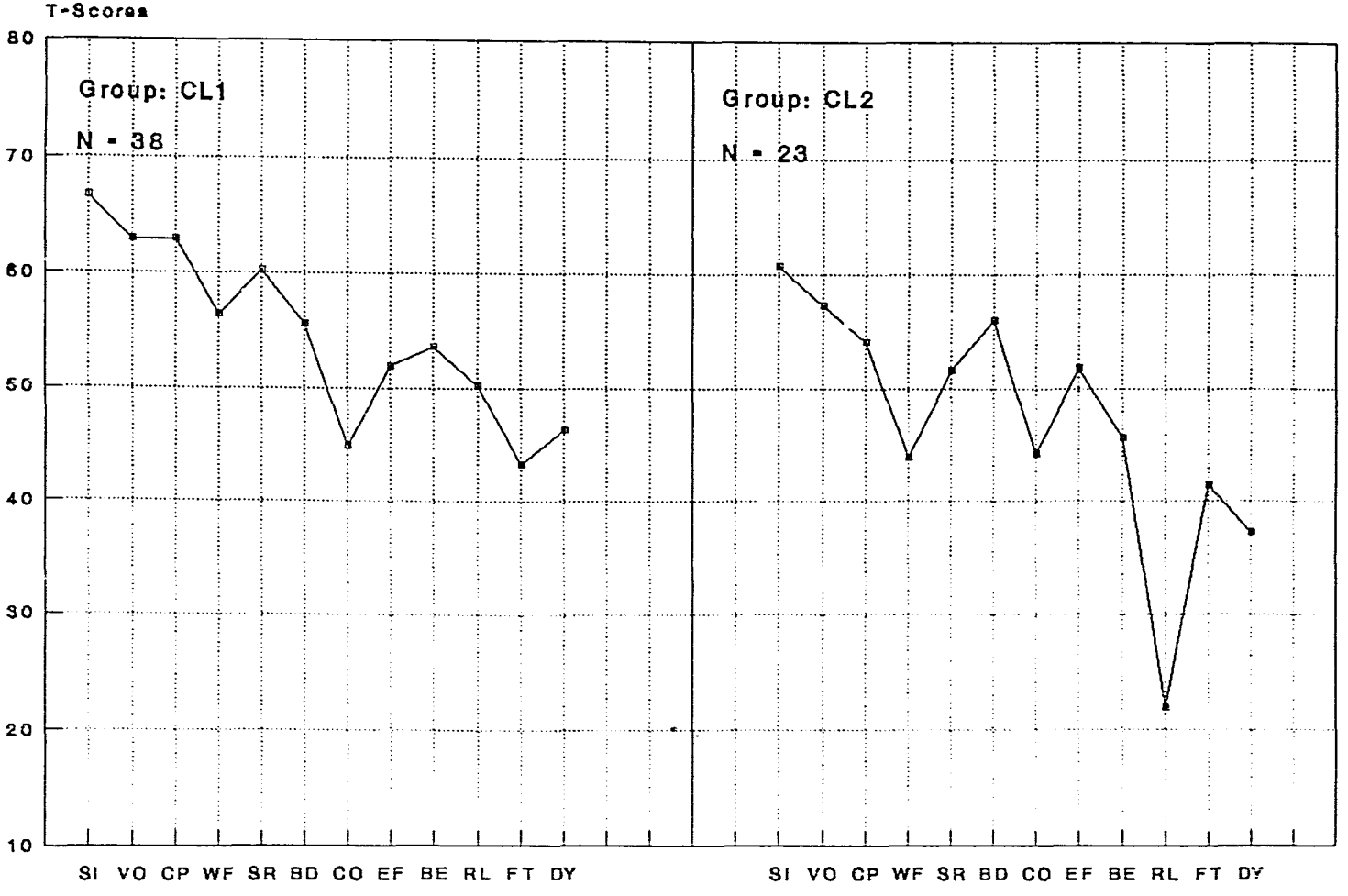


Fig 4 (cont.) Cluster Profiles-Sample A

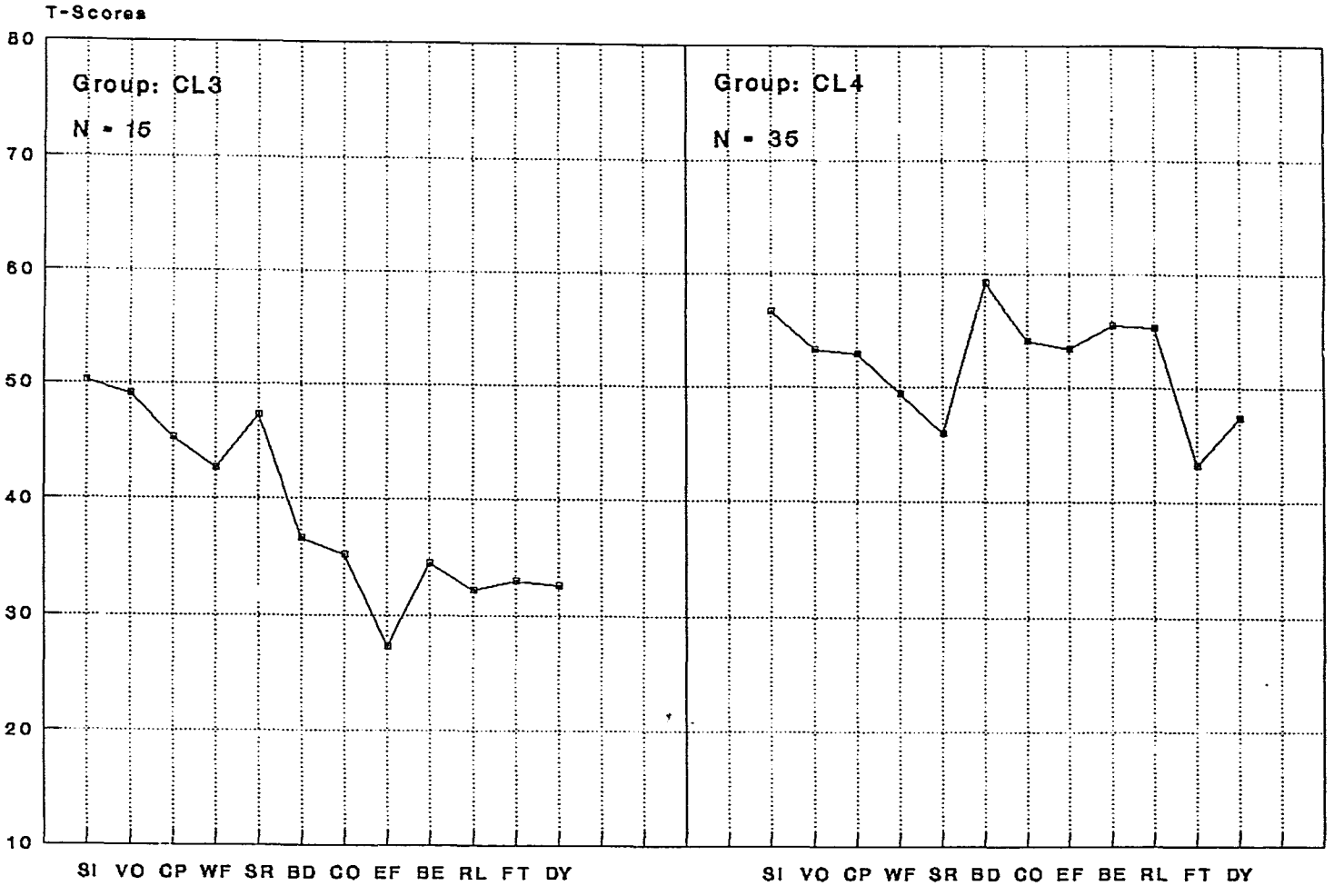


Fig 4 (cont.) Cluster Profiles-Sample A

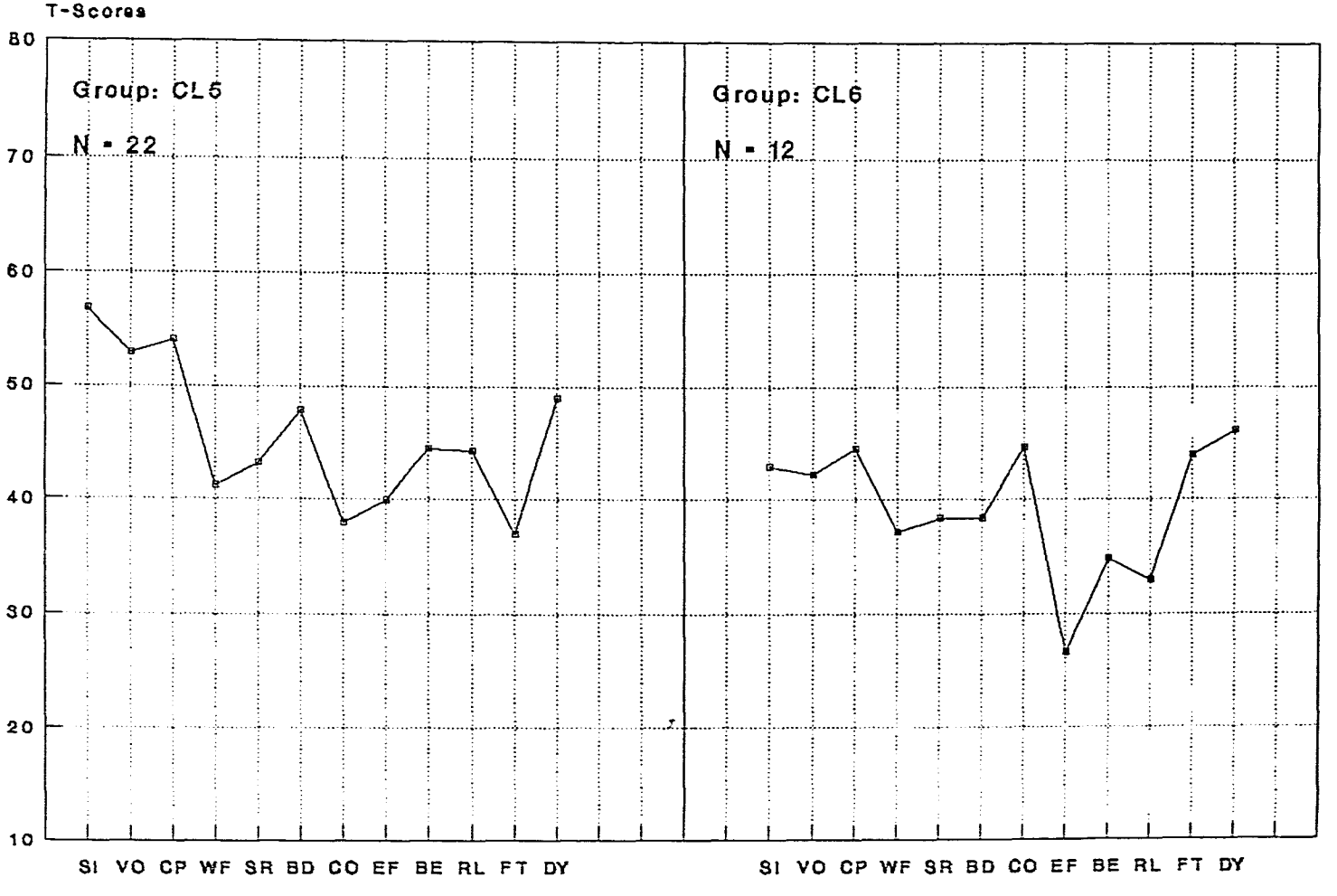


Fig 4 (cont.) Cluster Profiles-Sample A

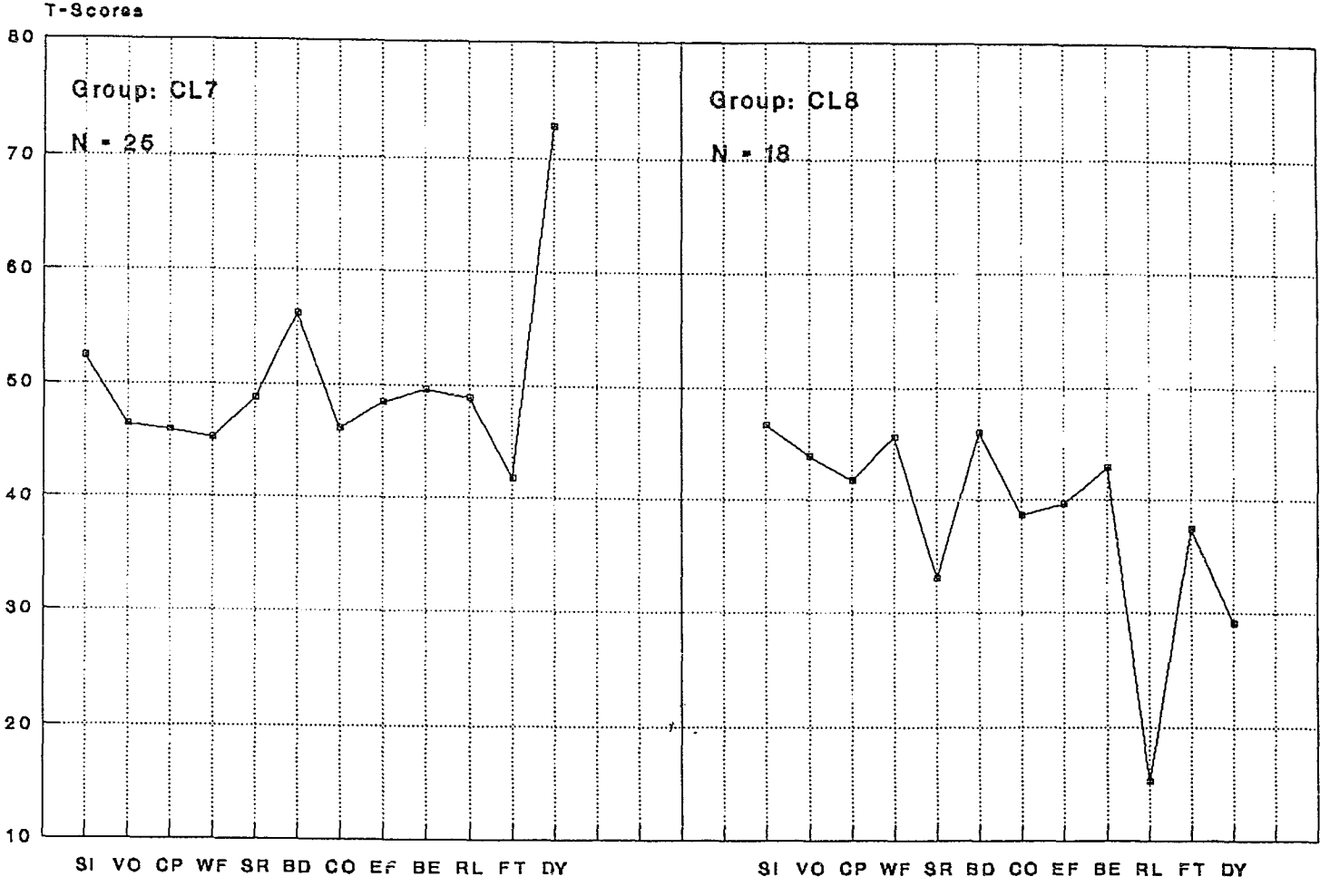
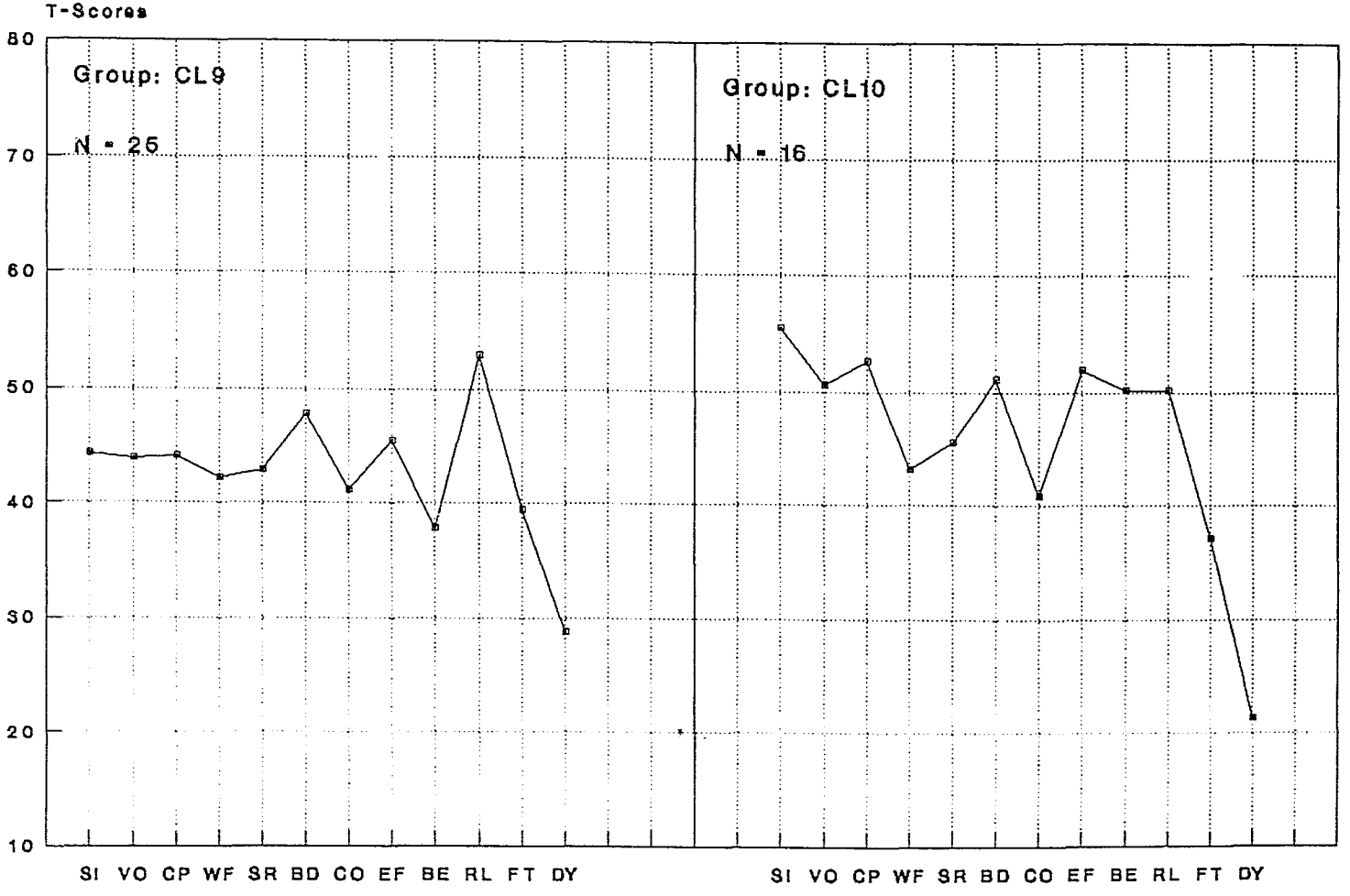


Fig 4 (cont.) Cluster Profiles-Sample A



2.In this cluster were 23 subjects with a variety of problems: Five of them had mild perceptual-motor weaknesses and five had mild language difficulties. Eleven had slightly more serious perceptual, memory or language difficulties, with associated articulation or gross motor problems, and one had very severe visual spatial/perceptual and motor deficits. One normal control subject was assigned to this cluster. In general, language abilities were more efficient in comparison to visual-perceptual-motor skills, although there were some expressive language problems. Verbal memory was generally intact (10% of total group).

3.Severe Mixed Visual-spatial/non-verbal Disorder:This cluster included 15 subjects who were all quite severely impaired in visual-spatial/non-verbal abilities and motor skills. In five of them, language skills were average or above average, verbal memory was good and auditory discrimination was weak; these children were also clumsy with problems in logical reasoning. In the other 10 subjects, language problems were also present, as well as difficulties in comprehension and reasoning. These children were talkative but their speech often lacked substance; and in the six more severe cases, verbal memory was poor (N = 15, 6.5% of total group).

4.Expressive Language Disorder: This cluster consisted of children with comparatively mild language deficits, which mainly involved problems with naming and fluency,

sequencing and sometimes verbal comprehension. Verbal memory was good in some but poor in others. In most of these cases visual skills and visual memory were good, but some had visual perceptual and visual-motor problems, to a varying degree. Nine normal control subjects were also assigned to this cluster (N = 35,15.3% of the total group).

5.Moderate Perceptual Disorder with Expressive Language and Verbal Memory Problems: Cases in this cluster have fairly serious perceptual deficits relative to their verbal and language abilities. However, there are also difficulties in language expression as well as in understanding directions, and verbal memory is deficient. At least half this group have mild articulation problems combined with graphomotor difficulties (N = 22, 9.6% of total group).

6.Severe Mixed Language-Perceptual Disorder: Cases in this cluster have severe disorders of either language, perceptual or a "mixed-language-perceptual" type. Most of the children have some problems in both areas, although in all of them except three, either VIQ or PIQ is within average range. The impairments (either language or perceptual) are generally quite severe in the particular area affected. The three with "mixed-language-perceptual" disorders have almost equal VIQ/PIQ scores, in the Low Average range. All these subjects show marked difficulties with reasoning and comprehension, and conceptual abilities are also weak (N = 12, 5.2% of total group).

7.Receptive-Expressive Language Disorder: The cases in this cluster all have mild to moderate language disorders, with generally more serious problems than the cases in Cluster 4. Both expressive and receptive language skills are impaired to some extent; vocabulary is limited in most cases, and some subjects have a poor verbal memory. In many cases, there are visual perceptual and visual-motor problems to a varying degree, and two normal control subjects are assigned to this cluster (N = 25, 11% of the total group).

8.Severe Mixed Language Disorder: This cluster consists mainly of a moderately serious "mixed-language disorder" group of cases, with comprehension and reasoning problems as well as poor verbal memory. Perceptual deficits are almost equal to the level of language impairment in most cases, and the pace of processing and response is sometimes quite slow. Motor skills are generally weak, and some cases display poor articulation and graphomotor difficulties (N = 18, 7.9% of the total group).

9. This cluster includes subjects with severe language disorders, with "mixed-language" disorders (similar to those in Cluster 8), as well as subjects with moderately serious perceptual or "mixed-perceptual" disorders. A common factor would seem to be very low scores in either overall language or overall non-language functioning (i.e. VIQ's or PIQ's in the 70's or below), as well as deficits

in comprehension or reasoning (N = 25, 10.9% of the total group).

10.Moderate Visual Perceptual Disorder with Anomia and Gross Motor Deficits. Language skills are basically adequate in this cluster of cases, except for marked difficulties in naming and verbal expression. Most cases talk freely, but many have problems with articulation as well as pronounced graphomotor difficulties. Visual memory is good and gross motor skills are deficient (N = 16, 7% of the total group).

When the majority of cases were fairly similar in their patterns of strengths and deficits, an appropriate label was attached to the cluster. As can be seen from the cluster descriptions listed above, 8 out of the 10 clusters could be labelled, but the remaining two clusters could not be named due to marked heterogeneity.

Interpretation of the Clusters (Sample B)

Profiles of the six clusters that emerged from Sample B data are shown in Figure 5. Means and standard deviations of the clustering variables for each subtype can be found in Table 13. The six clusters can be described as follows:

1.Normal Control Group. As the label implies, this cluster consisted of two normal control subjects in this age group, as well as one bright clinic referred child, who proved to be without any learning problems. However, he was reluctant

TABLE 13

Means of the Clustering Variables. Sample B

VARIABLES	GROUPS					
	CL1	CL2	CL3	CL4	CL5	CL6
Similarities	80.0 (0.0)	60.0 (6.9)	65.9 (6.5)	47.4 (7.6)	49.4 (7.1)	46.9 (5.0)
Vocabulary	77.7 (4.1)	57.2 (6.9)	64.4 (5.6)	45.2 (8.7)	48.5 (8.3)	44.4 (6.3)
Comprehension	65.3 (10.8)	55.2 (4.6)	63.8 (5.7)	44.9 (7.0)	48.4 (5.5)	45.2 (6.5)
Block Design	68.7 (7.5)	50.9 (7.3)	59.7 (6.0)	41.4 (7.4)	55.8 (9.1)	45.3 (6.0)
Coding	44.7 (13.7)	53.9 (8.9)	42.8 (10.2)	37.5 (6.1)	47.2 (8.8)	44.3 (11.3)
Word Fluency	68.7 (4.1)	50.8 (7.9)	52.2 (9.1)	43.7 (9.7)	43.2 (7.1)	43.6 (5.8)
Sentence Repetition	67.7 (2.5)	51.9 (6.5)	57.8 (8.3)	44.1 (5.9)	45.4 (6.9)	44.5 (7.8)
Embedded Figures	68.0 (13.2)	46.5 (11.9)	48.4 (5.4)	36.7 (6.1)	48.0 (11.6)	47.3 (8.4)
Beery V.M.I.	65.0 (2.0)	44.9 (8.3)	49.8 (9.6)	36.6 (6.8)	55.7 (7.5)	43.1 (4.3)
Right-Left Orientation	58.7 (2.1)	34.1 (11.2)	41.8 (9.6)	34.7 (11.6)	46.5 (6.5)	40.7 (7.6)
Dynamometer	59.7 (8.9)	53.4 (9.6)	49.3 (11.7)	44.1 (7.5)	46.3 (13.6)	54.8 (3.9)

Figure 5: Cluster Profiles - Sample B

Variable List

SI - Similarities (WISC-R

VO - Vocabulary (WISC-R)

CP - Comprehension (WISC-R)

BD - Block Design (WISC-R)

CO - Coding Test (WISC-R)

EF - Embedded Figures

WF - Word Fluency

SR - Sentence Repetition

FT - Finger Tapping

RL - Right-Left Orientation

DY - Dynamometer

BE - Beery Visual-motor Test

Fig 5. Cluster Subtype Profiles-Sample B

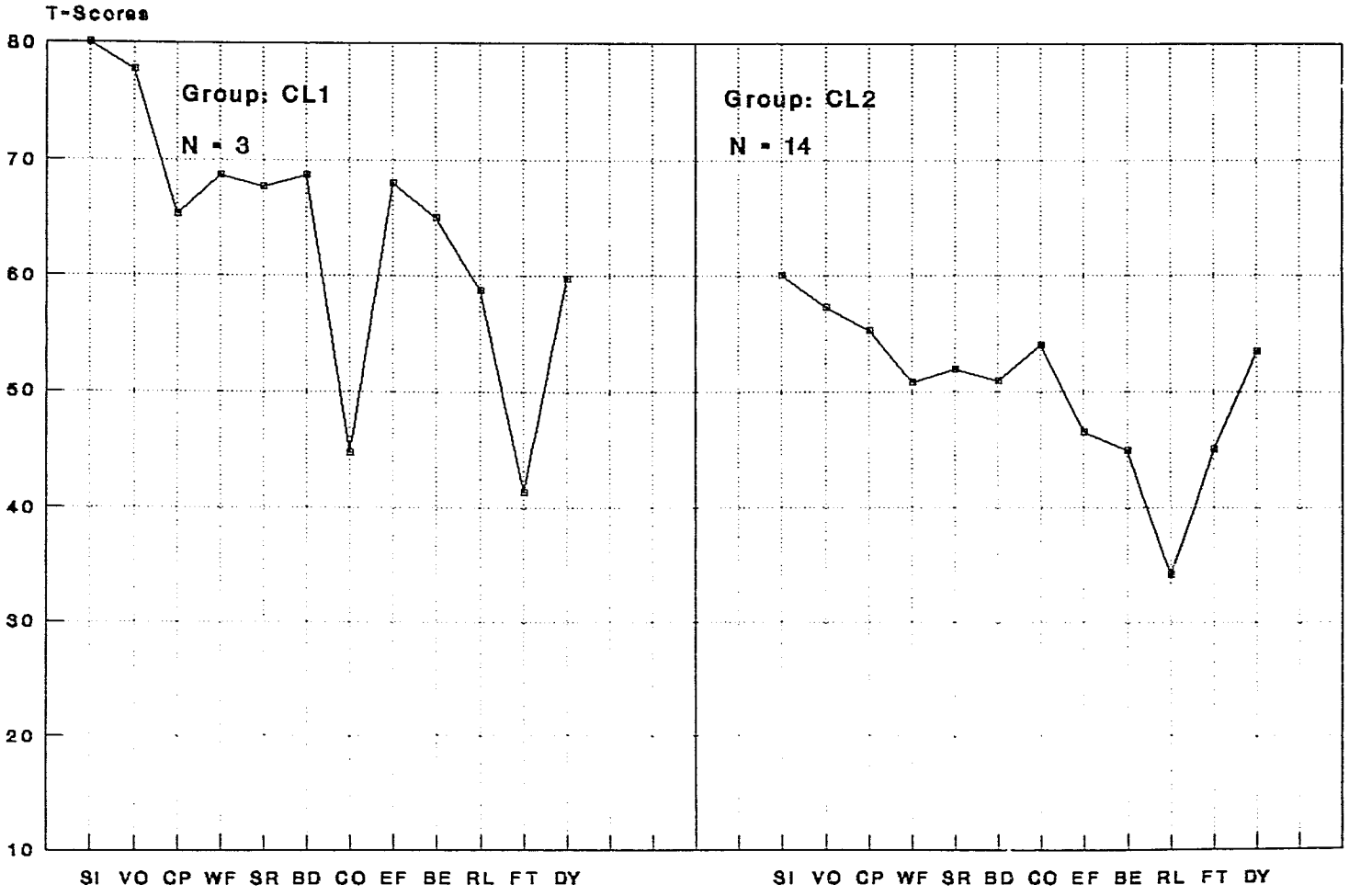


Fig 5 (cont.) Cluster Profiles-Sample B

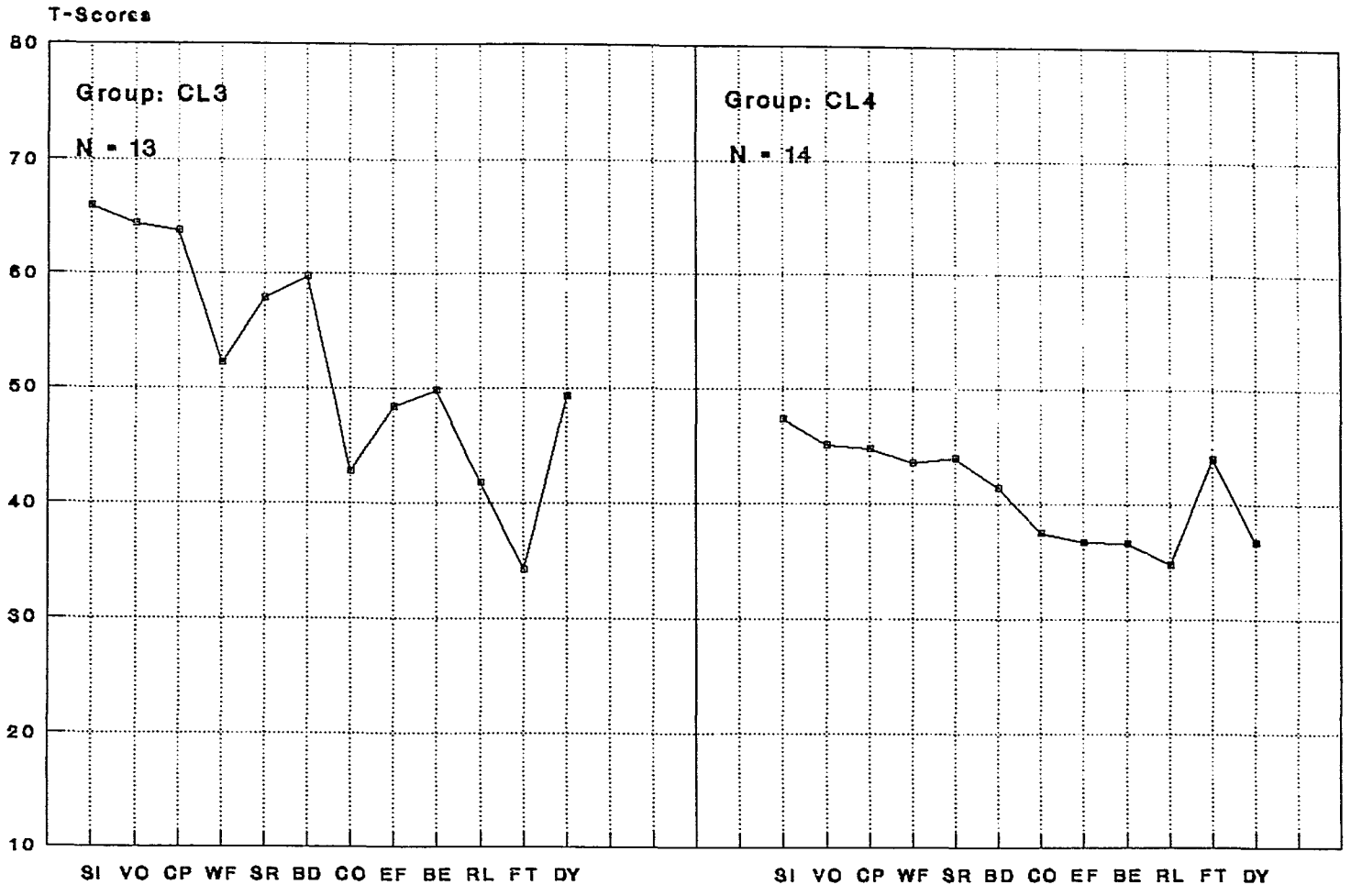
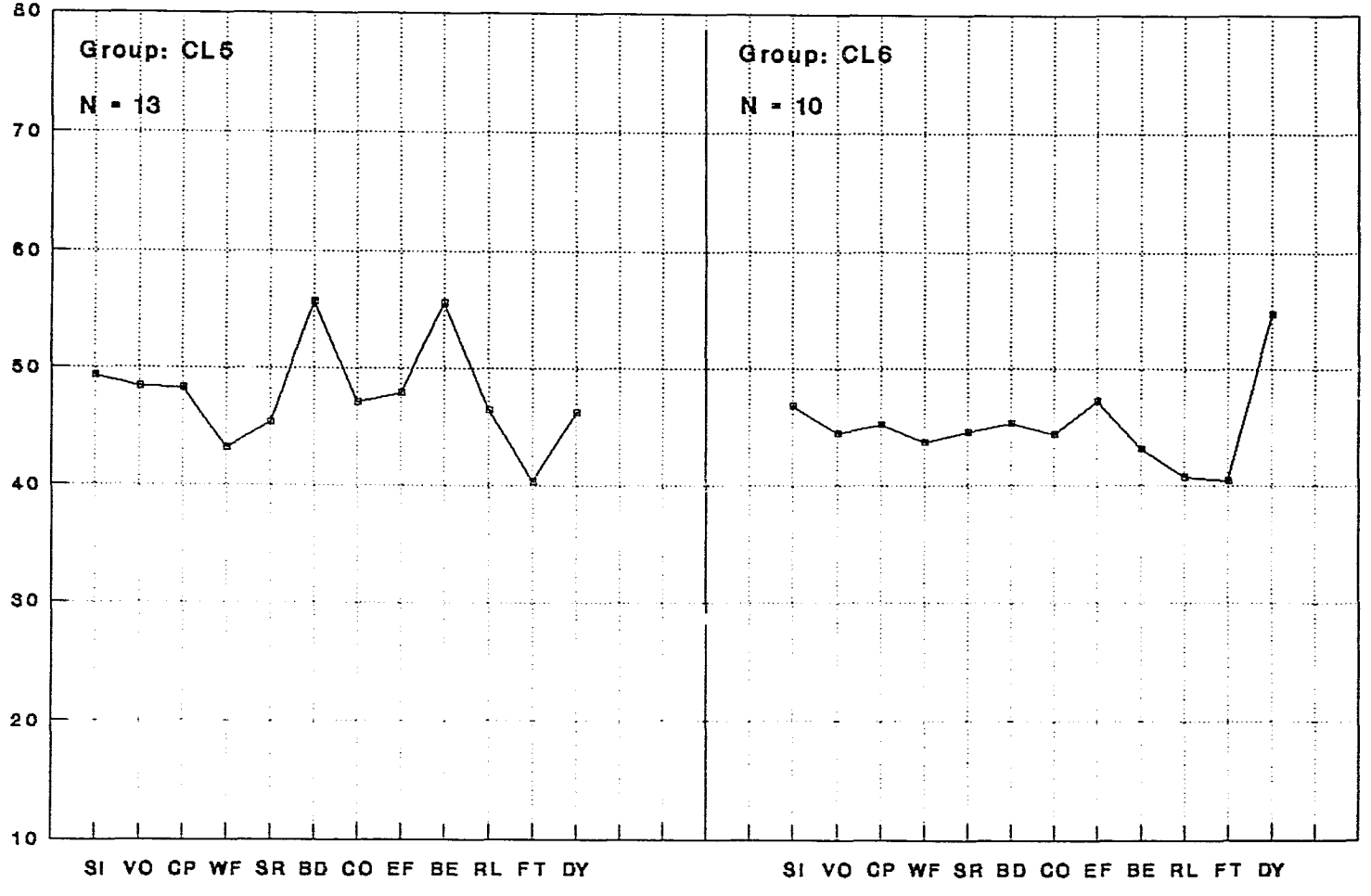


Fig 5 (cont.) Cluster Profiles-Sample B



to perform written work, which was frequently incomplete and his attention was variable (N = 3, 4.5% of the total group).

2.Moderate Visual Perceptual Disorder with Mild Language and Sequencing Problems: The cases in this cluster had quite marked visual-perceptual and visual-motor deficits, as well as some mild language weaknesses, which included naming and fluency problems as well as difficulty in understanding verbal instructions. There were general problems in sequencing and verbal memory was good. In all these cases, articulation problems were evident and there were difficulties in printing or graphomotor tasks (N = 14, including one normal control subject, 21% of the total group).

3.Mild Perceptual Motor Disorder: The cases in this cluster all showed evident visual-perceptual deficits, while language skills were essentially good, ranging from very articulate to mild word-finding difficulties. Comprehension and visual memory were both good; there were no problems with auditory discrimination or articulation; and gross motor skills were variable (N = 13, 19.4% of the total group).

4.Severe Mixed Perceptual-Language Disorder: Nine of the cases in this cluster had more severe impairment in visual/spatial perceptual organization than in language

skills, which were relatively intact in some subjects. However, in five cases, language impairment was equal to or more severe than perceptual deficiency. Almost all cases were described as clumsy, with problems in reasoning and comprehension. Almost all of them also had articulation and graphomotor difficulties (N = 14, 21% of the total group).

5.Language Disorder: This cluster consisted entirely of language impaired cases, including those with mainly expressive language problems as well as those with receptive and expressive difficulties. Visual perceptual abilities varied as did verbal memory. Many of these cases were slow in thinking and processing (i.e. those with receptive language deficits), and most were fairly quiet and shy by nature (N = 13, 19.4% of the total group).

6.Moderately Severe Mixed-Language Disorder: In this cluster, language deficits are more predominant, but perceptual, non-verbal weaknesses are evident. Most cases have reasoning and comprehension difficulties and also frequently have problems in concept formation. Verbal memory is variable but gross motor skills are intact (N = 10, 15% of the total group).

In Sample B, there was generally less heterogeneity in cluster groupings, so that all six clusters could be labelled. However, both Cluster 4 and Cluster 6 included more of a mixture of case profiles than the other clusters,

although there was a general similarity in relation to level of impairment.

Disposition of the Control Group Subjects

In the final cluster solution of Sample A cases, the normal control subjects were classified as follows: Fourteen of them were assigned to Cluster 1 (Mild Perceptual-motor deficit group); Nine were assigned to Cluster 4 (Expressive Language Disorder group); Two were assigned to Cluster 7 (Mild to moderate Receptive-expressive language disorder group); and one case was assigned to Cluster 2 (a heterogeneous group including cases with mild language and mild perceptual-motor problems as well as those with more serious visual perceptual and motor deficits).

Twelve of the control subjects had below average scores in finger tapping and 8 of them scored low in the test of handgrip strength (dynamometer). These findings are reflected in the first graph on page 101 (Fig.2. Normal controls).

The 14 subjects in Cluster 1 all had IQ scores within the Bright average to Superior range, and Verbal IQ was greater than Performance IQ in every case. Three of them had below average scores in the Coding test; five subjects scored low in finger tapping, and in three cases, handgrip was below average. Consequently, the average profile for

this group of control subjects would be quite similar to that of the cases in Cluster 1 (Mild perceptual-motor deficit group), who are generally bright children, with some perceptual deficits relative to their more efficient verbal skills, combined with motor weaknesses. It should be noted, however, that the exact same group of control subjects emerged on Cluster 1 in the six variable analysis (performed during internal validation procedures), in which measures of motor skill were not included. This leads one to conclude that such measures were not essential to the cluster solution, which possibly emphasised verbal and language strengths compared to perceptual abilities in addition to the generally high level of scores in most areas.

The 9 control subjects in Cluster 4 all had IQ scores within the average to Bright average range, and VIQ was less than PIQ in every case. Four of these subjects scored slightly below the average level in tests of finger tapping and four showed some weaknesses in handgrip strength. In 3 cases, verbal memory was somewhat weak and 3 achieved lower than average scores on the Digit Span test. Five of these subjects were also observed to be fairly quiet and not spontaneously talkative. Thus, it would be appropriate for these control subjects with VIQ < PIQ to cluster with this group of clinic-referred cases, whose problems included expressive language, short-term memory and motor deficits.

Three of the control group subjects were clustered into groups with more serious problems. Two of these were assigned to Cluster 7, in which there were visual-motor, fine-motor and memory deficits as well as language difficulties which involved both receptive and expressive components. The two control group cases proved to have low scores in tests of verbal comprehension, vocabulary, verbal fluency and following verbal directions as well as in short term memory and finger-tapping. One of them also scored very low in the Object assembly test on the WISC-R, but despite his test profile, managed quite well on the tests of academic skill, with reading and spelling above average, and mathematics at an average level for his age. The other control subject achieved low scores on oral arithmetic and visual memory tests in addition to those previously listed, and her performance on the WRAT appeared to reflect the deficits in her test profile: Reading was average (SS=100); arithmetic was below average (SS=93); and spelling was weak (SS=81). These results will be examined in greater depth during the external validation procedures.

The third control subject was assigned to Cluster 2, which included a mixture of cases with both mild and fairly serious disorders. This subject achieved low scores in the Similarities, Comprehension, Object Assembly, Coding and Picture Arrangement subtests of the WISC-R as well as in a number of other measures, which included: Naming, Visual

Memory, Trail Making test, Right-left orientation; Benton stereognosis, Finger praxis, Purdue pegboard, Dynamometer and Motor steadiness. However, his performance on the WRAT was good: Reading and spelling were above average (SS=111 and SS=125 respectively), while arithmetic was at an average level for his age (SS=104). It was later revealed that this boy had suffered recurring febrile convulsions from infancy until the age of 5 years, when the seizure condition finally responded to medication.

In the final cluster solution of Sample B, the three normal control cases in this age group were assigned as follows: Two of them were classified in a small group of children without problems or with minimal problems (Cluster 1); and one was grouped with cases who had perceptual deficits combined with mild language and sequencing difficulties (Cluster 2). This latter subject proved to have comparatively low scores in visual-motor skills and finger tapping, and her Verbal IQ was 17 points lower than her superior Performance IQ. On the WRAT, her reading and arithmetic were average, but spelling was slightly weak for her age (SS=90).

The implications surrounding the disposition of these control group subjects along with some additional pertinent information concerning their history will be discussed later in Chapter 6.

CHAPTER 5

Hypothesis Testing Analyses and Results

Hypothesis 1

The prediction that the classifications would identify the three most commonly reported subtypes: a language disorder, a visuo-perceptual disorder, and a mixed language/perceptual disorder, was clearly supported. In the clinical sorting, Groups LX, LR and GL are language disorder subtypes; Groups VP1, VP2L, VP3A, VP4M and NV5 are visuo-perceptual disorder subtypes; and Groups ML1, ML2, MNV are "mixed" subtypes. In the cluster analyses solutions: In Sample A, Clusters 4 and 7 are language disorder subtypes; Clusters 1, 3 and 5 are visuo-perceptual disorder subtypes; and Clusters 8 and 9 are "mixed language and perceptual" subtypes. In Sample B, Cluster 5 is a language disorder subtype; Clusters 2 and 3 are visuo-perceptual disorder subtypes; and Clusters 4 and 6 are "mixed language and perceptual" subtypes.

Hypothesis 2

The expectation that the present typologies would identify several subtypes reported independently in the literature by a number of investigators was partially supported: a) a global language impairment could describe Groups LR and GL in the clinical sorting, and Clusters 7 and 8 in the Cluster analysis solution; b) a visuo-

perceptual disorder is evident in both the present typologies, as shown in Hypothesis 1; c) a sequencing-finger localization disorder could describe the VP2L group in the clinical typology, and such symptoms could be found in Cluster 10 of the clustering solution, but neither group is fully characterized by such problems; d) a specific naming or other linguistic disorder characterizes the expressive language group (LX) in the clinical typology, although problems in naming appear to be fairly general throughout the language disorder groups, as well as in two of the perceptual disorder groups (VP2L and VP3A). Similarly, this type could be equivalent to the Cluster 4 subtype in the statistical grouping,(Sample A), and Clusters 2 and 5 subtypes (Sample B); e) an articulatory graphomotor disorder clearly emerged in the clinical classification: Types(DF) in Group 5; Type(G) in Group 8; Type(Qb) in Group 9; and many subjects in Group 7. However, as can be seen, children with such symptoms appeared throughout the major subgroups of visual-perceptual and mixed disorders, and were grouped into a separate class within the particular subtype to which they had been assigned, on the basis of other classifying attributes. Likewise, in the clustering typology, no specific articulatory graphomotor subtype was identified, except that half the subjects in Subtype 5 (Sample A) had these problems, when their complete test results were examined. However, given the fact that no measure of articulation

could be included in the total variable set, it was not possible for the statistical analysis to identify this subtype; f) a severe generally impaired type could be found in Group 11/12 (MNV) in the clinical typology, and in subtypes 6 (Sample A) and 4 (Sample B) in the statistical solution; g) a minimally impaired type was clearly revealed by both typologies: Group 4(VP1) in the clinical classification and in Cluster 1 (Sample A) and Cluster 3 (Sample B) of the statistical analysis.

Hypothesis 3

Reading Disability Subtypes

In order to answer the question of whether Denckla's (1977,1979) division of reading disabled children into five (or six) subtypes could be supported, subjects with poor reading skills, as determined by WRAT scores, were selected from the total sample used for the clinical inferential classification. This procedure yielded a subset of 191 reading disabled subjects, whose test results and particular type of reading problems were re-examined carefully. Following this, using Denckla's criteria for subtype membership (see Tables 2 and 3), each subject was assigned towhat seemed to be the most appropriate category in Denckla's subtyping of reading disabilities, and tagged with this label.

Table 2. Dyslexia Subtypes (Denckla, 1977)

1.	Language disorder with prominent anomia	(N = 28)
2.	Articulatory-graphomotor dyscoordination syndome	(N = 6)
3.	Visual-perceptual syndrome, combined with anomia	(N = 2)
4.	Dysphonemic sequencing disorder	(N = 7)
	poor repetition scores	
	phonemic substitutions and missequences	
5.	Verbal memorization (learning) disorder	(N = 5)
	Sentence repetition and Paired associate learning both poor	(13 to 15 years)
	although general language skills intact.	

Table 3. Dyslexia Subtypes (Denckla, 1979)

1. Global-mixed language disorder
   a. All tests of language fall below age expectations (comprehension, repetition, and naming tests)
   b. Verbal IQ is below 90 and performance IQ is at least 95

2. Articulatory-graphomotor disorder (Mattis et al., 1975)
   a. Fine motor coordination and pencil use deficient
   b. Language tests normal; articulation deficient

3. Anomic-repetition disorder
   a. Circumlocutory and paraphasic errors account for most excessive errors on confrontation naming
   b. Sentence and digit span shorter than, as well as qualitatively worse than, expected for age group (not true after ten years)
   c. Articulation and comprehension normal
   d. *"Scatter" among subtests on verbal IQ*

4 Dysphonemic-sequencing disorder
   a. Sentence and digit span "failed" by virtue of omissions, substitutions, errors of sequence
   b. Naming errors (not excessive in number) also characteristically phonemic and/or sequential details
   c. Complex synactical constructions misunderstood
   d. Articulation and verbal IQ at least average

5. Verbal learning (memorization) deficiency

6. Correlational (sequential-simultaneous?) deficiency

Note: numbers 1, 2, 3, and 4 also recognized by Mattis, 1977.

Subsets of reading disabled subjects from both Sample A and Sample B were then subjected to re-analysis, using the same clustering procedures as previously described.

Results from Sample A

Of the 10 clusters which emerged from Sample A, five proved to be reasonably homogeneous, interpretable clusters, and five clusters were very heterogeneous, as can be seen from the following summary ("DD types" denotes Denckla's dyslexia subtyping category):

Cluster 1: Mild to Moderate Perceptual Disorder, with mild language disabilities. (DD types: dysphonemic-sequencing (5); visual perceptual disorder (2),N = 7).

Cluster 2: Mixed-language-disorder group, which includes both receptive and expressive deficiencies as well as some cases with comprehension and reasoning problems and poor verbal memory. (DD types: dysphonemic-sequencing (5); anomic repetition disorder (2); visual processing deficits (1); a mixture of all the above (4) N = 12).

Cluster 3: Moderately severe perceptual disorder combined with mild expressive language and sequencing problems (naming and fluency); auditory discrimination poor in most cases. (DD types: dysphonemic-sequencing (3); visual processing deficits with anomia (4); anomic-repetition disorder (1); a mixture of problems (1) N = 9).

Cluster 4: Receptive and mixed-language disorders, with perceptual difficulties, verbal memory deficits and weak visual memory, as well as poor auditory discrimination and motor difficulties. (DD types: dysphonemic sequencing (11); visual processing (3) N = 14).

Cluster 5: Language disorder, including expre sive as well as receptive and mild mixed-language disorders; all of average intelligence. (DD types: dysphonemic-sequencing (6); mixed dysphonemic-sequencing and visual processing (5),N=11).

Cluster 6: Mild to moderate perceptual-motor disorder, in which language skills are good, except for mild word-finding and sequencing problems. Verbal memory is intact. (DD types:dysphonemic sequencing combined with poor visual processing (7); visual processing problems (3), N = 10).

Cluster 7: Mixed language and perceptual-motor deficits; seriously impaired group, with intelligence in low average range, and poor verbal memory. (DD types: anomic-repetition syndrome (3); dysphonemic-sequencing combined with poor articulation and graphomotor skills (2); dysphonemic sequencing (1); poor visual processing (1); a mixture of all types (1), N = 8).

Cluster 8: Another heterogeneous group of expressive language, receptive language and mixed-language-perceptual disorders. (DD types: dysphonemic-sequencing (9);

dysphonemic sequencing and poor visual processing (3); visual processing problems (3), N = 15).

Cluster 9: Fairly severely impaired language group, some with adequate visual perceptual abilities and others with some deficits in this area. (DD types: dysphonemic-sequencing (5); a general mixture of types (1); global language impairment - low in all language abilities, with lowest reading score (1), N = 7).

Cluster 10: Also quite a severely impaired group, mainly those with mixed-language-perceptual and mixed-perceptual-language disorders, as well as those with severe (global) language disorders. (DD types: visual processing poor (5); dysphonemic-sequencing (1); mixed types (1); global language impairment (3). All were reading at very low levels (N = 10).

Results from Sample B

Six clusters resulted from the cluster analysis procedures performed on Sample B data, and could be briefly described as follows:

Cluster 1: Severe mixed-perceptual disorder group, with non-verbal as well as language deficits; marked problems in reasoning, non-verbal problem-solving and comprehension; verbal memory is poor in most cases. (DD types: Visual processing combined with anomia (6); dysphonemic-sequencing disorder (1), N = 7).

Cluster 2: Language disorder group, including expressive and receptive difficulties. (DD types: dysphonemic-sequencing (4); anomic-repetition syndrome (2); visual processing with anomia (1), N = 7).

Cluster 3: Mixed language disorder group, in which language impairment is more severe than perceptual deficiency; verbal memory poor; problems in reasoning and comprehension. (DD types: dysphonemic-sequencing (2); anomic repetition syndrome (1); mixed visual processing and dysphonemic-sequencing (1), N = 4).

Cluster 4: Mild Perceptual Motor Disorder, with problems in perceptual processing and visual-motor skills; language is good in most cases, but some have mild word-finding difficulties. (DD types: visual processing problems (6); dysphonemic-sequencing (2), N = 8).

Cluster 5: Moderate Perceptual Motor Disorder, in which fairly serious perceptual deficits are combined with mild language and sequencing problems. (DD types: visual processing problems (6); visual processing with sequencing difficulties (3); mixed problems (1), N = 10).

Cluster 6: This group is a heterogeneous mixture of cases with expressive language difficulties; moderately serious perceptual and sequencing problems; and more severe deficits in visual-spatial, non-verbal skills, with accompanying reasoning and comprehension problems. (DD

types: visual processing problems with anomia (4); dysphonemic-sequencing (3); anomic-repetition syndrome (1); mixture of all the above (1), N = 9).

Given the heterogeneity of many of the clusters derived from the analysis of Sample A data, the fact that several different reading disorder subtypes emerged for each cluster grouping was not surprising. On those clusters which were relatively homogeneous, such as clusters 1,4,5,6 and 9, the corresponding reading disorder subtypes were limited to one or two, and also appropriately matched the character of the subtype; for example, in cluster 4, which is a language and mixed-language disorder subtype, the corresponding reading problem is the dysphonemic-sequencing disorder type (in Denckla's typology) for 11 cases, and visual processing disorder in the remaining 3 cases. The results are, therefore, exactly what one might expect, from the descriptions of cluster characteristics.

The cluster analyses performed on the data set from the younger age group (Sample B) typically yielded more clearly defined, homogeneous clusters than those from the analyses performed on Sample A data, possibly because of the smaller size of Sample B. The six cluster solution described above also proved to be fairly stable and replicable over several different analyses, using different sets of clustering variables. Also, similar to the Sample A analysis, the corresponding reading disorder subtypes (based on Denckla's

typology) appropriately matched the problem character of the relevant subtype.

These findings suggest only qualified support for the existence of Denckla's reading disability subtypes. However, this could relate to the fact that the variables used in the clustering procedures did not include several test measures which are judged to be relevant discriminating factors in reading disorders, for reasons described earlier in the methods section of this study. These included measures of naming, auditory sequencing and blending, visual sequencing and articulation. Had such variables been used in these two cluster analyses, it is possible that there might have been greater convergence between these results and Denckla's subtypes.

When exploring this question in relation to the clinical typology, all such information was available in the file, which was an advantage. In order to compare Denckla's subtypes with the clinical typology, the subjects with reading problems belonging to each clinical subtype were re-examined in terms of their assignment to one of Denckla's categories of reading disability, with the following results:

Subtype 1 (from Group LR)Receptive-expressive language disorder: Phonetic word analysis very weak in both reading and spelling in all cases (N = 32). (DD types: Dysphonemic-

sequencing disorder in all 32 subjects).

Subtype 2 (from Group LX)Expressive language disorder: All cases had been classified as having expressive language deficits as their main problem, but their type of reading difficulty varied. (Denckla subtypes were as follows: (a) Anomic-repetition disorder combined with a visual perceptual problem - 7 cases; (b) Dysphonemic-sequencing disorder with typical symbol reversals and letter sequencing errors - 8 cases; (c) Mixed dysphonemic-sequencing/visual processing disorder group - 5 cases; (d) Visual processing disorder, with good phonic skills - 3 cases).

Subtype 3 (from Group GL)Severe Language Disorder: All 5 cases had severe reading problems, particularly with phonetic and blending skills; both visual and verbal memory are poor, and auditory discrimination is weak. Reading comprehension is also deficient. (DD type: Global language disorder, 5 cases).

Subtype 4 (from Group VP1)Mild Perceptual Motor Disorder: (DD types of reading disorders: dysphonemic-sequencing combined with visual processing deficits (4); anomic-repetition disorder combined with graphomotor, blending and perceptual symbol confusion problems (1); visual processing and sequencing problems (5), N = 10)

Subtype 5 (from Group VP2L)Moderate Perceptual Disorder with mild expressive language and sequencing problems: It is not surprising to find a large number of cases with reading problems in a group with such a combination of symptoms (26 out of 38 subjects - 68%). Three types of reading problem were represented, as follows: (a) visual processing disorder combined with anomia; phonic skills more efficient, but problems with sequencing or auditory discrimination. Printing also difficult - (16 cases); (b) dysphonemic-sequencing disorder combined with poor naming, visual processing or auditory discrimination problems - (8 cases); (c) dysphonemic-sequencing disorder only (2 cases). N = 26.

Subtype 6 (from Group VP3A)Moderate Perceptual Disorder with Anomia and gross motor deficits: Cases with reading difficulties were also numerous in this group (20 out of 29 cases, 70%), and types of reading problems were similar to those in subtype 5, namely:(a) visual processing disorder with anomia, sequencing or auditory discrimination problems (9 cases, of whom 5 displayed articulatory-graphomotor difficulties; (b) dysphonemic-sequencing disorder (2 cases); (c) mixed dysphonemic-sequencing/visual processing/ naming or auditory discrimination problems (9 cases, three of whom displayed articulatory-graphomotor problems), N = 20.

Subtype 7 (from Group VP4M)Moderately Severe Perceptual Disorder with expressive language and verbal memory problems

Types of reading problems are as follows: (a) visual processing disorder with associated anomia or auditory discrimination problems; poor visual memory (6 cases); (b) dysphonemic-sequencing disorder; visual memory intact (2 cases); (c) dysphonemic-sequencing disorder with anomia and/or visual processing problems; visual memory intact, (8 cases); (d) dysphonemic-sequencing disorder with naming problems and poor visual memory (1), N = 17.

Subtype 8 (from Group NV5)Moderately severe perceptual-spatial-disorder-with good verbal abilities: These are clumsy children, with gross motor deficits and poor printing. Many have articulatory-graphomotor problems. Because language skills are intact, reading disabilities are relatively few (8 cases out of 22), and reading problem types are as follows: (a) visual processing disorder with anomia and sequencing problems (5 cases); (b) visual processing disorder with auditory discrimination and sequencing problems (3 cases). In all 8 cases, printing was laboured and included reversals; writing messy and dysgraphic. In one older case (11 years), reading comprehension was weak.

Subtype 9 (from Group ML1)Mild Mixed Language Disorder: Three types of reading disabilities are represented in this group, as follows: (a) visual processing disorder with

anomia and sequencing problems (8 cases - all with problems in printing); (b) dysphonetic-sequencing disorder with typical symbol reversals (6 cases); (c) mixed dysphonemic-sequencing and visual processing disorder, with anomia or visual memory problems (7 cases), N = 21.

Subtype 10 (from Group ML2)Moderately severe mixed language disorder. There were four reading problem types in this group, as follows: (a) visual processing disorder (2 cases); (b) dysphonemic-sequencing disorder (18 cases); (c) mixed dysphonemic-sequencing, anomic-repetition and visual processing problems (14 cases); (d) anomic-repetition disorder with visual processing problems (4 cases), N = 38.

Subtype 11 (from Group MNV)Severe mixed perceptual disorder
Severe non-verbal deficits combined with language weaknesses. This group is divided into two groups, each with its own type of reading problem, as follows:
(a) dysphonetic-sequencing disorder with associated visual discrimination, naming, visual memory, auditory discrimination or vocabulary weaknesses; visual processing is generally efficient, but printing poor, (N = 4).
(b) visual processing disorder with associated naming or fluency problems; many cases with articulatory-graphomotor difficulties, which are quite severe; phonic skills are reasonably efficient, although younger cases have difficulty with blending; reading comprehension is poor on older cases. (N = 17).

The above analysis of reading disorders in the clinical typology would appear to provide considerable support for the existence of all five of Denckla's (1977) reading disability subtypes, namely: the anomic repetition disorder; the visual perception syndrome combined with anomia; the global language disorder (or language disorder with prominent anomia); the dysphonemic-sequencing disorder; and the articulatory-graphomotor disorder. Such reading disability types are not always clearly grouped together and delineated as specific subtypes in this classification of a larger, generally learning disabled population. However, the existence of such syndromes or patterns of deficit is evident, despite the fact that they emerge in several different locations in the broader classification scheme.

Hypotheses 4 and 5

Arithmetic Disability Subtypes

Rourke and colleagues investigated groups of children who experienced specific difficulties with arithmetic, and compared them on a number of auditory-perceptual, verbal, visual-perceptual-organizational and motor variables (Rourke & Finlayson, 1978; Rourke & Strang, 1978; Strang & Rourke, 1983). They identified two different types of arithmetically impaired children: a) a group in which the subjects were relatively adept in arithmetic, compared with

their poor performance in reading and spelling (Group 2). This group scored well on tests of visual-perception, and relatively poorly on measures of auditory perception or verbal abilities, particularly word blending, speech sound perception and sentence memory; b) a group in which the subjects performed poorly in arithmetic compared with their average or above average performance in reading and spelling (Group 3). This group scored well on tests of auditory perception and verbal skills, but were somewhat deficient in visual-perceptual organizational abilities (Rourke & Finlayson, 1978).

In order to test the hypotheses concerning the relationship between poor arithmetic, poor reading/spelling and particular profile strengths and weaknesses, an additional analysis was required. The scores on the Wide Range Achievement Test (WRAT) from the whole sample (both Sample A and Sample B) were submitted to the same cluster analysis procedures as before, using Ward's minimum variance method. This analysis produced 11 subgroups, which divided the subjects on the basis of their patterns of reading, spelling and arithmetic achievement. Those with poor arithmetic scores relative to their reading/spelling scores were selected in order to test Hypothesis 4. Those with poor reading/spelling scores relative to their somewhat better arithmetic scores were selected for testing Hypothesis 5. However, the final selection from this group

of subjects was based on the criteria described by Strang and Rourke (1985b), as follows: Using the group labels of these authors, for Group 2 (poor reading and spelling): The WRAT reading and spelling centile scores did not exceed 14 and the grade scores were at least 1.8 years below WRAT arithmetic scores. In Group 3 (poor arithmetic): the WRAT reading and spelling grade scores exceeded the WRAT arithmetic scores by at least 2.0 years. It was also emphasised (Strang & Rourke, 1985b) that the subjects in Group 2 were relatively proficient in arithmetic (although still impaired relative to age norms), compared to their performance in reading and spelling.

Using these criteria for selection, 37 subjects from Sample A and 8 subjects from Sample B were identified as appropriate for Group 3; while 20 subjects from Sample A and 15 subjects from Sample B were found to fit the criteria for Group 2. The means on 16 appropriate variables were calculated for each of these four groups of subjects, and T-score profiles were plotted in order to examine strengths and weaknesses.

Hypothesis 4

Figure 6 shows the profiles of subjects with poor arithmetic relative to their average reading and spelling performances (Group 3). The profile for Sample A subjects indicates low scores in visual-spatial organizational skills as expected, but auditory perceptual, verbal

Figures 6 and 7: Arithmetic Disability

Variable List:

SI - Similarities Test (WISC-R)

VO - Vocabulary (WISC-R)

CP - Comprehension Test (WISC-R)

BD - Block Design (WISC-R)

OA - Object Assembly (WISC-R)

CO - Coding (WISC-R)

WF - Word Fluency

SR - Sentence Repetition

EF - Embedded Figures

BE - Beery Test of Visual-motor Integration

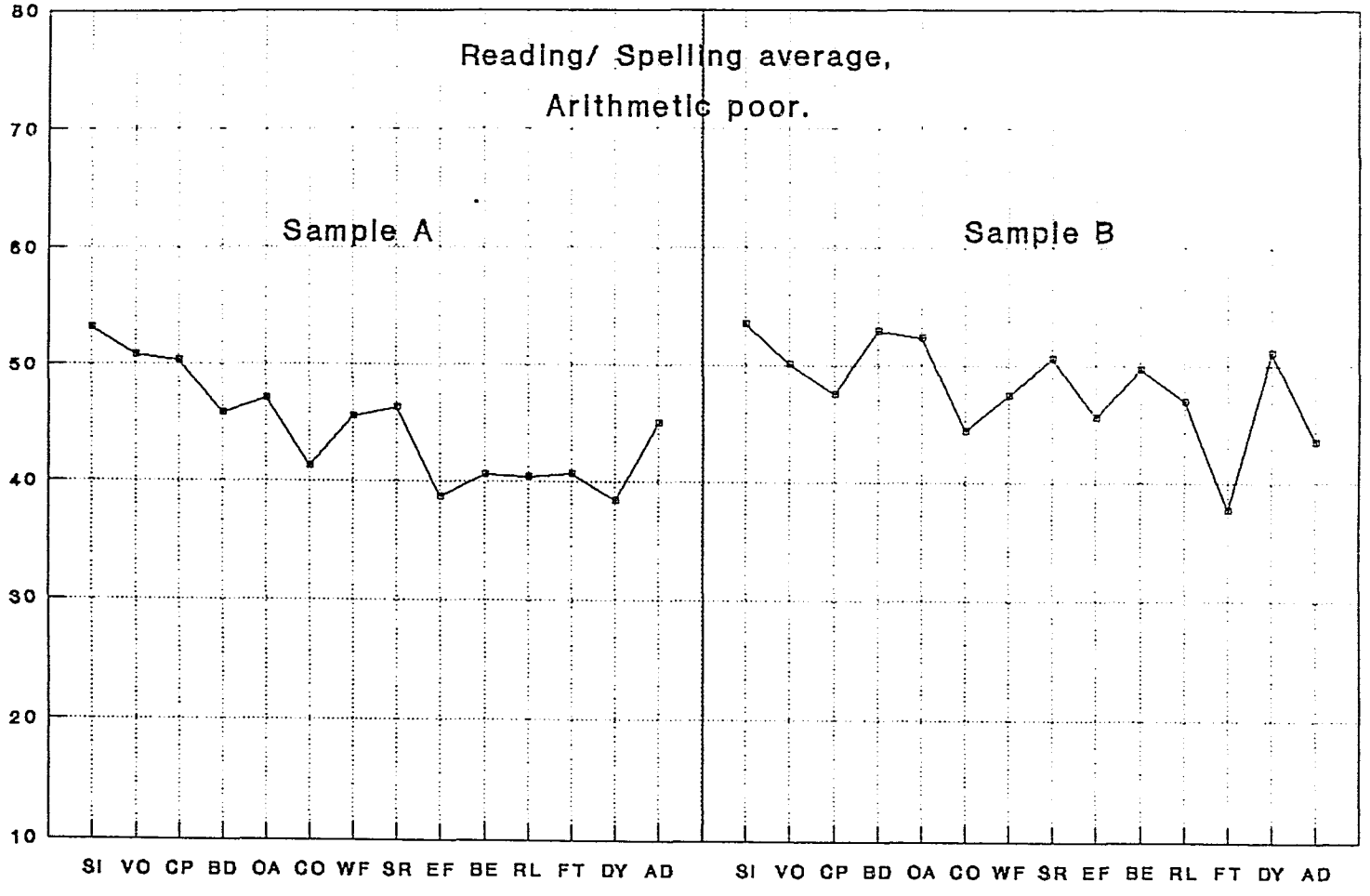
RL - Right-Left Orientation

FT - Finger Tapping

DY - Dynanometer

AD - Auditory Discrimination

Fig 6. Arithmetic Disability: Group 3

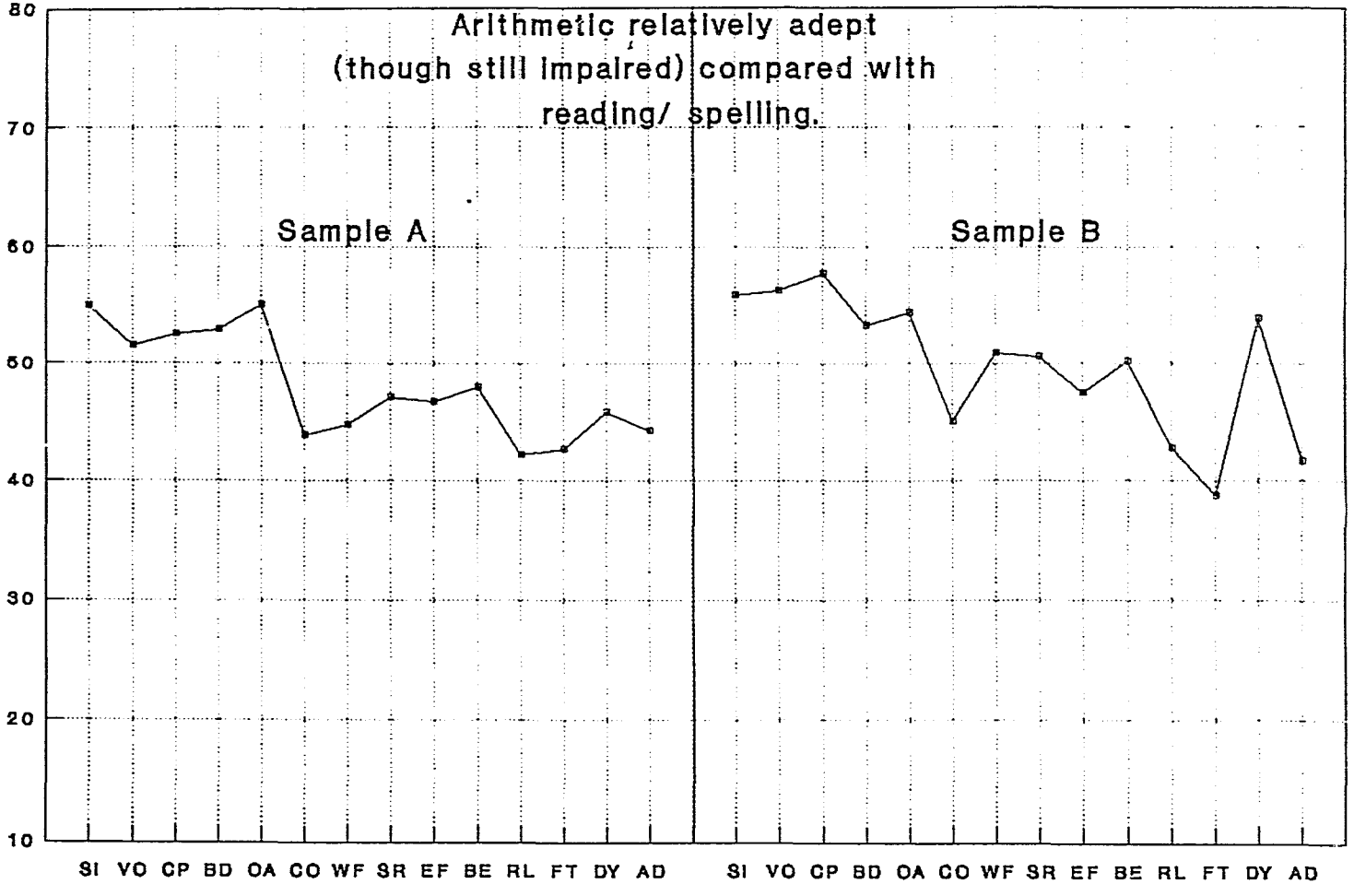


expressive and verbal memory abilities are equally deficient. The profile for Sample B subjects reveals low scores on visual-motor speed and visual figure-ground tasks, but average or above average performance on visual-spatial problem-solving and visual-motor design copying tasks. In addition, while verbal memory, vocabulary and language concepts are satisfactory, as expected, the profile indicates below average scores in auditory perception and verbal expression.

Hypothesis 5

Figure 7 shows the profiles of subjects who are relatively adept at arithmetic (although still impaired in this area) in comparison with their poor performances in reading and spelling (Group 2). In Sample A, the profile shows deficits in auditory perception, language expression and verbal memory, while scores on visual perceptual-spatial, problem-solving tasks are above average, all of which was predicted. In Sample B, the profile indicates above average performance on visual-spatial-perceptual, problem-solving tasks, as well as a deficit in auditory discrimination, but language skills, verbal expression and verbal memory are intact, which only partially supports the predicted results.

Fig 7. Arithmetic Disability: Group 2



Hypothesis 6

The Effects of Age on Subtype Patterns

In order to test the questions relating to the effects of age on subtype patterns, separate cluster analyses were performed on each of the three age groups, following the same hierarchical cluster analysis routine as used on the complete sample. The results of these analyses are summarized below:

Age 6 to 8 Years. Six clusters emerged, which are briefly described as: 1) Normal group, without problems (N = 3); 2) Moderate visual-perceptual disorders with mild language and sequencing problems, particularly anomia (N = 14); 3) Mild perceptual motor disorders in which language skills are relatively intact (N = 14); 4) Serious mixed-visual perceptual/language disorders with comprehension and reasoning problems; clumsy children, some with articulatory and graphomotor disorders (N = 13); 5) Language disorders, which include both receptive and expressive types (N = 13); 6) Mild to moderately severe mixed-language disorders, in which language deficits are more predominant, but perceptual, non-verbal weaknesses are evident (N = 10).

Aged 8 to 11.5. Eight clusters emerged from the analyses of this age-group, and are briefly described, as follows: 1) Mild perceptual-motor group combined with 13 normal control cases (N = 28); 2) Moderate perceptual-motor with

mild language and sequencing problems (N = 13, including 1 normal control case); 3) Language disorders, which include both receptive and expressive types (N = 13, including 1 normal control case); 4) Severe mixed-visual-perceptual-language disorders with comprehension and reasoning problems (N = 23); 5) A mixture of cases with moderately severe visual/non-verbal deficits and some verbal expressive problems as well as cases with mixed-language-perceptual (mainly language) disorders and comprehension/reasoning deficits. All have poor verbal memory (N = 21, including 1 normal control case); 6) A group of cases with fairly severe mixed-language-perceptual disorders, comprehension and reasoning deficits, and poor verbal memory (N = 21); 7) A mixture of cases with mild perceptual motor disorders and cases with language disorders (both receptive and expressive types) (N = 12); 8) A group with serious visual-spatial deficits and relatively intact language skills, except for some anomia and sequencing problems. These cases tend to be clumsy, with difficulties in logical reasoning (N = 17).

Aged 11.5 to 17. Analyses of this age group indicated six clusters, briefly described as follows: 1) Mild perceptual motor disorder group combined with 3 normal control cases (N = 10); 2) Moderately serious perceptual motor disorders with some receptive language difficulties (N = 16, including two normal control subjects); 3) Mild language

disorders, both receptive and expressive types (14 cases, including 4 normal control subjects); 4) More serious language disorders of the receptive-expressive type as well as global language disorders, all with verbal memory problems (N = 13); 5) A mixture of moderately severe perceptual-language disorders with mixed language-perceptual disorders, most of whom have comprehension and reasoning problems as well as motor deficits (N = 11); 6) A group with severe visual/spatial, non-verbal impairment, poor verbal memory as well as comprehension and reasoning difficulties (N = 4).

Table 14 provides a chart which summarizes the clusters from these three analyses for a more convenient comparison. As this chart shows, there is considerable concordance in five subtypes which emerged at each of the three age levels. As the 8 to 11.5 year age group was a larger sample (N = 148) than either the younger age group (N = 67) or the adolescent group (N = 67), the optimal cluster solution indicated a greater number of clusters, so that there were three additional and different subtypes for this age group. Two of these involved somewhat heterogeneous mixtures of cases: one a more severe group with mixed perceptual-language disorders and mixed language-perceptual disorders; and one with milder disorders, both visual-perceptual and language. However, unique to this age group was the subtype involving moderately serious deficits in visual-spatial/

Table 14: Summary of Cluster Analyses on Three Age Groups.

Cluster #	6 to 8 years	N	8 to 11.5 years	N	11.5 to 17 years	N
1	Normal	3	Normal combined with mild visual perceptual motor disorder (13 NC's)	28	Normal combined with mild visual perceptual motor disorder (3 NC's)	10
2	Mild visual perceptual motor disorder	14				
3	Moderate visual perceptual disorder with mild language deficits (anomia)	14	Moderate visual perceptual disorder with mild language deficits (anomia) (including 1 NC)	13	Moderate visual perceptual disorder with mild language deficits (anomia (including 2 NC's)	16
4	Severe mixed visual perceptual and language disorder; poor comprehension, reasoning; clumsy; artic-graphomotor	13	Severe mixed visual perceptual and language disorder; some severe language disorders; poor reasoning and comprehension	23	Severe mixed visual spatial, non-verbal and language disorder; poor comprehension and reasoning.	4
5	Language disorder groups Expressive and receptive	13	Language disorder group Expressive and receptive (including 1 NC)	13	Language disorder group Expressive and receptive (including 4 NC's)	14
6	Moderately severe mixed language/ visual perceptual disorders	10	Moderately severe mixed language/visual perceptual disorders	21	Moderately severe mixed language/visual perceptual disorders	11
7			Mixture of moderately severe visual perceptual language disorders and mixed language/perceptual disorders (including 1 NC)	21	Receptive-expressive language disorder and Global language disorders	12
8			Mixture of mild visual perceptual motor and mild language disorders	12		
9			Moderate visual/spatial/ non-verbal disorder with relatively intact language (anomia in some)	17		

non-verbal abilities while language skills were relatively intact. The adolescent age group also had an additional subtype which was different from the five subtypes common to all three age groups. This subtype was also unique to this age group and involved a more severe group of language disordered cases, including those classified as "Global language disorder" in the clinical typology.

Subtypes in which visual perceptual and visual-motor deficits were prominent, whether mild, moderate or more severe and mixed with language problems, were fairly equally represented across age groups. Similarly, apart from the severe language disorder subtype in the adolescent age-group, subtypes in which language disorders were prominent were also equally represented across age groups.

Data from the clinical partition into subtypes was also examined in order to provide information relating to age group differences, as follows:

Aged 6 to 8: First, the proportion of the total sample of 6 to 8 year old cases which had been assigned to each broad diagnostic category was calculated. Out of the 320 cases used for the clinical classification, 88 were in this age group. Of these 88 cases:

a) 41 (47%) were assigned to subtypes in which the main problem involved a visual perceptual disorder, usually with some mild language deficits, such as naming, word-finding or fluency weaknesses as well as sequencing

difficulties.

b) 26 (30%) were assigned to subtypes which included cases with fairly serious "mixed" language/visual-perceptual disorders,in which comprehension and reasoning skills were weak.

c) 18 (21%) were assigned to subtypes in which the main problem involved a language disorder, either receptive/ expressive or expressive only.

Aged 8 to 11.5: Again, the proportion of the total sample of 8 to 11.5 year old cases which had been assigned to each broad category was calculated. Out of the 320 cases used for the clinical classification, 163 were in this age group. Of these 163 cases:

a) 61 (37%) were assigned to subtypes in which the main problem involved a visual perceptual disorder, usually with some mild language deficits, such as naming, word-finding or fluency problems as well as sequencing difficulties.

b) 74 (45%) were assigned to subtypes which included cases with fairly serious "mixed" language/visual-perceptual disorders, in which comprehension and reasoning skills were weak.

c) 28 (17%) were assigned to subtypes in which the main problem involved a language disorder, either expressive only or receptive-expressive.

Aged 11.5 to 17: Again, the proportion of the total sample of 11.5 to 17 year old cases which had been assigned to each broad diagnostic category was calculated. Out of the 320 cases used for the clinical classification, 69 were in this age group. Of these 69 cases:

a) 20 (29%) were assigned to subtypes in which the main problem involved a visual perceptual disorder, usually with some mild language deficits, such as naming, word-finding or fluency weaknesses as well as sequencing difficulties.

b) 24 (35%) were assigned to subtypes which included cases with fairly serious "mixed" language/perceptual disorders, in which comprehension and reasoning skills were weak.

c) 25 (36%) were assigned to subtypes in which the main problem involved a language disorder, either receptive or expressive.

Table 15 provides a more detailed listing of the proportion of cases from each age group which were classified into each specific subtype. The main results of interest are those which show that the greatest proportion of younger aged cases (6 to 8 years) were classified into a visuoperceptive disorder subtype, with associated mild expressive language (anomia) and sequencing problems (22%). The greatest proportion of subjects aged 8 to 11.5 years were classified into a subtype with moderately serious

Table 15. Age Effects - Clinical Typology.

Proportion of age-group samples assigned to each diagnostic category

	6 - 8 years		8 to 11.5 years		11.5 to 17 years	
	Sample N = 88		Sample N = 163		Sample N = 69	
Diagnostic Category	No. Assigned	Percent	No. Assigned	Percent	No. Assigned	Percent
Visual Perception	41	47	61	37	20	29
Mixed	26	30	74	45	24	35
Language Disorders	18	21	28	17	25	36
Subtype						
VP1	8	9	19	12	8	12
VP2	19	22	11	7	7	10
VP3A	4	5	22	14	3	4
VP4M	4	5	20	12	9	13
NV5	6	7	14	9	2	3
MNV	8	9	11	7	6	9
ML1	7	8	15	9	2	3
ML2	11	13	23	14	4	6
LX	10	11	12	8	6	9
LR	8	9	16	10	19	28

visuoperceptive deficits as well as problems with verbal expression and memory. Many of these cases have quite marked articulation and graphomotor difficulties (26%). The greatest proportion of adolescent aged cases, however, were classified into the more severe receptive-expressive language disorder subtype.

Hypotheses 7 and 8

Social, Emotional and Behavioural Factors

Hypothesis 7

In 1979, Denckla described two kinds of language disorders in children. The first of these was an audiophonetic disorder, in which single-word vocabulary growth is good but such children show "a tin ear for language"; morphology and syntax also often lag years behind. These children need to receive short messages, delivered slowly, and become "glazed eyed" when language comes at them too quickly. When learning to read, such children have difficulties with phonics and blending, but can usually rely upon whole word visual recognition techniques, because of their good visual skills. They are eventually greatly benefitted by reading, once they reach a certain level of mastery, gaining greater understanding from written language than they do from spoken language. Such children tend to be shy and quiet in group situations; they avoid large social gatherings, and are "loners" by

choice, having numerous interests and hobbies.

The second type of language disorder described by Denckla (1979) was the anomic-repetition (expressive) disorder, in which such children may talk a good deal and comprehension is good, but they have considerable trouble with word retrieval. Such naming and word-finding difficulties persist, and their speech tends to be circumlocutory as a result (i.e. talking by slow associative approximations). This can often lead to teacher or peer-group irritation, as well as frustration and resulting emotional outbursts on the part of the child, himself. Denckla (1979) suggests that dysnomia (along with most mild to moderate developmental language disorders) has a profound effect upon the social-emotional life of such children.

In order to test Hypothesis 7, all subjects with profiles that indicated a language disorder were selected from the two samples, A and B. From these cases, two groups were then selected, in accordance with the characteristics described by Denckla (1979). These two groups represented the "audiophonetic" group and the "dysnomic" group, and proved to be comparable and almost identical to Group LR (Receptive-expressive language disorder) and Group LX (expressive language disorder) in the clinical typology. Information concerning social, emotional and behavioural functioning of these subjects was then examined, with the

following results:

Audiophonetic Group

Thirty five subjects were identified in this group, and the majority of them were described (by teachers, parents or personal observation) as shy and quiet (71%), although quite friendly. Many of them lacked confidence, but on the whole, their self esteem was good. This group of children tended to be self-directed, with numerous interests, and enjoyed being alone in order to pursue their hobbies. However, ist of them had close friends, peer relations were good, and there were no problems about maintaining social relationships. They usually preferred one or two friends at a time, as opposed to group activities. Many of them also participated in a number of sports, in which they excelled. When younger, these cases tended to be easily distractible with variable attention, and could become easily upset. In general, however, these children were conscientious workers, whose main problems at school related to their difficulties in verbal expression as well as in grasping verbal directions. so that they were reluctant to speak out or ask for help and clarification. They were slow to respond to questions or directions, as well as easily embarrassed. This group was slow to learn to read, work rate was slower than usual, and they had problems in remembering what they had learned.

Dysnomic Group

23 subjects were identified as belonging to this group, and 39% of them were described as being shy and quiet (by teachers, parent checklists or from observation), although friendly (43%). Approximately 40% of these children were somewhat reluctant to talk, and another 30% talked easily, but had difficulties in verbal expression. This group of cases also lacked self-confidence and needed reassurance at times, but self esteem appeared to be good. Peer relations were not a problem; these children had friends, and had no difficulty in maintaining social relationships. They also liked to participate in sports of all types. This group of children tended to be more easily distractible with variable attention than the audiophonetic disorder group. They also tended to be more restless, and had more difficulties with printing and written work. They were also slow to learn to read, as well as more inclined to become upset when frustrated.

Hypothesis 8

Strang and Rourke (1985a) identified a particular type of arithmetically disabled child, with a pronounced impairment in the perception, analysis, organization and synthesis of non-verbal (visual or tactile) information, although their language abilities were at an average or above average level. However, despite being fairly talkative with an excellent rote verbal memory, the

conversation of such children tends to be verbose but vapid and superficial. Social and emotional adjustment in such cases is also poor. Strang and Rourke called this particular disability the Non-verbal Perceptual Organizational Output Disability (NPOOD). The concept of this complex deficit was later expanded by Rourke (1988), and was now referred to as the Non-verbal Learning Disability Syndrome (The NLD syndrome). Rourke emphasised the extreme difficulty that such cases experience in novel problem-solving tasks or in adapting to unfamiliar materials or situations. There are also significant deficits in social perception, social judgement and social interaction skills, with an overreliance on inappropriate, rote behaviours. Such children tend to become socially withdrawn and isolated , with signs of depression and other forms of emotional disturbance as they grow older (Rourke,1988).

In order to test Hypothesis 8, subjects were selected from both Sample A and Sample B, on the basis of the pattern of their test profiles, which were required to show marked deficits in visual-spatial problem-solving in comparison to average or above average rote memory as well as verbal and language abilities. The files of these cases were then examined for information regarding their social and emotional functioning.

Twenty five subjects were identified as appropriate

for this group, according to the criteria listed above. There were 17 males and 8 females ranging in age from 6 years-5 months to 16 years-11 months. The seven cases who were in the younger aged group (6 to 8 years) were all described as highly active, distractible and restless, with a limited attention span, particularly during their preschool years. This type of behaviour had gradually improved, although these cases were still inclined to be emotional and excitable, as well as easily frustrated with frequent temper outbursts. Many of these children had been very shy as preschoolers, and in others, social behaviour had been aggressive at this age, although this had also improved. However, these children were still described as strong-willed, stubborn and resistant to direction from others. In general, by the age of 6 or 7, these youngsters were displaying a fairly similar behaviour pattern, which included: acute anxiety about separating from mother; much timidity and uncertainty about unfamiliar situations; an eagerness to please others and develop friendships with peers, but there were problems in social interaction, and many of these children had become "loners", preferring to be by themselves.

In the older group of 18 cases, there was some variation in terms of reported social behaviour and relationships. In nine cases, it was reported that there were no social problems or that peer relations were good,

or that the child had close friends. However, most reports added that the child was better with one friend at a time, and could not manage well in groups or competing situations, where he was the "odd man out" and usually became very upset, reacting emotionally. In the other nine cases, all had difficulties with social interaction, which was remarkably similar in some respects, but varied in other ways. Instead of a general summary of this group, a few characteristic examples will be described: One ten year old girl seldom contributes to class discussion and has great difficulty working in a group, often sitting with her coat on and her head down. Classmates have made friendly overtures, but she has great difficulty maintaining such relationships, acting strangely so that most classmates eventually ignore her. She seldom joins in games or activities; prefers to be by herself; is extremely shy at school and does not communicate easily; she is a voracious reader, and goes off alone to read in a corner of the library; her moods are variable, and she gets angry fairly easily.

A nine year old boy, whose moods swings are pronounced and has problems switching from one activity to another, is reported as being impulsive, impatient and complaining, with generally immature behaviour. He is clumsy and hypoactive, with very poor motor coordination. He does not settle down in class, is argumentative, and feels picked on by others, adopting a "victim" role, and associates only

with children who also have problems.

A charming but tormented 10 year old girl, who is verbally bright and appears quite confident, tends to be a perfectionist and frustrates easily. Like all the others in this group, she cannot grasp abstract concepts in mathematics or science, and is unable to perform basic arithmetic problems. Other children often exclude her from certain games, because she cannot add and keep score accurately. She is sensitive and upset about her failures, hates to admit to being wrong, cannot stand losing face, and sulks in her room for days. She has friends, but is very demanding of them and always wants to be the leader. When this privilege is denied, she gets very hurt, complains of unfairness, cannot handle criticism, and always feels "left out". In fact, she fails to perceive the effect that her own behaviour has on others.

Finally, an almost 17 year old girl, who writes poetry and invents wonderful stories, has always had difficulty in initiating or maintaining social relationships with her own age group. Like so many of these children, she is very good with little children and adults, but is shy and inhibited about talking out in groups of her peers, confessing, "I always seem to say the wrong thing". Although she has an excellent vocabulary, and her use of language is one of her strong points, her conversation tends to be repetitive and lacking in substance. Consequently she is inclined to be withdrawn and a "loner" at school, and is showing signs of

depression.

It is interesting to note that in the majority of these cases, motor development was slower than usual, and speech development was also slow in some instances, but quite advanced in others. However, even when there was no delay in the onset of speech, in many of these cases articulation was reported as poor in the early years. In the 6 to 8 year old group, all seven had pronounced articulation problems when younger and all of them still had some difficulties in this respect. Also, all had experienced problems in learning to print as well as in printing and writing tasks throughout their school years. As stated above, arithmetic and later, science and mathematics were very difficult for these subjects. Also, in the early school years, many of them had problems in learning to read, although they later became fluent readers. However, reading comprehension tended to lag behind mechanical reading skill in those over 11 or 12 years.

The 25 subjects identified as appropriate for this group were all classified into one of two broad groupings in the clinical typology, namely: the Moderately Serious Perceptual Motor Disorders (Group NV5), and the Severe Perceptual/non-verbal Disorders (Group MNV). In the statistical typology, many of these subjects (13) were grouped together on Cluster 3, three on Cluster 5, three on Cluster 9, four on Cluster 6, and one on Cluster 8.

Hypothesis 9

Concordance between the Clinical and Statistical Typologies

Sample A

In order to examine the questions relating to validation of the clinical-inferential classification in Phase I, the following procedures were used: a) careful inspection and comparison of the clinical and statistical subtyping solutions, with the expectation that the same cases might be found on comparable subtypes, and b) cluster means were calculated for each of the variables used in the cluster analyses, and these profiles were plotted on a T-score format (Figure 4, pages 122 to 127). Similarly, T-score profiles on the same variables were plotted for each of the 12 clinical typology groupings (Figure 2, pages 98 to 104). Comparable clinical and cluster group profiles have been combined for visual comparison in Figure 8. Table 8 provides a key to the abbreviated codes for the clinical typology subtypes (Sample A).

Cluster 1 was comparable to Group VP1 and approximately half of the normal control group in the clinical typology. Out of a total of 38 cases in this cluster, 17 were subjects who had been classified on Group VP1 of the clinical typology, and 14 were normal control subjects. Examination of the appropriate graphs (CL 1,Group VP1 and the Normal control group) reveals similar deficits in coding and motor strength, as well as generally similar capabilities, with

Table 8. Abbreviation Codes for Subtypes in Clinical Typology.

Code	Brief Description of Subtype
LX	Expressive Language Disorder: visual perceptual skills and visual memory are good.
LR	Receptive-Expressive Language Disorder: processing slow and both verbal expression and comprehension affected.
GL	Global Language Disorder: severe language impairment and poor verbal memory. Visual perception is within average range, but verbal scores between 55 to 78.
VP1	Mild Perceptual-Motor Disorder: visual spatial and visuomotor deficits; language is essentially good.
VP2L	Moderate Perceptual-Motor Disorder with mild language and sequencing problems (verbal expressive weaknesses and understanding directions).
VP3A	Moderate Visual Perceptual Disorder with Anomia and Gross Motor Deficits. Language is generally adequate, although pronounced problems with naming. Work pace very slow in many cases.
VP4M	Moderately serious Visual Perceptual Disorder, with Expressive Language and Verbal Memory Problems.
NV5	Moderately Severe Perceptual-Spatial Disorder, with good language abilities; talkative; clumsy; gross motor deficits; reasoning poor. (Typical non-verbal learning disability subtype).
ML1	Mild Mixed-Language Disorder; intelligence in average range; comprehension and reasoning problems. Language deficits greater than perceptual deficits, although both present.
ML2	Moderately severe Mixed-Language Disorder, with Poor Verbal Memory. More impaired than ML1.
MNV	Severe Mixed-Perceptual/Non-verbal Disorder. Perceptual deficits greater than language deficits, although both are present.

Figure 8: Clinical/Cluster Profile Comparisons. Sample A

Variable List:

SI - Similarities Test (WISC-R)

VO - Vocabulary (WISC-R)

CP - Comprehension Test (WISC-R)

WF - Word Fluency

SR - Sentence Repetition

BD - Block Design Test (WISC-R)

CO - Coding Test (WISC-R)

EF - Embedded Figures

BE - Beery Test of Visual-motor Integration

RL - Right-Left Orientation

FT - Finger Tapping

DY - Dynanometer

AD - Auditory Discrimination

Fig 8. Clinical/Cluster Profile Comparisons - Sample A

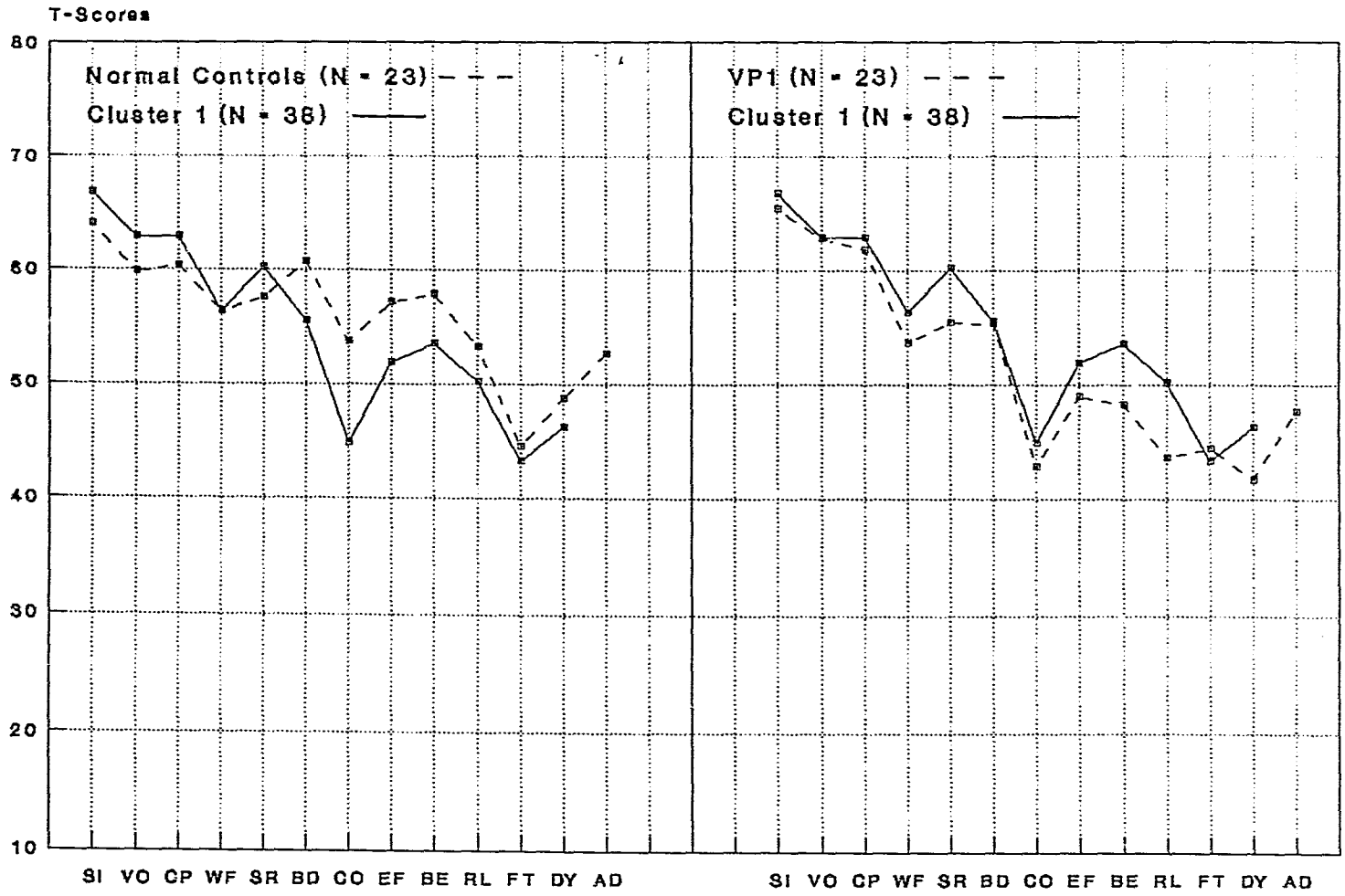


Fig 8 (cont.) Clinical/Cluster Profile Comparisons - Sample A

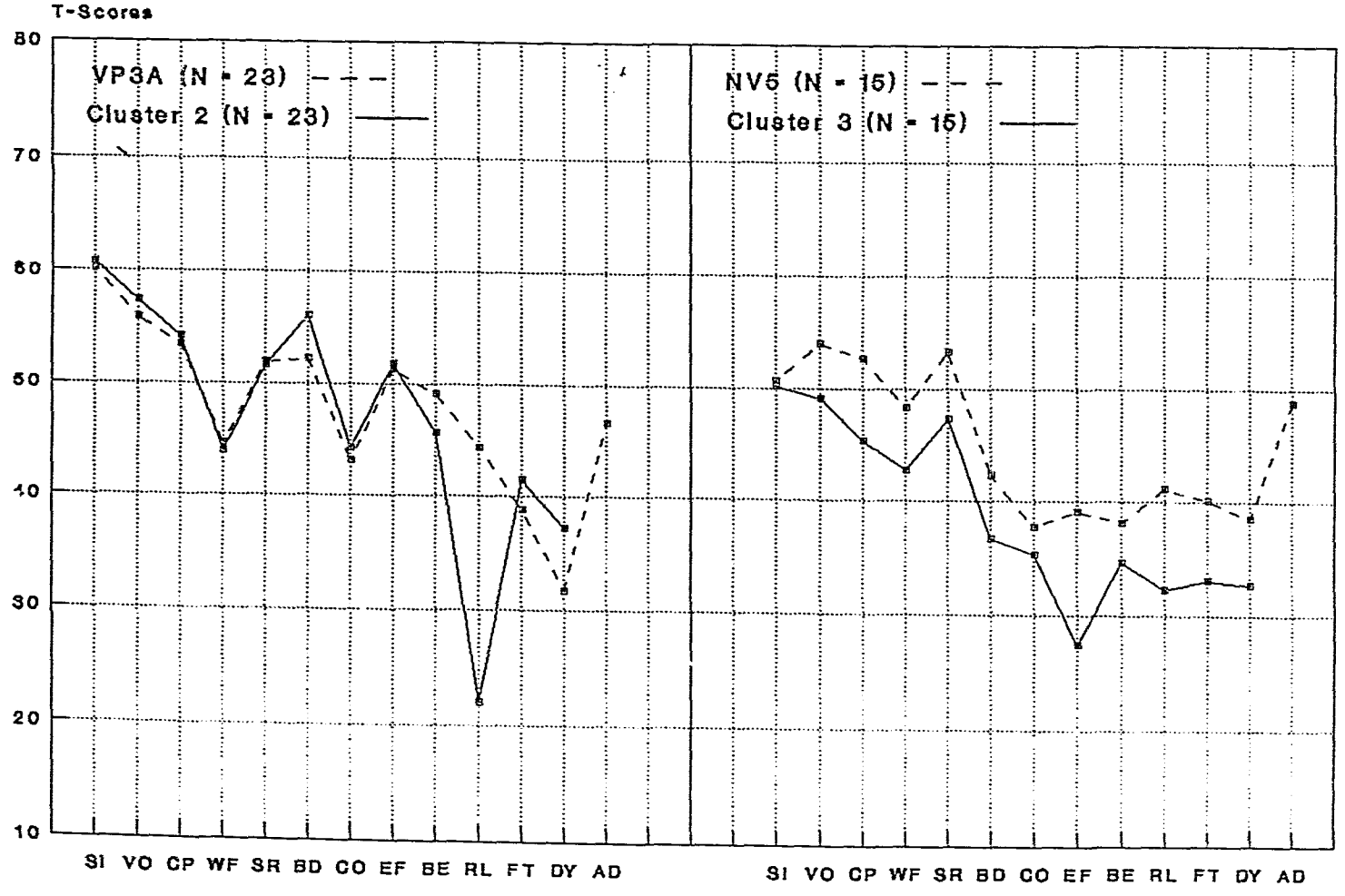


Fig 8 (cont.) Clinical/Cluster Profile Comparisons - Sample A

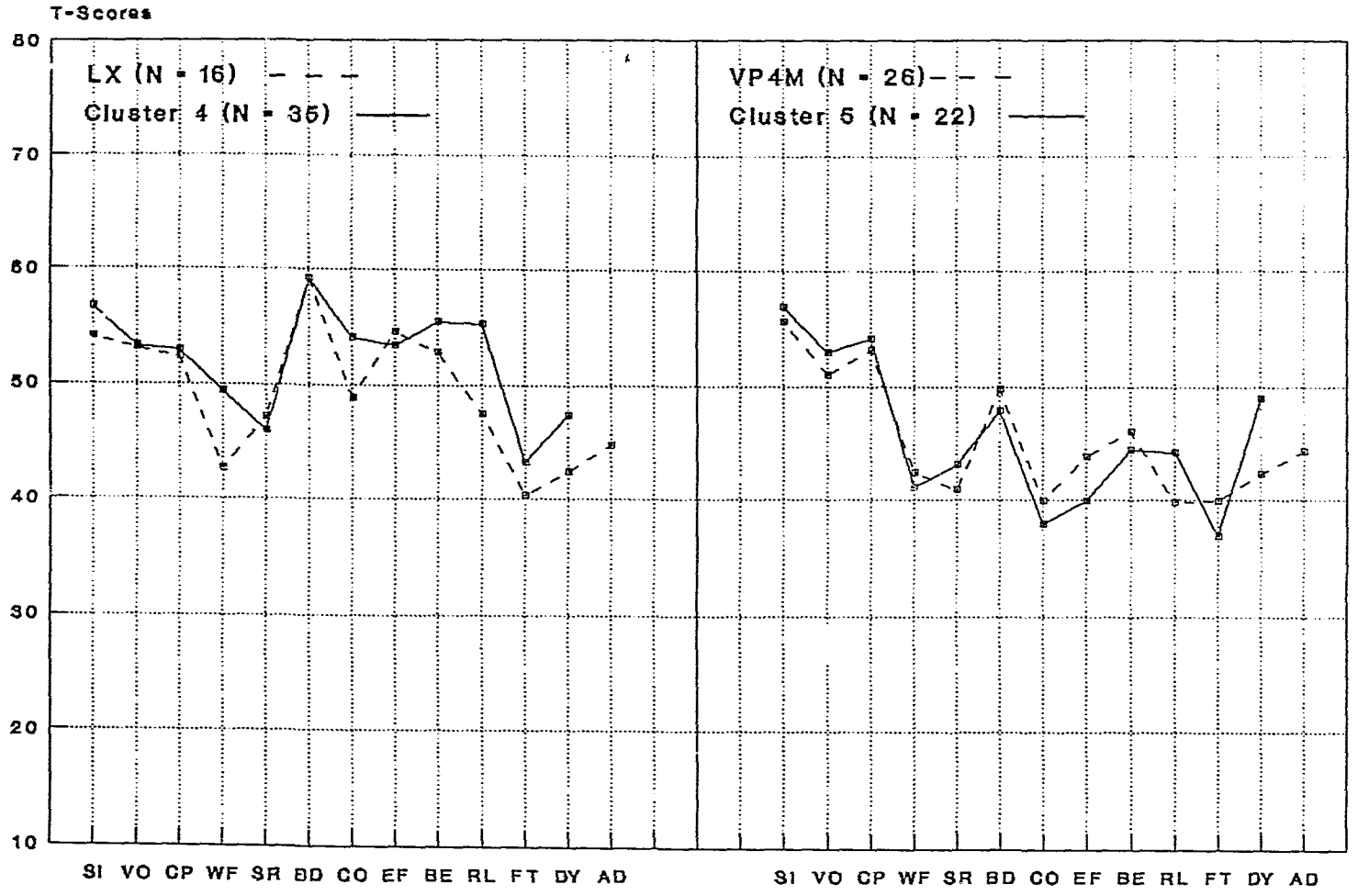


Fig 8 (cont.) Clinical/Cluster Profile Comparisons - Sample A

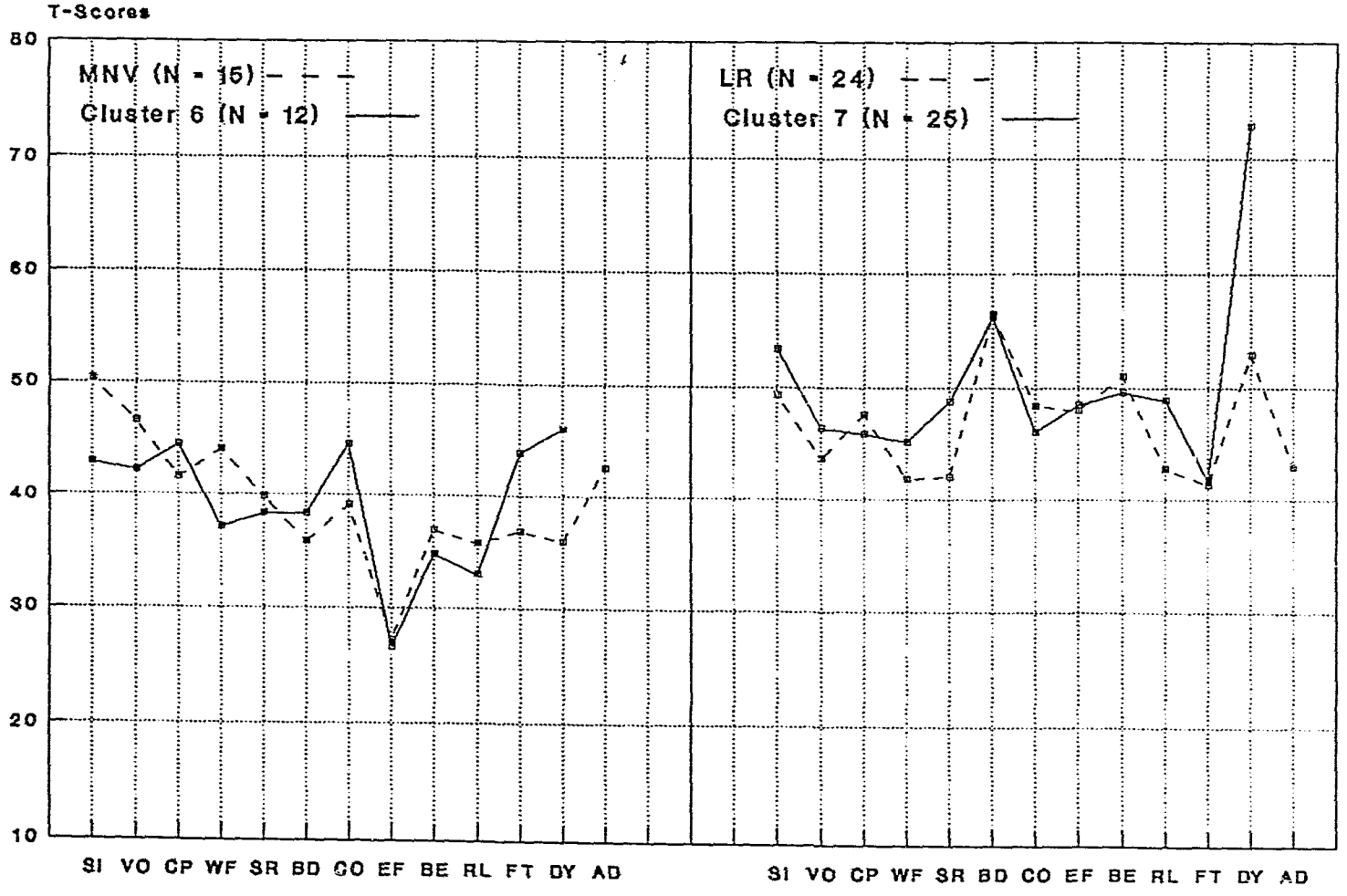


Fig 8 (cont.) Clinical/Cluster Profile Comparisons - Sample A

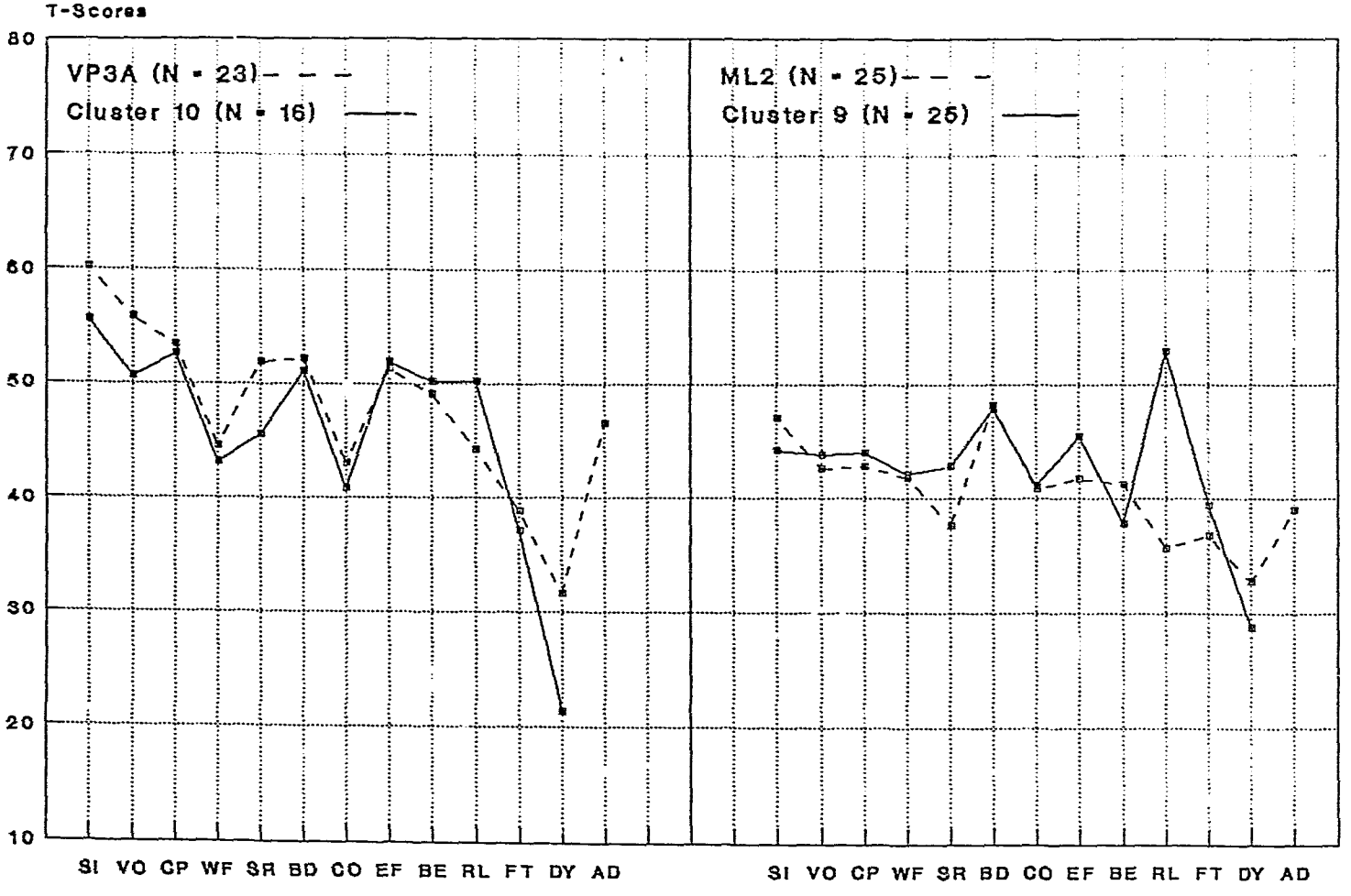
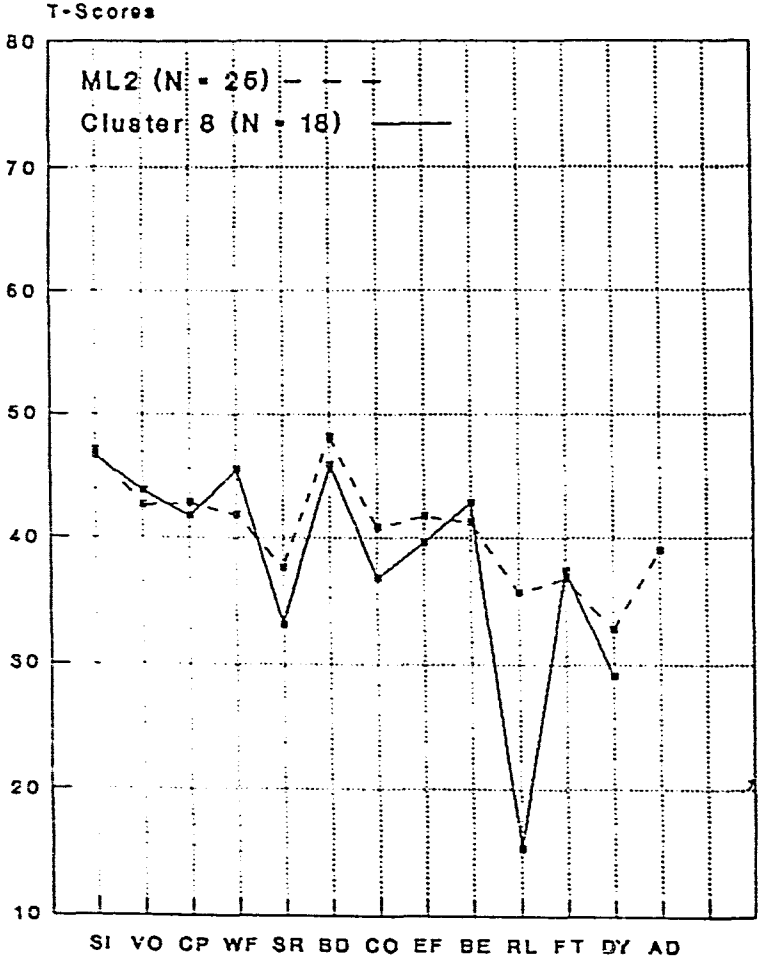


Fig 8 (cont.) Clinical/Cluster Profile Comparisons - Sample A



Variable List:

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CO - Coding Test (WISC-R)

EF - Embedded Figures

BE - Beery Test of Visual-motor Integration

RL - Right-Left Orientation

FT - Finger Tapping

DY - Dynanometer

AD - Auditory Discrimination

Cluster 1 profile being a combination of the other two.

Cluster 2 was a heterogeneous group, with mild perceptual motor and language difficulties. Out of 23 cases in this cluster, 5 were subjects from Group VP1; nine were from Group LXLR; three were from Group VP4M; four were in Group VP3A; one was from Group NV5; and one was a normal control subject. The common factor in this group appeared to be the level of severity, which was mild to moderate. Inspection of the graph of this cluster profile (CL 2) showed considerable similarity to the group profile of Subtype VP3A in the clinical typology.

Cluster 3 consisted of cases with a severe visual-spatial, non-verbal disorder, in which there was also considerable language impairment. Thus, it was comparable to Group MNV on the clinical typology. Out of 15 cases on this cluster, nine were classified on Group MNV; four were subjects from Group NV5 (which is the less severe version of Group MNV); one was from Group VP2L and one from Group ML1. Comparison of the group profiles (CL 3 and Group MNV) showed definite similarities, with language concepts and vocabulary being at average or near average levels, word fluency and verbal memory at low average levels, and low scores on visual-spatial, non-verbal problem-solving tasks.

Cluster 4 suggested a group with a mild language disorder, comparable to Group LX or LR and one third of the normal

control group in the clinical typology. Out of 35 cases in this cluster, 16 cases were classified on Groups LX or LR, and 9 cases were from the normal control group; three of the remaining 10 cases were from Group VP3A; two were from Group ML2; two were from Group VP1; two more were from Group VP4M, and one was from Group VP2L. Comparison of the appropriate group profiles (CL 4 and Group LX (or LR) profiles) showed greater similarity between CL 4 and Group LX, which were at similar levels of severity. There were also several other areas of agreement, such as: lower scores on verbal memory and verbal fluency as well as weaknesses in motor strength, in comparison to above average scores on most visual-spatial non-verbal problem-solving tasks.

Cluster 5 consisted of cases with moderate perceptual impairment combined with some expressive language and verbal memory problems. Thus, it was comparable to Group VP4M in the clinical typology. Out of 22 cases in this cluster, 12 cases had been classified in Group VP4M; 7 were in Group VP2L; and 3 were in Group NV5. Inspection of the appropriate cluster and group profiles (CL 5 and Groups VP4M and VP2L) showed substantial similarity to Group VP4M, with strengths in language concepts, vocabulary and block design as well as comprehension and gross motor skill. Verbal memory and fluency, as well as visual-motor, visual figure-ground and right-left orientation skills were all

fairly weak in comparison.

Cluster 6 consists of cases with severe disorders in either language, perceptual/non-verbal organization or a mixture of these. Thus, it was comparable to Groups MNV and GL on the clinical typology. Out of 12 cases in this cluster, four were classified in Group MNV; four were in Group GL; and three were in Group ML2. Inspection of the appropriate graphs of group and cluster profiles (CL 6 and Groups MNV, GL and ML2) showed that Group MNV corresponded more closely to Cluster 6 than the others.

Cluster 7 was another language disordered group, but the level of impairment was more serious than in Cluster 4. Thus, it was comparable to Group LR or Group ML1 in the clinical typology. Out of 25 cases in this cluster, 11 were classified in Group LR; six were in Group ML1; four were in Group VP2L; 2 were in Group VP4M; and two more were normal control subjects. Examination of the appropriate graphs of cluster and group profiles (CL 7 and Groups LR and ML1) revealed that Group LR clearly corresponded more closely to Cluster 7 than the other groups.

Cluster 8 is described as a moderately severe "mixed-language disorder", with more severe impairment than the cases in Cluster 7. Thus, the comparable group in the clinical typology would be Group ML2. Out of the 18 cases in this cluster, there were 9 who had been classified into

Group ML2; four cases in Group LR; one in Group GL; and four in various perceptually impaired groups. Inspection of the appropriate group and cluster profiles (CL 8, Groups ML2, GL and LR) showed a reasonable correspondence between Group ML2 with Cluster 8.

Cluster 9 was also a heterogeneous group of fairly severely impaired cases, including those with severe language or "mixed-language" disorders and those with moderately severe perceptual or "mixed-perceptual" disorders. Out of 25 cases in this cluster, nine were classified in Group ML2, and 6 cases were in Group ML1; two were in Group GL, and two more in Group LR; three were in Group NV5; two were in Group VP4M; and one was in Group MNV. The largest group included both "mixed-language" disorders, suggesting that Groups ML1 and ML2 were comparable groups to Cluster 9. Inspection of the cluster and group profiles, however, indicated greater correspondence with Group ML2.

Cluster 10 consisted of cases with a moderately serious perceptual disorder; adequate language ability except for pronounced naming and other expressive problems; and deficient gross motor skills. Thus the comparable group in the clinical typology would be Group VP3A. Out of 16 cases in this cluster, 9 were classified into Group VP3A in the clinical typology; five were in Group LX; and two were in Group VP1. The group and cluster profiles also showed a marked correspondence between Group VP3A and Cluster 10.

Overall. 55.9% of the cases in the cluster analysis groupings on Sample A involved the same subjects that had been classified into the comparable subtype in the clinical typology.

Sample B

Similar procedures to those used for Sample A were employed in order to compare subtyping solutions for Sample B subjects. The T-score profiles on the means of the clustering variables for each of the six clusters can be found in Figure 5 (see pages 132 to 135). The profiles of each of the clinical typology groupings for Sample B subjects are shown in Figure 3 (see pages 107 to 111). Comparable clinical and cluster group profiles have been combined for visual comparison in Figure 9. Table 11 lists the seven group clinical typology for Sample B.

Cluster 1 was comparable to the normal control group and also Group VP1 in the clinical typology. Out of a total of 3 cases in this cluster, two had been classified with the normal control group, and one had been classified into Group VP1 of the clinical typology. Inspection of the cluster and group profiles (CL1 and Group VP1 and the normal control group) suggested that the CL1 profile was a combination of the other two.

Cluster 2 is labelled as a group with a moderate visual perceptual disorder combined with mild language and

TABLE 11

Abbreviated Codes for Clinical Typology Subtypes:Sample B

Code	Title of Subtype
VP1	Mild Perceptual-motor Disorder
VP2L	Moderate Perceptual-motor Disorder with mild language and sequencing problems
VP34	Moderately Serious Visual Perceptual Disorder, with anomia. gross motor deficits, and verbal memory problems
NV5	Moderate Perceptual-spatial Disorder with good language abilities and poor reasoning
MNV	Severe Mixed- Perceptual/Non-verbal Disorder
LXR	Language Disorders: Both Expressive and Receptive
ML12	Mixed-Language Disorders (mild to moderate) with perceptual deficits and reasoning problems

Figure 9: Clinical/Cluster Profile Comparisons. Sample B

Variable List:

SI - Similarities Test (WISC-R)

VO - Vocabulary (WISC-R)

CP - Comprehension Test (WISC-R)

WF - Word Fluency

SR - Sentence Repetition

BD - Block Design Test (WISC-R)

CO - Coding Test (WISC-R)

EF - Embedded Figures

BE - Beery Test of Visual-motor Integration

RL - Right-Left Orientation

FT - Finger Tapping

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AD - Auditory Discrimination

Fig 9. Clinical/Cluster Profile Comparisons - Sample B

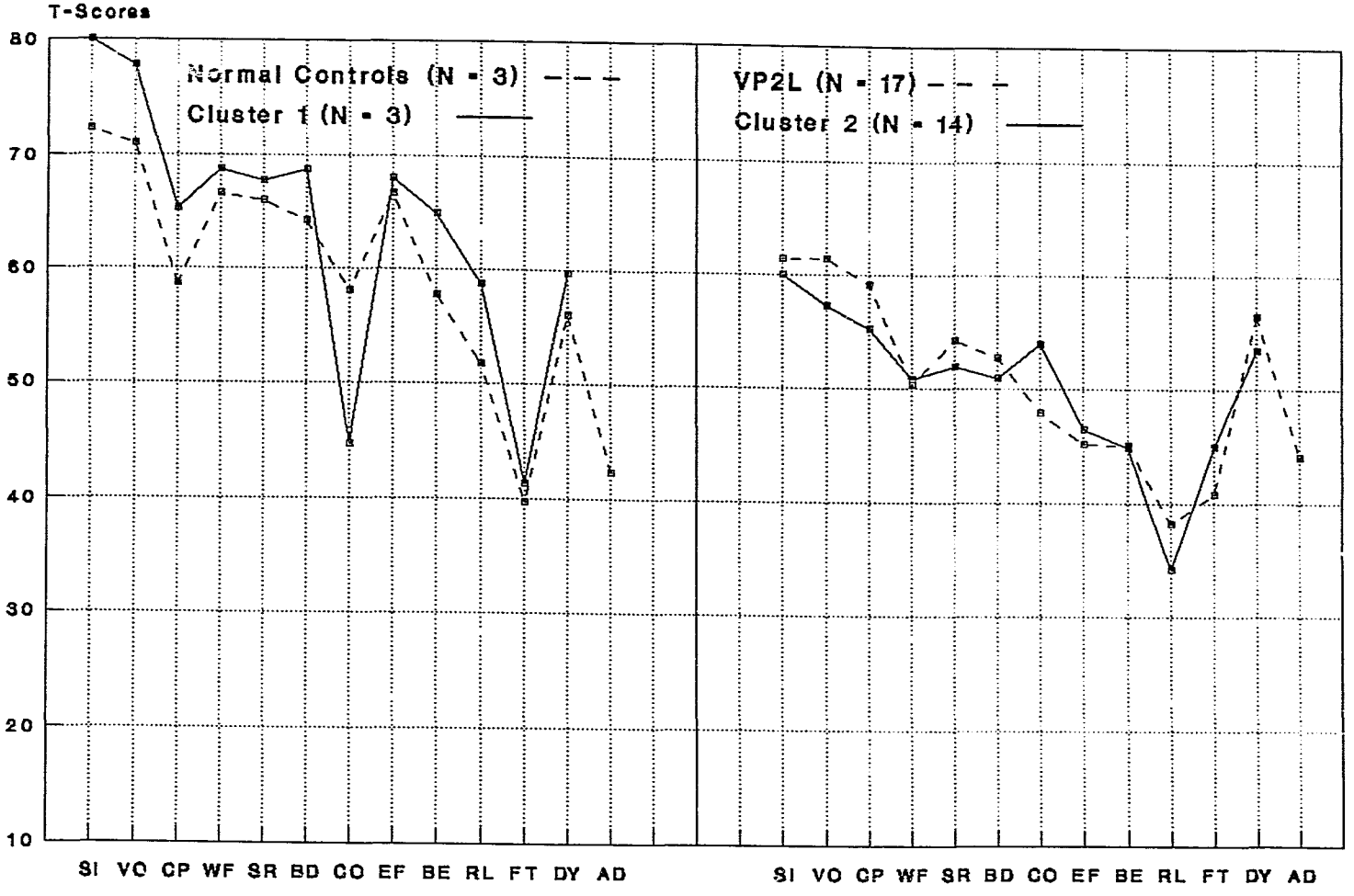


Fig 9 (cont.) Clinical/Cluster Profile Comparisons - Sample B

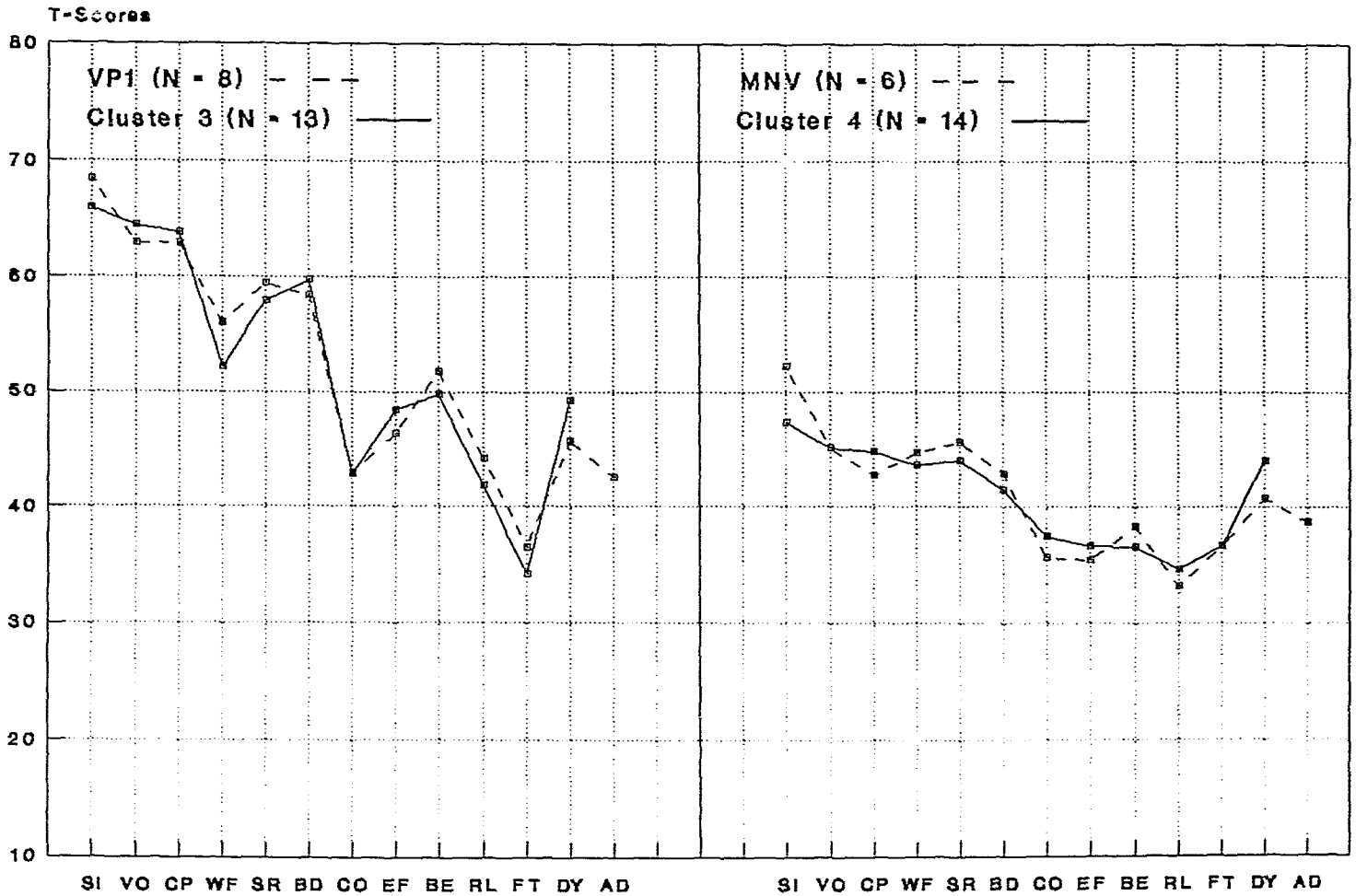
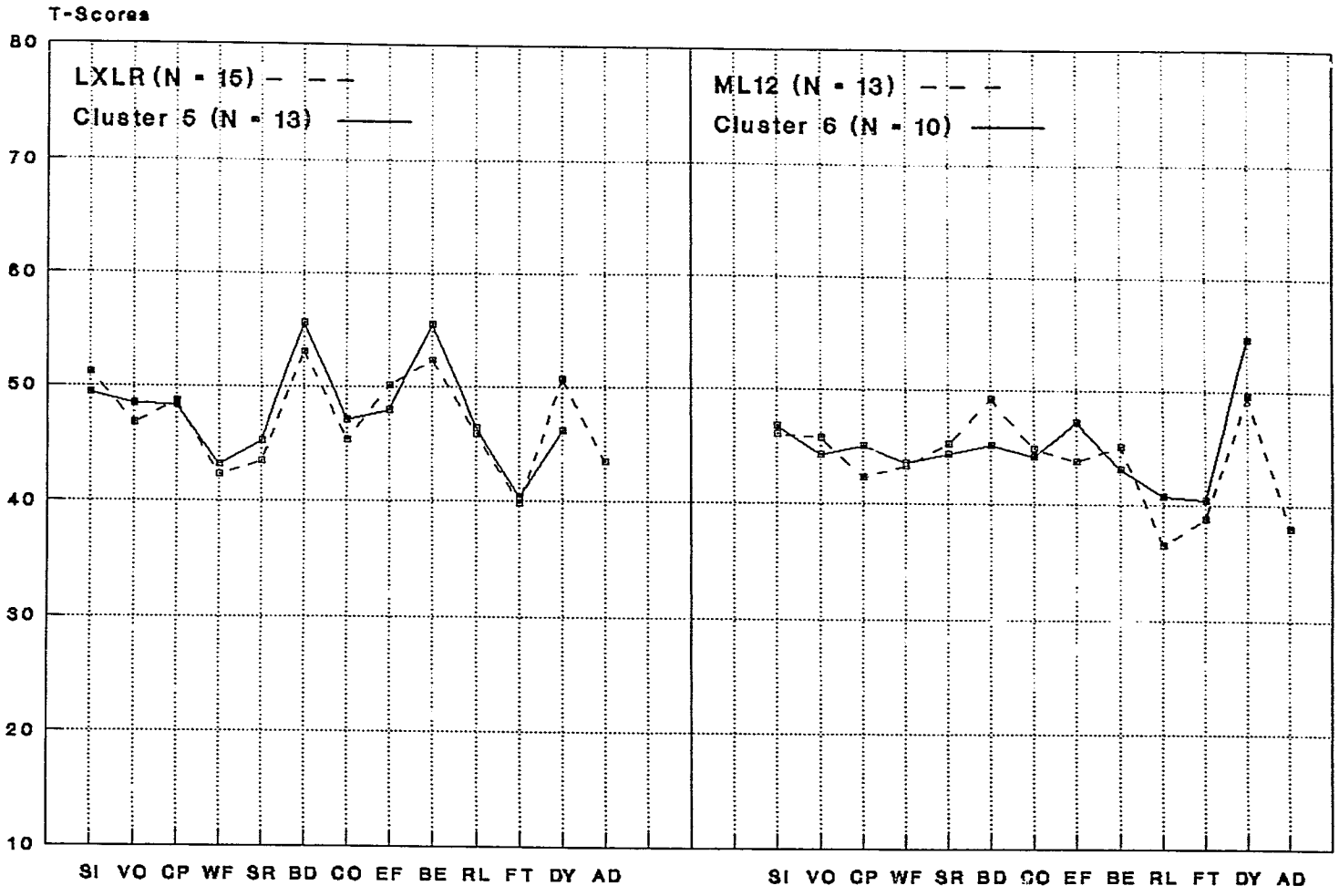


Fig 9 (cont.) Clinical/Cluster Profile Comparisons - Sample B



sequencing problems. Thus, it is comparable to Group VP2L in the clinical typology. Out of 14 cases in this cluster, 10 had been classified into Group VP2L; three cases were in Group VP34; and one was a normal control subject. Inspection of the group and cluster profiles showed that Cluster 2 corresponded with Group VP2L more closely than with any other clinical group, except for a marked difference in Coding scores, which were above average in Cluster 2 and below average in Group VP2L.

Cluster 3 was labelled as a group with a mild perceptual motor disorder, which indicates that it is comparable with Group VP1 in the clinical typology. Out of 13 cases in this group, 8 were classified in Group VP1; four were in Group VP2L; and one was in Group LXR. Comparison of the cluster and group profiles showed a marked similarity between Group VP1 and Cluster 3.

Cluster 4 is described as a severe mixed perceptual-language disordered group. Thus. it should be comparable to Group MNV in the clinical typology. Out of 14 cases in this cluster, 5 were classified with Group MNV; four were in Group NV5; three were in Group ML12; and one was in Group VP34. Inspection of the group and cluster profiles showed that the Group ML12 profile was the one most similar to the Cluster 4 profile.

Cluster 5 was labelled a language disordered group, so that it should be comparable to Group LXR in the clinical typology. Out of 13 cases in this cluster, 9 were with Group LXR in the clinical groupings; two were in Group ML12; one was in Group VP2L; and one was in Group VP34. Comparison of the cluster and group profiles revealed a strong similarity between Group LXR.

Cluster 6 was labelled as a moderately severe "mixed-language" disorder. Thus, it should be comparable to Group ML12 in the clinical typology. Out of 10 cases in this cluster, 7 were classified into Group ML12, and three were in Group LXR. Inspection of the group and cluster profiles revealed substantial concordance between Group ML12 and Cluster 6.

Overall, 58.6% of the cases in the cluster analysis groupings on Sample B involved the same subjects that had been classified into the comparable subtype in the clinical typology.

CHAPTER 6

DISCUSSION

Hypotheses 1 and 2

Hypotheses 1 and 2 were concerned with the replication of findings in previous studies involving subtypes of learning disabilities. The prediction in Hypothesis 1 that the three most commonly reported subtypes would be identified by the two typologies was clearly confirmed.

The predictions in Hypothesis 2 that several additional subtypes reported in the literature by more than one writer would be identified was only partially confirmed. The finger localization-sequencing disorder that has been suggested by some investigators did not emerge as a specific subtype on either of the classifications. As the finger localization measure had been eliminated from the variable set due to missing data, this was to be expected in the cluster analysis typology. However, examination of the test scores in both samples revealed that poor finger localization was frequently present in cases where visual perceptual deficiency was the primary problem. Consequently, deficits in finger localization would likely be a common symptom in the perceptually disordered and "mixed" subtypes in the clinical typology, which proved to be so, upon further inspection of the data. Therefore, it would not have been a particularly valuable variable for

discriminating between subtypes in the present study, which included an unusually large number of cases with visual/ non-verbal processing disorders.

Hypothesis 3

This hypothesis was concerned with reading disabilities and the evidence which could suggest replication of Denckla's (1977,1979) subtyping of reading disabilities. The cluster analyses performed on subsamples of poor readers (from A and B) provided qualified support at best for the existence of Denckla's subtypes, particularly the analysis from Sample A data, in which the clusters were much more heterogeneous than those in Sample B. However, such findings were possibly to be expected when one considers that the variables used in the clustering procedures did not include several test measures which are judged to be relevant discriminating factors in reading disorders.

The clinical typology, however, indicated considerable support for five of Denckla's (1977) subtypes, despite the fact that they emerged in several different locations in the broader classification scheme. These five subtypes included: anomic repetition disorder; visual perception syndrome with anomia; global language disorder; dysphonemic-sequencing disorder; and articulatory-graphomotor disorder.

One could even make a case for the existence of Denckla's verbal memorization disorder subtype, which was only found in older aged children (13 to 15 years) in her typology. As was shown in the section relating to age-effects on subtype patterns, the older aged cases in this subject sample are predominantly represented in those language disordered groups in which verbal memory and verbal learning are deficient. By the time they reach the age of 12, the cases in such language disordered groups have reached a certain level of mastery in reading, although their oral reading is still somewhat slow and stilted. However, they are able to read well enough for comprehension, and their main problem at this age involves verbal memory and verbal learning.

In her later (1979) subtyping of reading disorders, Denckla omits the visual perceptual syndrome with anomia from her list of subtypes, maintaining that this comparatively small group only accounts for some early but relatively transient reading difficulties in children. Denckla (1979) emphasises the importance of disorders of verbal learning and language as correlates of reading disorders, citing Vellutino (1978), who discredits the relevance of such factors as visual perception in relation to dyslexia.

However, numerous other researchers in the field of reading disabilities appear to feel otherwise, and regard

visual processing problems as one of the important factors when considering reading difficulties (Bakker,1982; Boder, 1973; Ingram et al.,1970; Johnson & Myklebust, 1967). Denckla's views on this point are, therefore, somewhat controversial.

The present study provides some evidence to suggest that such visual processing problems are most evident in the younger age groups (See Table 15). However, many older children with visual perceptual deficits continue to have difficulty, even after they have acquired phonic decoding skills, because their sight word vocabulary is still fairly limited, and they frequently do not take the time to work out unfamiliar words phonetically, but guess instead. Also, many words are phonetically irregular, which increases the error rate. Reading pace is slower than usual and such children find reading to be a slow and tiresome process, avoided when possible. All children with visual perceptual problems over the age of nine will state that they never read for pleasure, but only read what they have to for school. The present study also confirms the fact that numerous cases with reading difficulties clearly belonged to groups in which a visual perceptual disorder was the primary problem, including Groups VP1, VP2L, VP3A, and NV5 in the clinical typology; Clusters 1, 3 and 6 from Sample A analysis; and Clusters 4 and 5 from Sample B analysis.

However, it is also interesting to note that, in the

present study, anomia or word-finding problems appear to be a frequently associated deficit in visual perceptual disorders, which confirms Denckla's finding in the 1977 typology. Similarly, children with anomic-repetition disorders often have associated visual perceptual deficits. These observations would tend to support Denckla's contention that a language-based problem is an essential element in reading disorders, and that visual perceptual deficits are irrelevant other than contributing to the usual word and symbol reversals, particularly in the younger age groups. It was also noted that in Group NV5, in which visual perceptual-spatial skills are quite impaired in the relative absence of any language problems, there were comparatively few reading disabled cases (3 out of 12 - 25%). Also that those which did have reading problems usually had some minor deficits in verbal expression. In contrast, cases with reading difficulties were numerous in the perceptually disordered Groups VP2L and VP3A (68% and 70% respectively), which are groups with expressive language weaknesses or anomia as well as sequencing difficulties. This question is obviously one which warrants further study.

Hypotheses 4 and 5

These hypotheses were concerned with the replication of Rourke and Finlayson's (1978) findings in regard to children with specific arithmetic disabilities. Neither of

the ability profile patterns for these arithmetically impaired groups proved to be exactly as expected.

Neither group of subjects (either Sample A or B) with poor arithmetic scores relative to their average reading and spelling performance exhibited profile patterns which conformed with those predicted in Hypothesis 4. However, the Sample A group with poor reading and spelling skills compared with their arithmetic performed as expected in the prediction, while the expected profile pattern was only partially achieved by the group from Sample B.

These results may not necessarily refute the original findings, but could very possibly reflect some difficulties experienced during the subject selection process. The criteria, while apparently precise, still demanded some measure of judgement (particularly for the selection of Group 2 subjects), which was difficult at times and not always consistent.

Hypothesis 6

This hypothesis was concerned with the effects of age upon subtype patterns, such as: a) whether subtypes would prove to be stable across the age span of the subject sample,or b) whether there was evidence to show age related patterns or developmental variations. A brief summary of the relevant literature on this topic follows:

Satz and his colleagues (Satz & Sparrow,1970; Satz & Van Nostrand,1973; Satz, Taylor, Friel & Fletcher, 1978) postulated a theory that reading disabilities reflect a lag in brain maturation which differentially delays those skills which are in primary ascendancy at different chronological ages. Thus, skills which develop ontogenetically earlier in childhood (visual perceptual and sensory integration) are more likely to be delayed in younger children with immature maturation; and conversely, those skills which develop more slowly in childhood (language and formal operations) are more likely to be delayed in older children with immature maturation. Hence they predicted that younger children (aged 6 to 8 years) with reading disability would tend to show a higher incidence of visual perceptual and visual-motor deficits than older children with reading disability (i.e. those skills in primary ascendancy at earlier stages of development). They also predicted that older children with reading disability (aged 9 to 12) would show more impairment on conceptual-linguistic tasks, as those are the age-appropriate primary ascendant skills.

However, in their longitudinal study of subtype patterns, Morris, Blashfield and Satz (1986) demonstrated that two of their five subtypes (which included normal children) showed inconsistent developmental patterns compared with normal development. The first group showed

deficient verbal skills with increasing improvement of visual-perceptual-motor abilities with age. The second group showed deficient visual-perceptual-motor skills when younger and increasing deficits in verbal conceptual abilities with age. The authors suggested that such developmental patterns with abilities developing at quite different rates was quite distinct from either the generally "slow learner" or the normal achiever.

Rourke and Orr (1977) found some support for the developmental lag theory of Satz and colleagues, specifically that the younger retarded readers in their sample showed poor performance on visual perceptual and visual-motor tasks compared with age-matched normal readers. However, only five of the 19 retarded readers made any substantial gains in reading achievement in their four year follow-up, and the other 14 made little, if any progress, which lends support to the deficit model of reading disability.

In the results of their 3 to 5 year follow-up study of developmentally disabled children, Gottesman, Belmont and Kaminer (1975) also found that the reading disabled children made minimal gains in reading, despite special schooling and remediation. The children who had been older on clinic admission (aged 11 to 15 years) showed lower levels of reading skill on follow up than did those children who had been younger on admission (aged 7 to 10

years), although both groups showed similarly severe degrees of reading retardation. Also, a small group of language impaired children (12%) showed significantly poorer progress over the years than did the rest of the group.

Finally, Spreen and Haaf (1986) found that learning disabled subjects showing a visuospatial deficit in childhood maintain their impairment over the age-span and that reading and arithmetic problems persist into adulthood. Similarly, severely impaired or non-impaired performance also seems to persist into adulthood. However, in their sample, those subjects in a linguistically impaired subtype when younger appeared in overall low performance adult clusters, suggesting that such deficits worsen during the teen and early adult years, with a poor long-term outcome.

Although the present study has no longitudinal component, the results show that the older age subjects (aged 11.5 to 17 years) were more strongly represented in the language disorder subtypes, particularly the more severe "global" language disorder (which group consisted entirely of adolescents) and the more serious "mixed-language" subtypes. This finding could indicate support for Spreen and Haaf's (1986) suggestion that linguistic deficits worsen during the teen and early adult years. On the other hand, the evidence that even older teenagers

(aged 15 to 17 years) are strongly represented (36%) on the linguistic disorder subtypes (which include mild and moderate disorders) allows for more optimism in regard to outcome for this age group.

Another result of interest is that the greatest proportion (47%) of younger aged cases (6 to 8 years, most of whom were poor readers) were classified into visuoperceptive disorder subtypes, which is consistent with the predictions of Satz and Van Nostrand (1973) as well as the findings reported by Rourke and Orr (1977). However, the present study also indicates that all five subtypes which were identified by cluster analysis in the youngest age group were also evident in the other two age groups. This finding provides evidence to support the notion that subtypes do persist over time, and at least across the school-age span.

Hypotheses 7 and 8

These two hypotheses were concerned with the social, emotional and behavioural factors associated with learning disabilities in children. While some of these behavioural, social and emotional problems are secondary consequences of the difficulties such children encounter due to their learning disabilities, others are believed to be directly related to the pattern of central processing deficiency in any particular case (i.e. based upon central nervous system dysfunction).

In hypothesis 7, children with two different kinds of language disorder were examined in order to test Denckla's (1979) suggestion that developmental language disorders can have a profound effect upon the social-emotional life of such children. The results of these excursions into the files for information relating to social, emotional and behavioural functioning showed children who tended to be shy and quiet in social or group situations, were easily embarrassed, and generally preferred being alone to pursue their interests. However, in none of these cases was there any mention of major emotional outbursts or unhappiness, except that the dysnomic group were described as being more inclined to become upset when frustrated. The predictions in hypothesis 7 were, therefore, only partially confirmed.

In hypothesis 8, the files of subjects, whose profiles of test results showed marked problems in visual-spatial functioning in relation to average or above average language abilities (Ozols and Rourke, 1985), were examined for information concerning their social and emotional adjustment. The results of this search would appear to confirm the prediction that such cases would display fairly severe social problems, although there were the normal variations in the way in which this was manifested. For example, there was a distinct dichotomy between those children (in the 8 to 17 age group) whose behaviour continued to be highly active, speedy, distractible,

restless and impatient, with limited attention and somewhat egocentric behaviour (the "hyperactive" syndrome in other words), and those who were clumsy, hypoactive, and fearful of new situations. Both had social problems for much the same reasons, but the differences between these two groups seemed to relate largely to the presence of gross motor deficits in the latter group.

Hypothesis 9

This hypothesis addressed the question of validation of the clinical-inferential classification of Phase I with the statistical subtyping solutions of Phase II, which involved examination of the degree of concordance between these two typologies of the same subject samples.

The first step in this procedure was to determine the reliability, coverage, descriptive validity and predictive validity of each of the two typologies, where possible, in accordance with the programme outlined by Blashfield and Draguns (1976). The internal validation procedures on the cluster solution for Sample A showed that from 30 to 36 percent of the cases were reclustered when the analysis was repeated under different conditions, using different variable sets, and different methods, which indicates heterogeneity within clusters. Reliability of the cluster solution was, therefore, questionable. However, although five of the clusters were heterogeneous to some extent,

there was considerable homogeneity in the remaining five clusters, which remained stable and reproducible across several different conditions. Reliability testing of the cluster analysis from Sample B data, however, revealed only 6 to 18 percent reclustering of the cases during replication under different conditions. The clusters that emerged from this subject sample were, as a result, more stable and homogeneous than those from Sample A.

It would appear that heterogeneity in cluster solutions is not uncommon in subtyping studies involving learning or developmentally disabled children in which cluster analysis procedures are used (Gdowsi, L char & Kline, 1985; Spreen & Haaf, 1986; Watson, Goldgar & Ryschon; 1983). Heterogeneity of the sample is, no doubt, the main reason for this problem, and in the present study, Sample A is large and also includes a wide variety of disabled and normal children, at all levels of severity. Sample B contained a comparatively small group of subjects, within a limited age range, and consequently the clusters which emerged were more homogeneous as well as stable and reproducible under different conditions.

However, despite these problems, most of the clusters proved to be meaningful and interpretable in both Sample A and Sample B cluster solutions, so that there is evidence of descriptive validity. Coverage in both classifications was excellent, with 98% of subjects classified by the

clinical typology and 96% classified by the cluster analyses. Such good coverage was, of course, obtained at the expense of homogeneity within subtypes, which was judged to be a more realistic approach. Predictive validity cannot be determined until the completion of the external validation of these typologies, which is currently in progress.

Finally, the evidence of concordance between the two typologies as outlined in the previous section would seem to indicate a fairly good degree of similarity. In relation to individual case disposition, 56% of the cases in Sample A and 59% of the cases in Sample B involved the same subjects that had been classified into the comparable subtype in the clinical typology. However, when the graphs of the cluster profiles are compared with the graphs of the clinical group profiles, in at least 10 of the 16 cluster subtypes in both samples, there is marked correspondence with a comparable subtype in the clinical typology. In the remaining clusters, the match is not so striking, but there is one clinical group with which correspondence is close enough to make the two subtypes comparable.

General Discussion

The subtypes which emerged on the cluster analyses and which were identified on the clinical typology included five visuoperceptual disordered groups, which is uncommon in the literature concerned with subtypes of learning disabilities. The population sample in the present study, however, was drawn from a community mental health clinic, to which many children were referred with concerns about behavioural, social or emotional problems and were subsequently seen for an assessment as part of the service provided. Behavioural and social disturbances are frequently associated with evidence of visuoperceptive deficits, which would account for the unusually large number of cases with such disorders in the present investigation. Such a comparatively unusual population sample has also made it possible for the large visuoperceptive disordered group to be subdivided into several separate subtypes, each with differing symptoms, which has proved to be an interesting result.

While the larger sample of subjects in the present study has disadvantages such as leading to greater heterogeneity within clusters, it has also provided the opportunity to examine the broad picture of such disabilities and to obtain a more complete view of deficit patterns emerging at each level of severity. A good example of this is the articulatory-graphomotor syndrome, which has

been identified in a numberof subtyping studies involving reading and learning disabilities, with quantitatively defined criteria for inclusion as a subtype (Denckla, 1977; Mattis et al.,1975). In the present study, this syndrome was clearly evident in its most severe form (where the stringent criteria for inclusion as a subtype would be satisfied) in the severe "mixed" language and perceptually disordered groups, such as Groups MNV or ML2. The syndrome emerged again on several groups with milder mixed or visuoperceptual disorders (the VP2L subgroups), in which there were numerous cases with mild to moderate articulation problems coupled with real difficulties in completing written work, which becomes a laborious task. And, in its very mildest form (although it is not labelled as such) this syndrome emerges in the form of a mild speech impediment (a lisp) combined with a strong reluctance to perform written work, which is tiring. Such children were usually included in the mild-perceptual-motor subtype on the clinical typology.

Such examples lead to questions concerning the common assumption that discrete subtypes of learning disabilities with strictly defined criteria can actually be identified within this heterogeneous population, in which there is such wide variability in deficit patterns. In the present study, it became increasingly evident that such a procedure could not be based only upon common attributes and profile

patterns, but that level of severity was an equally significant factor. In fact, an important theoretical premise upon which the clinical classification was based involved recognising that learning disabilties in children occur along a continuum of severity, ranging from quite subtle to very severe, so that "cut-off" diagnostic rules which label childen as "learning disabled" or not, are inappropriate for this particular population. It is suggested that learning disabled (LD) children or adults are, in fact, just a sample of the normal population, with the normal variation of strengths and weaknesses evident in most people, but whose particular weaknesses have made it more difficult for them to handle academic learning and performance at school. Few people are perfect, and the weaknesses of some people might involve sports, music or art, but do not affect their learning of academic skills. Consequently, there are many children with comparatively mild symptoms characteristic of a certain type of learning disability, who are having difficulties in school in either learning, behaviour or both. However, because they fall short of certain diagnostic requirements (on a check list, for example), they are excluded from consideration as being mildly LD as a reason for their problems, as well as from receiving appropriate help or understanding.

Also relevant to this discussion is the location of the control group subjects on the cluster analyses solutions.

Contrary to the anticipated outcome, the control group did not emerge together as a single cluster in Phase II of the study, which implies that there were no clear differences between this group and the target population. Such a result could be interpreted in at least two ways: First, a) that the cases grouped together with the control subjects on the same clusters are inapproriately categorized as LD, and should be considered "normal" - i.e. that the sampling strategy has been too general, so that it includes cases that do not fit the definition of the population of interest (labelled "artificial groups" by Morris and Fletcher, 1988); or b) that the control group subjects are not free from problems and so should not be considered "normal", which could lead to questions concerning the selection of a normal control group.

It is suggested, however, that the explanation for this result is a combination of both factors mentioned above, namely: the inclusion of subjects which did not fit the usual definition of LD, and the use of control subjects who, perhaps should not be labelled "normal".

The majority of the control subjects (N = 23) were clustered in groups with either mild perceptual-motor problems or mild expressive language difficulties (Clusters 1 and 4 respectively). The control subjects in these clusters were generally performing at slightly above average to superior levels, similar to the target group

cases in each cluster. They were also either stronger in verbal/language than perceptual skills (Cluster 1) or more efficient perceptually than verbally (Cluster 4), which is a typical dichotomy in the normal population, and again similar to the LD group cases in each of the two clusters. The problems of the LD cases were not severe in either of these two subtypes, and many scores were within the normal range, with a few specific deficit areas. Thus, one must conclude that the clustering of these cases together was appropriate, and such a conclusion would also be consistent with the findings of several previous studies in which a a "minimally impaired" (or "unexpected learning disabled") subtype was identified (Fisk & Rourke 1979; Lyon et al., 1982; Lyon & Watson, 1981; Petrauskas & Rourke, 1979; Satz & Morris, 1981; Spreen & Haaf, 1986). Given the broader than usual parameters for the selection of the LD sample, this finding is not surprising. In fact, it supports the theoretical premise of this study that LD occurs along a continuum of severity, and that those with comparatively subtle symptoms at the "mild" end of the continuum may often be dismissed as "normal", and their problems ignored or misinterpreted.

However, a number of these control group subjects proved to have low scores on several test variables as well as some quite serious medical and developmental problems or behavioural concerns reported on the Parent Information

Form. For instance, in Cluster 1, several control subjects had low scores in finger tapping, handgrip strength or visual-motor skills. Medical histories included a compacted skull due to forceps delivery; a heart murmur at birth with open-heart surgery at 3 years; mild sensori-neural hearing loss in one ear; many with allergies and numerous cases with recurrent ear infections. In Cluster 4, several control cases had low scores in finger tapping, handgrip strength, verbal memory, digit repetition, visual-motor copying, speech perception or visual discrimination. Medical histories included a fractured skull in infancy; birth defects such as cleft palate and strabismus; febrile convulsions in infancy; slow speech and motor development; and serious problems in vision. In Cluster 1, three control subjects scored below average in arithmetic and three scored below average in spelling on the WRAT. In Cluster 4, four control subjects scored below average in reading and spelling and two obtained below average scores in arithmetic on the WRAT.

The three control subjects who were clustered into groups with more serious problems have been described earlier in some detail (see pages 140 and 141). The reason for such cluster placement is evident as all these subjects achieved low scores in a number of areas. Such findings inevitably lead to questions about the selection of control subjects as well as wondering about "What is normal?" or

"Is anyone normal?". In this study, the teachers were asked to select "average or above average learners", who were without any behavioural, social or other problems that could be causing concern on the part of teachers. Judging by their behaviour during testing, where all the control subjects proved to be pleasant, polite and cooperative, it was likely that these children had no behaviour problems at school. However, eleven of them obtained below average scores on at least one or sometimes two subtests of the WRAT, which is a measure of academic achievement. These subjects are, nevertheless, clearly "normal", without any abnormal behaviours and coping quite well in school (i.e. not failing) even though they may be a poor speller or not so good in arithmetic.

The wide variability in the profiles of children with LD is another source of heterogeneity in statistical subtype solutions. In clinical situations, even when it becomes evident that there is a major problem in some particular area, such as language or visuoperceptive ability, the additional symptoms can vary greatly from case to case. Although each particular symptom may be clinically important in terms of treatment or remediation, this variability in test scores amongst cases of a fairly similar basic "type" can result in assignment to different clusters during statistical subtyping procedures, which adds to the heterogeneity of clusters. Satz and Morris

(1981) avoided this problem by deliberately limiting the clustering variables to four factors, which would reduce test redundancy and random error variance, increase subtype interpretation, and produce a statistically more reliable classification. However, although this approach yielded good, clearly defined, replicable and homogeneous subtypes, one is left wondering whether, in fact, the results reflected the true variation and numerous subdivisions that characterize "real life" subtypes of learning disabled children. In fact, one is led to conclude that there are no clear boundaries between subtypes of learning disabilities, due to the great variability in numerous additional or secondary symptoms, which preclude the notion of a set of strict inclusion rules for subtype assignment. This fact became evident during the clinical inferential classification process, in which such "rules" were continually relaxed as the assignment to various groups proceeded, which involved repeated evaluations of the relative importance of various factors.

Conclusions

Despite all the problems with heterogeneity, the results of this study still indicate that there are, indeed, some definable as well as meaningful subtypes of learning disabilities, which are clinically relevant. The statistical subtyping solution also provides considerable support for the subtypes derived from clinical-sorting

techniques. Although there is not complete correspondence in terms of actual case assignment to the same subtype in each classification, the group and cluster profiles provide evidence of very satisfactory concordance between the two typologies.

The subtypes which were identified by the cluster analyses included four visuoperceptive disorders at different levels of severity - mild, moderate, and severe; two language disorder groups (one mild and one moderately severe); and two severely impaired mixed subtypes. Articulatory-graphomotor disorders were also evident, in three of the perceptually impaired subtypes, and the mildest of the perceptual motor disorders could be described as a minimal deficits subtype. Thus the subtypes identified are consistent with the findings in previous rstudies: language disordered subtypes have been identified by most investigators (Lyon & Watson, 1981; Mattis et al., 1975; Petrauskas & Rourke, 1979; Satz & Morris, 1981; Spreen & Haaf,1986); also many have identified a visual processing disorder (e.g. Satz & Morris, 1981; Spreen & Haaf,1986); several studies have identified a minimal deficits subtype (e.g.Spreen & Haaf, 1986; Watson et al., 1983) as well as the articulatory-graphomotor syndrome (Denckla, 1979; Mattis et al.,1975).

This study was explorative and innovative in that it used two different methods for developing typologies on the

same sample of subjects: one in which the approach was clinical and represented the phyletic component of the classification; and one in which the approach was objective and empirical, based upon measurement, which represented the phenetic component of the classification. The addition of a qualitative, clinical component might contribute more to the diagnostic relevance of the classification than is usual in strictly empirically derived typologies, and thus to more appropriate intervention strategies. Also, the subject sample in this study was larger than in most other subtyping studies. Although this has, possibly, contributed to the heterogeneity of the clusters, it also increases generalizability of the results. The approach to selection of the subject sample of learning disabled children is also unusual in comparison with other subtyping studies. However, it is consistent with one of the underlying theoretical principles of the study, i.e. that the concept of LD (as a central processing disorder) encompasses more than just difficulties in acquiring academic skills or learning new material, but can include problems in performance, behaviour, social interaction, as well as emotional status. This approach is also consistent with Benton's (1978) comments about "casting a wide net" and including children with a wide variety of problems when studying dyslexia, so as to avoid working with a very "atypical" subject sample.

Limitations of the Study

The study would have been strengthened by employing two or more additional clinicians to examine and interpret the test profiles independently, so as to achieve a consensus agreement during the clinical sorting process, which would have provided greater reliability for the clinical classification.

The use of clinically acquired data, as opposed to data collected for research purposes, led to a problem of missing values which resulted in the elimination of many variables. Had these been available, the interpretation and relevance of the cluster analysis subtypes might have been improved.

Although data manipulation methods were employed as internal validation procedures in this study, the additional use of statistical measures designed to assess the degree of compactness and separation of the clusters would have been advisable.

It is important to emphasise that the use of cluster analysis as a multivariate classification method has its own inherent limitations, and includes many techniques which are considered controversial. Different algorithms and computer software packages may yield different results from the same procedures, and apparently clustering methods are not built upon a firm statistical foundation and are

basically only heuristic. Thus, validation of cluster solutions is particularly critical since most methods will produce what appear to be meaningful solutions with random data (Morris, Blashfield & Satz. 1981).

A final limitation of the study is that, although external validation procedures are in progress, this important phase of the study is not yet completed. The present results represent a first step in the process of trying to identify valid and clinically relevant subtypes of learning disabled children, and further work is still to be done.

Future Research

Future research on this same group of subjects will include completing the validation of the subtypes against a number of external criteria, none of which were used as dependent variables in the original clustering process. These criteria include measures of academic achievement (WRAT scores of reading, arithmetic and spelling; PIAT reading comprehension scores; Gates oral reading scores), socioeconomic status, and several measures of sensorimotor, motor and language skill not used in the cluster analysis. Separate one-way ANOVA analyses across subtypes for each of the variables would be conducted, which, if overall differences were significant, would be followed by post hoc comparisons using the Scheffe method. In addition, the validity of the subtypes will be tested against a wide

variety of categorical variables, which include information pertaining to behaviour, developmental and medical history, social interaction and emotional factors. Chi-square values would be used to test the significance of differences between subtypes in relation to these factors.

Further validation of subtypes in relation to academic performance includes cluster analyses using WRAT scores of reading, spelling and arithmetic as clustering variables, followed by comparison of the resulting groups with the final cluster solutions of the two samples. Also subtypes of each typology (clinical and cluster) will be examined in terms of phonic skills, word recognition, spelling errors, reading comprehension, graphomotor skills and written expression, as well as difficulties in arithmetic. Non-parametric measures would be used to test the significance of group differences.

The effects of sex differences on subtype patterns should also be investigated, by dividing the sample into two groups, male and female. Separate cluster analyses would then be performed in each group and comparisons would be made. The proportions of males and females in each subtype would also be examined, and the differences in sex distribution across subtypes would be tested using chi-square values.

Finally, an attempt to replicate the results of the present study using a different subject sample will form the basis of a future research project.

REFERENCES

Aaron, P.G. (1978). Dyslexia, an imbalance in cerebral information processing strategies. Perceptual and Motor Skills, 47, 699-706.

Adams, K.M. (1985). Theoretical, methodological, and statistical issues. In B.P. Rourke (Ed.), Neuropsychology of learning disabilities: Essentials of subtype analysis. New York: Guilford Press.

Applebee, A.N. (1971). Research in reading retardation: Two critical problems. Journal of Child Psychology and Psychiatry, 12, 91-113.

Bailey, K.D. (1973). Monothetic and polythetic typologies and their relation to conceptualization, measurement and scaling. American Sociological Review, 38, 18-33.

Bakker, D.J. (1967). Temporal order, meaningfulness, and reading ability. Perceptual and Motor Skills, 24, 1027-1030.

Bakker, D.J. (1973). Hemispheric specialization and stages in the learning-to-read process. Bulletin of the Orton Society, 23, 15-27.

Bakker, D.J. (1979). Hemispheric differences and reading strategies: Two dyslexias? Bulletin of the Orton Society, 29, 84-100.

Bakker, D.J. (1981). A set of brains for learning to read. In K.C. Diller (Ed.), Individual differences and universals in language learning aptitude. Rowley, Mass.: Newbury House.

Bakker, D.J. (1982). Hemisphere-specific dyslexia models. In R.N. Malatesha & L.C. Hartlage (Eds.), Neuropsychology and cognition - (Vol. 1). The Hague: Martinus Nijhoff Publishers.

Bakker, D.J. (1983). Hemispheric specialization and specific reading retardation. In M. Rutter (Ed.), Developmental neuropsychiatry. New York: Guilford Press.

Bakker, D.J. (1984). The brain as a dependent variable. Journal of Clinical Neuropsychology, 6, 1-16.

Bakker, D.J., Moerland, R. & Goekoop-Hoefkens, M. (1981). Effects of hemisphere-specific stimulation on the reading performance of dyslexic boys: A pilot study. Journal of Clinical Neuropsychology, 3, 155-159.

Bakker, D.J. & Vinke, J. (1985). Effects of hemisphere-specific stimulation on brain activity and reading in dyslexics. Journal of Clinical and Experimental Neuropsychology, 7, 505-525.

Bannatyne, A. (1971). Language, reading and learning disabilities. Springfield, Ill.: Charles C. Thomas.

Bateman, B.C. (1968). Interpretation of the 1961 Illinois Test of Psycho-linguistic Abilities. Seattle: Special Child Publications.

Bender, L. (1958). Problems in conceptualization and communication in children with developmental alexia. In P. H.Koch and J.. Zubin (Eds.), Psychopathology of communication. New York: Grune & Stratton.

Benton, A.L. (1975). Developmental dyslexia: Neurological aspects. In W.J. Friedlander (Ed.), Advances in Neurology, (Vol. 7) (pp. 1-47). New York: Raven Press.

Benton, A.L. (1978). Some conclusions about dyslexia. In A.L. Benton & D. Pearl (Eds.), Dyslexia: An appraisal of current knowledge. New York and London: Oxford University Press.

Birch, H.G . & Belmont, L. (1964). Auditory-visual integration in normal and retarded readers. American Journal of Orthopsychiatry, 34, 852-861.

Blashfield, R.K. (1980). Propositions regarding the use of cluster analysis in clinical research. Journal of Consulting and Clinical Psychology, 3, 456-459.

Blashfield, R.K. & Draguns, J. (1976). Toward a taxonomy of psychopathology: The purpose of psychiatric classification. British Journal of Psychiatry, 129, 574-583.

Blishen, B.J. & McRoberts, H. (1976). A revised socio economic index for occupations in Canada. Canadian Review of Sociology and Anthropology, 13, 71-79.

BMDP Statistical Software Inc., (1988). University of California Press, Berkeley, California, USA.

Boder, E. (1971). Developmental dyslexia: Prevailing diagnostic concepts and a new diagnostic approach. In H.R. Myklebust (Ed.), Progress in learning disabilities, vol. 2. New York: Grune & Stratton.

Boder, E. (1973). Developmental dyslexia: A diagnostic approach based on three atypical reading-spelling patterns. Developmental Medicine and Child Neurology, 15, 663-687.

Boder, E. & Jarrico, S. (1982). Boder Reading and Spelling Pattern Test: A diagnostic screening test for developmental dyslexia. New York: Grune & Stratton.

Coltheart, M., Patterson, K. & Marshall, J.C. (Eds.) (1980). Deep dyslexia. London: Routledge & Kegan Paul.

Corkin, S. (1974). Serial-ordering deficits in inferior readers. Neuropsychologia, 12, 347-354.

Critchley, M. (1964). Developmental dyslexia. London: William Heinemann Medical Books Ltd.

Critchley, M. (1970). The dyslexic child. Springfield, Ill.: Charles C. Thomas.

Cruickshank, W.M. (1968). The problems of delayed recognition and its correction. In A.H. Keeney & V.T. Keeney (Eds.), Dyslexia: Diagnosis and treatment of reading disorders. St. Louis: C. V. Mosby.

Cruickshank, W.A. (Ed.) (1966). The teacher of brain-injured children. Syracuse: Syracuse University Press.

Dalby, J.T. & Gibson, D. (1981). Functional cerebral lateralization in subtypes of disabled readers. Brain and Language, 14, 34-48.

Damasio, A.R. (1977). Varieties and significance of alexia. Archives of Neurology, 34, 325-326.

de Hirsh, K., Jansky, J. & Langford, W. (1966). Predicting reading failure. New York: Harper and Row.

Delacato, C.H. (1959). The treatment and prevention of reading problems. Springfield, Ill.: Charles C. Thomas.

Del Dotto, J.E. & Rourke, B.P. (1985). Subtypes of left-handed learning-disabled children. In B.P. Rourke (Ed.), Neuropsychology of learning disabilities: Essentials of subtype analysis. New York: Guilford Press.

Denckla, M.B. (1973). Research needs in learning disabilities: A neurologist's point of view. Journal of Learning Disabilities, 5, 44-50.

Denckla, M.B. (1972). Clinical syndromes in learning disabilities: The case for "splitting" vs. "lumping". Journal of Learning Disabilities, 5, 401-406.

Denckla, M.B. (1977). Minimal brain dysfunction and dyslexia: Beyond diagnosis by exclusion. In M.I. Blaw, I. Rapin & M. Kinsbourne (Eds.), Topics-in-child-neurology. New York: Spectrum.

Denckla, M.B. (1978). Minimal Brain Dysfunction. In J.S. Chall & A.F. Mirsky (Eds.), Education and the brain. Chicago, Ill.: University of Chicago Press.

Denckla, M.B. (1979). Childhood learning disabilities. In K.M. Heilman & E. Valenstein (Eds.), Clinical neuropsychology. New York: Oxford University Press.

Dennis, M. (1983). The developmentally dyslexic brain and the written language skills of children with one hemisphere. In Neuropsychology of language, reading and spelling, U. Kirk (Ed.). New York: Academic Press.

Derouesne, J. & Beauvois, M.F. (1979). Phonological processing in reading: Data from alexia. Journal of Neurology, Neurosurgery and Psychiatry, 42, 1125-1132.

Dingman, H.F. & Tarjan, G. (1960). Mental retardation and the normal distribution curve. American Journal of Mental Deficiency, 64, 991-994.

Doehring, D.G. (1968). Patterns of impairment in specific reading disability. Bloomington: Indiana University Press, 1968.

Doehring, D.G. (1976). Evaluation of two models of reading disability. In R.M. Knights & D.J. Bakker (Eds.), The neuropsychology of learning disorders: Theoretical approaches. Baltimore: University Park Press.

Doehring, D.G. (1978). The tangled web of behavioural research on developmental dyslexia. In A.L. Benton & D. Pearl (Eds.), Dyslexia: An appraisal of current knowledge. New York: Oxford University Press.

Doehring, D.G. (1985). Reading disability subtypes: Interaction of reading and non-reading deficits. In B.P. Rourke (Ed.), Neuropsychology of learning disabilities: Essentials of subtype analysis. New York: Guilford Press.

Doehring, D.G. & Hoshko, I.M. (1977). Classification of reading problems by the Q-technique of factor analysis. Cortex, 13, 281-294.

Doehring, D.G., Hoshko, I.M. & Bryans, B.N. (1979). Statistical classification of children with reading problems. Journal of Clinical Neuropsychology, 1, 5-16.

Doehring, D.G., Trites, R.L., Patel, P.G. & Fiedorowicz, C.A.M. (1981). Reading disabilities: The interaction of reading, language and neuro-psychological deficits. New York: Academic Press.

Dubes, R. & Jain, A.K. (1980). Validity studies in clustering methodologies. Pattern Recognition, 11, 235-254.

Eisenberg, L. (1967). Clinical considerations in the psychiatric evaluation of intelligence. In J. Zubin & G.A. Jervis (Eds.), Psychopathology of mental development. New York: Grune & Stratton, 502-513.

Eisenberg, L. (1978). Definitions of dyslexia: Their consequences for research and policy. In A.L. Benton & D. Pearl (Eds.), Dyslexia: An appraisal of current knowledge. New York: Oxford University Press.

Eustis, R.S. (1947). Specific reading disability. New England Journal of Medicine, 237, 243-249.

Everitt, B.S. (1974). Cluster Analysis. London: Halsted Press.

Everitt, B.S. (1979). Unresolved problems in cluster analysis. Biometrics, 35, 169-181.

Everitt, H. (1980). Cluster Analysis (2nd ed.). London: Heineman Educational Books.

Fisk, J.L. & Rourke, B.P. (1979). Identification of subtypes of learning disabled children at three age levels: A multivariate approach. Journal of Clinical Neuropsychology, 1, 289-310.

Fleiss, J.L. & Zubin, J. (1969). On the methods and theory of clustering. Multivariate Behavioural Research, 4, 235-250.

Fletcher, J.M. (1985). External validation of learning disability subtypes. In B.P. Rourke (Ed.), Neuropsychology of learning disabilities: Essentials of subtype analysis. New York: Guilford Press.

Fletcher, J.M. & Satz, P. (1980). Developmental changes in the neuro-psychological correlates of reading achievement: A six year longitudinal follow-up. Journal of Clinical Neuropsychology, 2, 23-27.

Fletcher, J.M. & Satz, P. (1985). Cluster analysis and the search for learning disability subtypes. In B.P. Rourke (Ed.), Neuropsychology of learning disabilities: Essentials of subtype analysis. New York: Guilford Press.

Freud, S. (1953). On aphasia. New York: International Universities Press.

Fried, I., Tanguay, P., Boder, E., Doubleday, C. & Greensite, M. (1981). Developmental dyslexia: Electrophysiological validation of clinical groups. Brain and Language, 12, 14-22.

Gaddes, W.H. (1985). Learning disabilities and brain function: A neuropsychological approach. (2nd ed.). New York: Springer-Verlag.

Garside, R.F. & Roth, M. (1978). Multivariate statistical methods and problems of classification in psychiatry. British Journal of Psychiatry, 133, 53-67.

Gdowski, C.L., Lachar, D., & Kline, R.B. A profile typology of children and adolescents: Empirically derived alternative to traditional diagnosis. Journal of Abnormal Psychology, 1985, 94, 3, 346-361.

Geschwind, N. (1979). Asymmetries of the brain: New developments. Bulletin of the Orton Society, 29, 67-83.

Gillingham, A. (1956). The prevention of scholastic failure due to specific language disability. Bulletin of the Orton Society, 6, 26-31.

Gottesman, R.L., Belmont, I. & Kaminer, R. (1975). Admission and follow-up status of reading disabled children referred to a medical clinic. Journal of Learning Disabilities, 8, 642-650.

Grace, G.M. (1990). Effects of hemisphere-specific stimulation on academic performance and event related potentials in dyslexic children. Doctoral Dissertation, University of Victoria.

Heir, D., leMay, M., Rosenberger, P. & Perlo, V.P. (1978). Developmental dyslexia: Evidence of a subgroup with a reversal of cerebral asymmetry. Archives of Neurology, 35, 90-92.

Hermann, K. (1956). Congenital word-blindness. Acta Psych.Neur. Scandinavia, Suppl. 108, 117-184.

Hinshelwood, J. (1896). A case of dyslexia: a peculiar form of word-blindness. Lancet, 2, 1451-1454.

Hinshelwood, J. (1900). Letter- word- and mind blindness. London: Lewis.

Hinshelwood, J. (1917). Congenital word-blindness. London: Lewis.

Holmes, C.L. & Pepper, R.J. (1977). An evaluation of the use of spelling error analysis in the diagnosis of reading disabilities. Child Development, 48, 1708-1711.

Hooper, S.R. and Boyd, T.A. (1986). Neurodevelopmental learning disorders. In J.E. Obrzut & G.W. Hund (Eds.), Child neuropsychology: Ciinical practice, Vol. 2. Orlando, Florida: Academic Press Inc.

Hynd, C.R. (1986). Educational intervention in children with developmental learning disorders. In J.E. Obrzut & G.W. Hynd (Eds.), Child neuro-psychology: Clinical practice, Vol. 2. Orlando, Florida: Academic Press Inc.

Ingram, T.T.S., Mason, A.W. & Blackburn, I. (1970). A retrospective study of 82 children with learning disability. Developmental Medicine and Child Neurology, 12, 271-281.

Jastak, J. & Jastak, R. (1978). Manual: The Wide Range Achievement Test. Wilmington, Delaware: Jastak Associates, Inc.

Jastak, S. & Wilkinson, G.S. (1984). Administration Manual for the WRAT-R (Wide Range Achievement Test - Revised). Wilmington, Delaware: Jastak Associates, Inc.

Johnson, L.A.S. (1970). Rainbow's end: The quest for an optimal taxonomy. Systematic Zoology, 20, 203-229.

Johnson, D.J. & Myklebust, H.R. (1967). Learning disabilities. New York: Grune & Stratton.

Jorm, A.F. (1979). The nature of the reading deficit in developmental dyslexia: A reply to Ellis. Cognition, 7, 421-433.

Joschko, M. & Rourke, B.P. (1985). Neuropsychological subtypes of learning disabled children who exhibit the ACID pattern on the WISC. In B.P. Rourke (Ed.), Neuropsychology of learning disabilities: Essentials of subtype analysis. New York: Guilford Press.

Kagan, J. (1965). Reflection-impulsivity and reading ability in primary grade children. Child Development, 36, 609-628.

Kawi, A.A. and Pasamanick, B. (1959). Prenatal and perinatal factors in the development of childhood reading disorders. Monographs of the Society for Research in Child Development, 24.

Keefe, B. & Swinney, D. (1979). On the relationship of hemispheric specialization and developmental dyslexia. Cortex, 15, 471-481.

Keeney, A.H. & Keeney, V.T. (1968). Dyslexia: Diagnosis and treatment of reading disorders. St. Louis: Mosby.

Kendell, R.E. (1975). The role of diagnosis in psychiatry. London: Blackwell Scientific Publications.

Kephart, N. (1960). The slow learner in the classroom. Columbus, Ohio: Charles E. Merrill.

Kephart, N. (1967). Perceptual-motor aspects of learning disabilities. In E. Frierson & W. Barbe (Eds). Educating children with learning disabilities. New York: Appleton-Century-Crofts.

Kinsbourne, M. & Warrington, E.K. (1963). Developmental factors in reading and writing backwardness. British Journal of Psychology, 54, 145-156.

Kinsbourne, M. & Warrington, E.K. (1966). Disorders of spelling. In J. Money & G. Schiffman (Eds.), The disabled reader: Education of the dyslexic child. Baltimore: Johns Hopkins Press.

Kirk, S.A. & Becker, W. (Eds.) (1963). Conference on Children with Minimal Brain Impairment. Urbana: University of Illinois (mimeo).

Kirk, S.A. (1963). Behavioural diagnosis and remediation of learning disabilities. In Conference on exploration into the problems of the perceptually handicapped child. Evanston, Ill: Fund for the Perceptually Handicapped Child.

Leisman, G. & Ashkenazi, M. (1980). Aetiological factors of dyslexia: IV. Cerebral hemispheres are functionally equivalent. Neuroscience, 11, 157-164.

Lorr, M. (1983). Cluster analysis for social scientists. San Francisco: Jossey Bass.

Lyon, R. (1978). The neuropsychological characteristics of subgroups of learning disabled readers. Unpublished doctoral dissertation, University of New Mexico.

Lyon, R. (1983). Learning disabled readers: Identification of subgroups. In H.R. Myklebust (Ed.), Progress in learning disabilities (Vol. 5). New York: Grune & Stratton.

Lyon, R. (1984). Subgroups of LD Readers: Clinical and empirical identification. In Myklebust, H. (Ed.), Progress in Learning Disabilities (Vol. V). New York: Grune & Stratton.

Lyon, R., Rietta, S., Watson, B., Porch, B. & Rhodes, J. (1981). Selected linguistic and perceptual abilities of empirically derived subgroups of learning disabled readers. Journal of School Psychology, 19, 152-166.

Lyon, R., Stewart, N. & Freedman, D. (1982). Neuropsychological characteristics of empirically derived subgroups of learning disabled readers. Journal of Clinical Neuropsychology, 4, 343-365.

Lyon, R., & Watson, B. (1981). Empirically derived subgroups of learning disabled readers: Diagnostic characteristics. Journal of Learning Disabilities, 14, 256-261.

Malatesha, R.N. & Dougan, D.R. (1982). Clinical subtypes of developmental dyslexia: Resolution of an irresolute problem. In R.N. Malatesha & P.G. Aaron (Eds.), Reading disorders: Varieties and treatments. New York: Academic Press.

Marshall, J.C. (1984). Towards a rational taxonomy of the developmental dyslexias. In R.N. Malatesha & H.A. Whitaker (Eds.), Dyslexia: A global issue. The Hague: Martinus Nijhoff.

Marshall, J.C. & Newcome, F. (1973). Patterns of paralexia: A psycholinguistic approach. Developmental Medicine and Child Neurology, 2, 175-195.

Mattis, S. (1978). Dyslexia syndromes: A working hypothesis that works. In A.L. Benton & D. Pearl (Eds.), Dyslexia: An appraisal of current knowledge. New York: Oxford University Press, 43-58.

Mattis, S., French, J.H. & Rapin, I. (1975). Dyslexia in young children and young adults: Three independent neuropsychological syndromes. Developmental Medicine and Child Neurology, 17, 150-163.

Maxwell, A.E. (1971). Multivariate statistical methods and classification problems. British Journal of Psychiatry, 119, 121-127.

McCarthy, D. (1970). Manual for the McCarthy Scales of Children's Abilities. New York: The Psychological Corporation.

Mezzich, J.E. (1978). Evaluating clustering methods for psychiatric diagnosis. Biological Psychiatry, 13, 265-281.

Mojena, R. (1977). Hierarchical grouping methods and stopping rules: An evaluation. Computer Journal, 20, 359-363.

Money, J. (1962). Reading disability: Progress and research needs in dyslexia. Baltimore, MD.: Johns Hopkins Press.

Morgan, W. Pringle (1896). A case of congenital word-blindness. British Medical Journal, 2, 1378.

Morris, R.D. & Fletcher, J.M. (1988). Classification in Neuropsychology: A theoretical framework and research paradigm. Journal of Clinical and Experimental Neuropsychology, 10, 640-658.

Morris, R. & Satz, P. (1984). Classification issues in subtype research: An application of some methods and concepts. In R.N. Malatesha & H.A. Whitaker (Eds.), Dyslexia: A global issue. The Hague: Martinus Nijhoff.

Morris, R., Blashfield, R. & Satz, P. (1981). Neuropsychology and cluster analysis: Potentials and problems. Journal of Clinical Neuropsychology, 3, 79-99.

Morris, R., Blashfield, R. & Satz, P. (1986). Developmental classification of reading-disabled children. Journal of Clinical and Experimental Neuropsychology, 8, 371-392.

Myklebust, H. (1978). Towards a science of dyslexiology. In H.R. Myklebust (Ed.), Progress in learning disabilities (Vol. 4). New York: Grune & Stratton.

Naidoo, S. (1972). Specific dyslexia. London: Pitman.

Obrzut, J.G. (1979). Dichotic listening and bisensory memory skills in qualitatively diverse dyslexic readers. Journal of Learning Disabilities, 12, 304-314.

Orton, S.T. (1937). Reading, writing and speech problems in children. New York: Norton.

Ozols, E.J. & Rourke, B.P. (1985). Dimensions of social sensitivity in two types of learning disabled children. In B.P. Rourke (Ed.), Neuropsychology of learning disabilities: Essentials of subtype analysis. New York: Guilford Press.

Petrauskas, R.J. & Rouke, B.P. (1979). Identification of subtypes of retarded readers: A neuropsychological, multivariate approach. Journal of Clinical Neuropsychology, 1, 17-37.

Pirozzolo, F.J. (1979). The neuropsychology of developmental reading disorders. New York: Praeger.

Quadfasel, F.A. & Goodglass, H. (1968). Specific reading disability and other specific disabilities. Journal of Learning Disabilities, 1, 590-600.

Rabinovich, R.D. (1968). Reading problems in children: Definitions and classification. In A.H. Keeney & V.T. Keeney (Eds.), Dyslexia: Diagnosis and treatment of reading disorders. St. Louis: C. V. Mosby.

Raven, J.C. (1965). Guide to using the Coloured Progressive Matrices. Dumfries, Scotland: Grieve the Printers Ltd.

Raven, J.C. (1960). Guide to the Standard Progressive Matrices. Dumfries, Scotland: Grieve the Printers Ltd.

Regehr, S.M. (1987). The genetic aspects of developmental dyslexia. Canadian Journal of Behavioural Science, 19, 239-253.

Reid, J.F. (1969). Dyslexia: A problem in communication. Educational Research, 10, 126-133.

Roberts, J.A.F. (1952). The genetics of mental deficiency. Eugenics Review, 44, 71-83.

Rosenthal, J.H., Boder, E. & Callaway, E. (1982). Typology of developmental dyslexia: Evidence for its construct validity. In R.N. Malatesha & R.G. Aaron (Eds.), Reading disorders: Varieties and treatments. New York: Academic Press.

Rourke, B. (1975). Brain-behaviour relationships in children with learning disabilities: a research program. American Psychologist, 30, 911-920.

Rourke, B.P. (1978b). Reading, spelling, arithmetic disabilities: A neuropsychological perspective. In H.R. Myklebust (Ed.), Progress in learning disabilities (Vol. 4). New York: Grune & Stratton.

Rourke, B.P. (1978a) Neuropsychological research in reading retardation: A review. In A.L. Benton & D. Pearl (Eds.), Dyslexia: An appraisal of current knowledge. New York: Oxford University Press, 141-171.

Rourke, B.P. (1982). Central processing deficiencies in children: Toward a developmental neuropsychological model. Journal of Clinical Neuropsychology, 4, 1-18.

Rourke, B.P. (1988). The syndrome of non-verbal learning disabilities: Developmental manifestations in neurological disease, disorder, and dysfunction. The Clinical Neuropsychologist, 2, 293-330.

Rourke, B.P. (1988). Socio-emotional disturbances of learning-disabled children. Journal of Consulting and Clinical Psychology, 56.

Rourke, B.P. & Adams, K.M. (1984). Quantitative approaches to the neuropsychological assessment of children. In R.E. Tarter & G. Goldstein (Eds.), Advances in clinical neuropsychology (Vol. 2). New York: Plenum.

Rourke, B.P. & Finlayson, M.A.J. (1978). Neuropsychological significance of variations in patterns of academic performances, verbal and visual-spatial abilities. Journal of Abnormal Child Psychology, 6, 121-133.

Rourke, B.P. & Orr, R.R. (1977). Prediction of the reading and spelling performances of normal and retarded readers: A 4-year follow up. Journal of Abnormal Child Psychology, 5, 9-20.

Rourke, B.P. & Strang, J.D. (1978). Neuropsychological significance of variations in patterns of academic performance: Motor, psychomotor, and tactile perception abilities. Journal of Pediatric Psychology, 3, 212-225.

Rutter, M. (1969). The concept of "dyslexia". In P. Wolff & R.C. MacKeith (Eds.), Planning for better learning. Clinics in Developmental Medicine, No. 33. London: SIMP/Heinemann.

Rutter, M. (1978). Prevalence and types of dyslexia. In A.L. Benton & D. Pearl (Eds.), Dyslexia: An appraisal of current knowledge. New York: Oxford University Press, 5-28.

Rutter, M. & Yule, W. (1973). Specific reading retardation. In L. Mann & D. Sabatino (Eds.), The first review of special education. Philadelphia: Buttonwood Farms.

Rutter, M. & Yule, W. (1975). The concept of specific reading retardation. Journal of Child Psychiatry, 16, 181-197.

Rutter, M., Tizard, J. & Whitmore, K. (1970). Education, health and behaviour. London: Longman.

Rutter, M., Graham, P. & Yule, W. (1970). A neuropsychiatric study in childhood. Clinics in Developmental Medicine, Nos. 35/36. London: SIMP/Heinemann.

SAS/STAT Guide (1987), SAS Institute Inc, Cary, N.C., USA.

Sarle, W.S. (1982). Documentation for SAS Clustering routine. In SAS User's Guide: Statistics. SAS Institute, Cary, N.C., USA.

Satz, P., Morris, R. & Darby, R.O. (1979). Subtypes of learning disabilities: A multivariate search. Paper presented to the IYC symposium, Vancouver, B.C., Canada. (cited by Satz & Morris, 1981).

Satz, P. & Morris, R. (1981). Learning disability subtypes: A review. In F.J. Pirozzolo & M.C. Wittrock (Eds.), Neuropsychological and cognitive processes in reading. New York: Academic Press.

Satz, P., Rardin, D. & Ross, J. (1971). An evaluation of a theory of specific developmental dyslexia. Child Development, 42, 2009-2021.

Satz, P. & Sparrow, S.S. (1970). Specific developmental dyslexia: A theoretical formation. In D.J. Bakker & P. Satz (Eds.), Specific reading disability: Advances in theory and methods (pp. 17-40). Rotterdam: Rotterdam University Press.

Satz, P., Taylor, G., Friel, J. & Fletcher, J.M. (1978). Some developmental and predictive precursors of reading disabilities: A six-year follow-up. In A.L. Benton & D. Pearl (Eds.), Dyslexia: An appraisal of current knowledge. New York: Oxford University Press.

Scheffé, H.A. (1959). The analysis of variance. New York: Wiley.

Senf, G.M. (1969). Development of immediate memory for bisensory stimuli in normal children and children with learning disorders. Developmental Psychology, 6, 28, Pt. 2.

Senf, G.M. and Freundl, P.C. (1971). Memory and attention factors in specific learning disabilities. Journal of Learning Disabilities, 4, 94-106.

Shallice, T. (1979). Case study approach in neuropsychology research. Journal of Clinical Neuropsychology, 1, 183-211.

Skinner, H.A. (1981). Toward the integration of classification theory and methods. Journal of Abnormal Psychology, 90 (1), 68-87.

Skinner, H.A. (1978). Differentiating the contribution of elevation, scatter and shape in profile similarity. Educational and Psychological Measurement, 38, 297-308.

Smith, M. (1978). Stability of WISC-R subtest profiles for learning disabled children. Psychology in the Schools, 15, 4-7.

Smith, M.M. (1982). Patterns of intellectual abilities in educationally handicapped children. Unpublished doctoral dissertation, Claremont College (cited by Malatesha & Dougan).

Smith, D.E.P. & Carrigan, P.M. (1959). The nature of reading disability. New York: Harcourt Brace World.

Smith, M., Coleman, J., Dokecki, P. and Davis, E. (1977). Recategorized WISC-R scores of learning disabled children. Journal of Learning Disabilities, 10, 437-443.

Sokal, R.R. (1974). Classification: Purposes, principles, progress, prospects. Science, 185 (4157), 1115-1123.

Sokal, R.R. & Sneath, P.H.A. (1963). Principles of numerical taxonomy. San Francisco: W.H. Freeman.

Spreen, O. (1978). The dyslexias: A discussion of neurobehavioural research. In A.L. Benton & D. Pearl (Eds.), Dyslexia: An appraisal of current knowledge. New York: Oxford University Press, 175-194.

Spreen, O. (1989). Learning disability, neurology, and long-term outcome: Some implications for the individual and for society. Journal of Clinical and Experimental Neuropsychology, 11, 389-408.

Spreen, O. & Benton, A.L. (1967, 1977). The Neurosensory Center Comprehensive Examination for Aphasia. University of Victoria.

Spreen, O. & Gaddes, W.H. (1969). Developmental norms for 15 Neuro-psychological Tests age 6 to 15. Cortex, 5, 171-191.

Spreen, O. & Haaf, R.G. (1986). Learning disability subtypes: A replication attempt and longitudinal patterns over 15 years. Journal of Learning Disabilities, 19, 170-180.

SPSS Advanced Statistics Guide (1985). SPSS Inc., Chicago, USA.

Strang, J.D. & Rourke, B.P. (1983). Concept formation/non-verbal reasoning abilities of children who exhibit specific academic problems with arithmetic. Journal of Clinical Child Psychology, 12, 33-39.

Strang, J.D. & Rourke, B.P. (1985a). Adaptive behaviour of children with specific arithmetic disabilities and associated neuropsychological abilities and deficits. In B.P. Rourke (Ed.), Neuropsychology of learning disabilities: Essentials of subtype analysis (pp. 302-328). New York: Guilford Press.

Strang, J.D. & Rourke, B.P. (1985b). Arithmetic disability subtypes: The neuropsychological significance of specific arithmetic impairment in childhood. In B.P. Rourke (Ed.), Neuropsychology of learning disabilities: Essentials of subtype analysis (pp. 167-183). New York: Guilford Press.

Strauss, A.A. and Kephart, N.C. (1955). Psychpathology and education of the brain-injured child. Vol. II: Progress in Theory and Clinic. New York: Grune and Stratton.

Strauss, A.A. and Lehtinen, L.E. (1947). Psychopathology and education of the brain-injured child. New York: Grune and Stratton.

Strauss, A.A. and Werner, H. (1938). Deficiency in the finger schema in relation to arithmetic disability. American Journal of Orthopsychiatry, 8, 719-724.

Strauss, A.A. and Werner, H. (1941). The mental organization of the brain-injured mentally defective child. American Journal of Psychiatry, 97, 1194.

Sweeney, J.E. & Rourke, B.P. (1978). Neuropsychological significance of phonetically accurate and phonetically inaccurate spelling errors in younger and older retarded spellers. Brain and Language, 6, 212-225.

Symmes, J.S. & Rapoport, J.L. (1972). Unexpected reading failure. American Journal of Orthopsychiatry, 42, 82-91.

Taylor, H.G., Satz, P. & Friel, J. (1979). Developmental dyslexia in relation to other childhood reading disorders: Significance and utility. Reading Research Quarterly, 15, 84-101.

Taylor, H.G., Fletcher, J.M. & Satz, P. (1982). Component processes in reading disabilities: Neuropsychological investigation of distinct reading subskill deficits. In R.N. Malatesha & P.G. Aaron (Eds.), Reading disorders: Varieties and treatments. New York: Academic Press.

Vellutino, F.R. (1979). Dyslexia: Theory and research. Cambridge, Mass.: MIT Press.

Wall, W.D. (1981). Recent research into dyslexia and remedial education. In Proceedings of a refresher course on dyslexia and remedial education. British Psychological Society.

Ward, J. (1963). Hierarchical grouping to optimize an objective function. Journal of the American Statistical Association, 58, 236-244.

Watson, B.V., Goldgar, D.E. & Ryschon, K. (1983). Subtypes of reading disability. Journal of Clinical Neuropsychology, 5, 377-379.

Wechsler, D. (1974). Manual for the WISC-R. The Psychological Corporation. New York.

Wiener, J.R. (1980). A theoretical model of the acquisition of peer relationships of learning disabled children. Journal of Learning Disabilities, 13, 506-511.

Wiener, M. & Cromer, W. (1967). Reading and reading difficulty: A conceptual analysis. Harvard Educational Review, 37, 620-643.

Wiig, E.H., Semel, M.S. & Crouse, M.B. (1973). The use of English morphology by high-risk and learning disabled children. Journal of Learning Disabilities, 6, 457-465.

Wilson, B.C. & Risucci, D.A. (1986). A model for clinical-quantitative classification. Generation 1: Application to language-disordered preschool children. Brain and Language, 27, 281-309.

Wolf, M. (1982). An approach to the combined study of acquired and developmental reading disorders. In R.N. Malatesha & P.G. Aaron (Eds.), Reading disorders: Varieties and treatments. New York: Academic Press.

Yeni-Komshian, G.H., Isenberg, P. & Goldstein, H. (1975). Cerebral dominance and reading disability: Left visual-field deficit in poor readers. Neuropsychologia, 13. 83-94.

Yule, W. (1973). Differential prognosis of reading backwardness and specific reading retardation. British Journal of Educational Psychology, 43, 244-248.

Yule, W., Rutter, M., Berger, M. & Thompson, J. (1974). Over- and under-achievement in reading: distribution in the general population. British Journal of Educational Psychology, 44, 1-12.

Zurif, e. G. & Carson, G. (1970). Dyslexia in relation to cerebral dominance and temporal analysis. Neuropsychologia, 8, 351-361.

APPENDIX A

Clinical Inferential Subtyping of Learning Disabilities

APPENDIX A

CLINICAL INFERENTIAL SUBTYPING OF LEARNING DISABILITIES

The hierarchical classification identified 10 broad subtypes, which could each be divided further into two or more subgroups, with a more precise differentiation between groups.

I. LANGUAGE DISORDERS

1. Group LX (Expressive Language Disorder): Language impairment in this group is largely expressive (word-finding, naming, sentence construction difficulties and fluency in general); verbal responses are either limited or cirumlocutory, and vocabulary is weak. General sequencing problems are evident; visual perceptual skills and visual memory are good; but there may be some problems in visual-motor copying. VIQ is within average range and less than PIQ. Sensorimotor and motor deficits may sometimes be present; cases in this group tend to be fairly quiet (not spontaneously talkative) and shy by nature. This subtype could be subdivided into two subgroups, as follows:

Type(LXa), in which verbal memory is intact; there are no problems in gross motor skills, although finger tapping is often weak; and auditory discrimination is adequate in the majority of cases.

Type(LXb), in which verbal memory and verbal learning are poor; auditory discrimination is weak in the majority of cases; and visual-motor copying skills are weak.

2. Group LR (Receptive-Expressive Language Disorder). Language impairment in this group involves both verbal expression and comprehension. There are difficulties in naming, grammatical construction and verbal fluency. General sequencing problems are evident. VIQ is less than PIQ, and is generally lower than in Group LX (74 to 103 in this sample). Cases in this group tend to be slow in thinking, processing, response and performance. This group is divided into two subgroups, as follows:

Type(LRa), in which verbal memory is good; visual perception is generally good, other than some weaknesses in visual-motor skills and visual memory; and sensorimotor and motor deficits are present.

Type(LRb), in which verbal memory is poor; visual perceptual skills are variable, ranging from good to a

number of general difficulties which may include visual-motor copying, visual memory, and low scores on some of the WISC-R performance tests.

3.Group GL (Global Language Disorder): Language impairment is quite severe in this group, with very low scores on all the verbal subtests of the WISC-R as well as on other language measures. There are problems in both expressive and receptive language abilities, including naming, vocabulary and reasoning skills. Auditory discrimination is weak; visual perceptual deficits may include visual-motor copying, visual figure-ground skills, and visual memory, but there are average scores on WISC-R performance subtests. VIQ is very low (55 to 78), whilst PIQ is average to above average (92 to 117). Sensorimotor and motor deficits may include right-left orientation, finger praxis, eye-tracking, handgrip strength and fine-motor skills. Verbal memory is poor, and speech is indistinct with minor articulation difficulties in some cases. Some talk quite freely, but ramble irrelevantly; others are quiet and very slow to respond.

VISUAL PERCEPTUAL/NON-VERBAL DISORDERS

As with the "Language Disorder" groups, the presence or absence of a verbal memory deficit proved to be an important factor in the classification process, mainly related to the degree of severity, it appeared, i.e. those with verbal memory deficits generally had more severe disorders.

4.Group VP1 (Mild Perceptual-Motor Disorder):Cases in this group show evident problems in visual perceptual, spatial and visual-motor abilities. Language skills are essentially good, ranging from extremely articulate and without any problems to mild word-finding problems or difficulty in following directions. Comprehension is good; there are no problems with auditory discrimination or articulation; visual memory is good; sensorimotor deficits range from none at all to problems in all areas; and handgrip strength is also variable. Verbal memory is good. This group can also be divided into two subgroups, as follows:

Type(VP1a), in which VIQ>PIQ with a discrepancy between scores ranging from 10 to 47 points (in this sample); handgrip strength is average or above average.

Type(VP1b), in which VIQ>PIQ, but discrepancy between scores is not as large as in (Ka), and ranges from 4 to 26 points (in this sample); handgrip strength is significantly weak.

5.Group VP2L (Moderate Perceptual-Motor Disorder with Mild Language and Sequencing Problems): Cases in this group show evident problems in visual perceptual, spatial and visual-motor abilities. However, there are also mild language difficulties, ranging from naming and fluency problems to difficulties in organizing thoughts and understanding verbal instructions. General difficulties in sequencing are also evident, and sensorimotor deficits vary. Verbal memory is good. This group can be divided into three subgroups, as follows:

Type(D), in which gross motor skills are average or above; auditory discrimination is intact; there are problems in articulation or speech pronunciation, as well as difficulties with writing and written work in general.

Type(F), in which gross motor skills are intact; auditory discrimination is poor; there are problems in articulation and speech pronunciation as well as marked difficulties in printing, writing and pencil work in general.

(Types D and F together could be labelled an "Articulatory-Graphomotor" subtype).

Type(E):Gross motor skills are intact; auditory discrimination is poor; there are no articulation or pronunciation problems; but many have difficulties in motor planning or constructional tasks, and writing is a problem for some.

6.Group VP3A (Moderate Visual Perceptual Disorder with Anomia and Gross Motor Deficits): VIQ>PIQ but the split is not more than 6 to 10 points; Visual perceptual problems are numerous and varied. Language is basically adequate, although there are pronounced difficulties in naming and verbal expression, with immature grammatical patterns. Some cases are fairly quiet and reluctant to expand responses; in others, speech is rambling and circumlocutory, and all have some difficulty in understanding questions or directions. Visual memory is good in almost all cases; gross motor skills are weak; and verbal memory is intact. This group can be divided into two subgroups, as follows:

Type (J),in which auditory discrimination is average. These cases talk freely and are quite fluent but almost all have problems with articulation and pronunciation. Printing and written work are also very difficult. Despite fluency, speech rate and work pace in general can be VERY SLOW. (Articulatory-graphomotor type).

Type(C): Auditory discrimination is poor. Cases in this group tend to be fairly quiet and reluctant to expand their reponses; they are shy and easily embarrassed. There are no articulation difficulties.

7.Group VP4M (Moderately Serious Visual Perceptual Disorder with Expressive Language and Verbal Memory Problems: Poor verbal memory characterizes this group of cases, with a mixture of fairly serious visual perceptual deficits and weaknesses in expressive language.There are also problems in sequencing as well as in understanding directions. Many cases in this group have articulation problems combined with graphomotor difficulties. Their perceptual/ non-verbal deficits range from moderate to serious (PIQ's are 100 to 69), while language abilities are within average range). cisual memory varies, as does auditory discrimination. There are two subgroups: one in which gross motor skills are good; and one in which gross motor skills are weak.

8.Group NV5:(Moderately Serious Perceptual-Motor Disorder): This group includes two subgroups with similar profiles of strengths and weaknesses, namely: Deficits in visual/spatial perception and organization, whilst language skills are good in comparison; auditory discrimination is poor; verbal memory is intact. The two subgroups are as follows:

Type (A): VIQ>PIQ, with quite a large split (between 12 and 26 points); Visual-spatial/non-verbal deficits are serious and include low scores on all or most of the performance subtests on the WISC-R. as well as on many other perceptual and motor measures. Language skills are usually quite articulate (with some subtle difficulties concerning content rather than expression).These children tend to be quite talkative, but have characteristic problems in logical reasoning. They are frequently described as clumsy, have difficulty learning to print, and are slow in pencil work or written work in general. Gross motor skills are deficient and they are usually poor in arithmetic.

Type (G): Similar to Group A, with average language ability combined with relatively low performance scores on the WISC-R (74 to 92). There are some difficulties in verbal expression in this group (poor naming and limited vocabulary); sequencing skills can also be weak. Gross motor ability is good. But the main differences include deficits in conceptual thinking in all cases as well as articulation and graphomotor problems in many of the cases.

III.MIXED LANGUAGE AND VISUAL PERCEPTUAL DISORDERS

In all the following "mixed" subtypes, low scores were recorded on either or both the Similarities or Comprehension subtests of the WISC-R.

Mixed Subtypes with Weaker Language Abilities

9.Group ML1:(Mild Mixed-Language Disorder): In this group, intelligence is within average range, with VIQ slightly < PIQ. All cases have comprehension and reasoning difficulties, and also frequently have problems in conceptual thinking. Language expression is difficult, verbal responses are limited, and speech rate is often quite slow. Verbal fluency is poor at younger ages, and improves at older ages. Visual perceptual deficits may include poor visual-motor copying, low scores on several WISC-R performance tests, as well as problems with visual figure-ground and spatial perception. Visual memory is adequate in most cases. Articulation is immature in many of these children, and printing or writing is extremely difficult for them. Verbal memory is average and gross motor skills are intact. The children in this group are particularly strong-willed by nature: some are active and restless, whilst others are merely stubborn, resistant and inclined to be disruptive.

10.Group ML2:(Moderately Severe Mixed-Language Disorder with Poor Verbal Memory): Reasoning and comprehension problems characterize this group, in which language impairment is more severe than visual perceptual deficits, although the latter are significantly present. Language deficits include problems in verbal expression, naming, word-finding and fluency; thought patterns tend to be disorganized. Many cases have minor articulation problems. These children tend to talk a lot, but their speech is circumlocutory, perseverative and long-winded. Verbal memory is poor. Sensorimotor and motor deficits may include right-left orientation, finger localization, finger praxis, eye-tracking, stereognosis, finger tapping and handgrip strength. In most cases, gross motor functioning is affected to some degree. Auditory discrimination is poor in almost all cases (with 5 exceptions). This group comprises three different subtypes, as follows:

Type Qa: This group typifies a "mixed" subtype, with VIQ's ranging from 74 to 80, and PIQ's ranging from 77 to 88. Auditory discrimination is good in 5 cases. Otherwise, the characteristics are as described above.

Type Qb: VIQ's are similar to those in (Qa), but PIQ's are slightly higher, ranging from 85 to 104. All cases in this group display articulation deficits and marked difficulties with graphomotor tasks.

Type Qc: In this group, VIQ's range from 80 to 94 and PIQ's from 91 to 109, so that it represents a generally slightly higher functioning group than the other three subtypes, and is otherwise characteristic of (Q)Groups. The members of this group all tend to be restless, impulsive, speedy, contrary and non-compliant by nature.

Mixed Subtypes with Weaker Visual Perceptual Skills

11/12.Group MNV:(Severe Mixed-Perceptual-Non-Verbal-Disorder:

There are two main groups under this heading: one in which verbal memory is deficient and one in which verbal memory is intact:

11.Group(W):(Moderately Severe Mixed Perceptual Disorder): In this group, verbal memory is intact but there are marked problems in comprehension, non-verbal problem-solving, and logical reasoning. Language deficits include both receptive and expressive difficulties. These children are talkative and perseverative in their speech, but their talk tends to be rambling and lacking in substance. They have difficulty in following directions. Auditory discrimination is average, and handgrip strength is poor in many (but not all) these cases. VIQ's range from 80 to 95; PIQ's range from 74 to 88.

12.Group(H):(Severe Mixed Perceptual Disorder): In this group, verbal memory is poor, and there are pronounced problems in reasoning, non-verbal problem-solving as well as abstract thinking. These children can be quite talkative and frequently use verbal mediation whilst performing non-verbal tasks. But, they have some difficulties in word retrieval and verbal expression, and can be reticent at times. Also, whilst vocabulary use may be sophisticated, comprehension is often lacking. Auditory discrimination is weak in many of these cases, and gross motor skills are below average.

APPENDIX B

Decision Rules for Classifying Typology Subtypes

APPENDIX B

DECISION RULES FOR CLASSIFYING TYPOLOGY SUBTYPES

SECTION A

1. *Is VIQ less than PIQ? If NO: then move straight to SECTION B.*

   If YES:

Could belong in any of the following groups:	Can eliminate assignment to:
LX, LR, GL, ML1, ML2, VP4M or VP3A	VP2L, VP1, NV5, MNH

2. Are either Similarities, Comprehension scores, or both, below average?

If YES: Could belong to any of the following: LR, GL, ML1, or ML2. Therefore, proceed with Path A1 (as follows):	If NO: Could belong to: LX, VP3A or VP4M. Proceed to Decision Path A2: (page 3)

Decision Path A1

A. If: a) there are articulation/graphomotor problems, or

   b) visual-perceptual impairment is almost equal to language deficiency, so that VIQ is less than PIQ--but difference not large

Then case could belong to one of the mixed-language subtypes: ML1 or ML2.

Decision Path A1 (continued)

Differences between these two types:

	ML1	ML2
1. Verbal expression	Fluency poor; speech rate often slow; responses limited	Talk a lot; speech circumlocutory; perseverative; long-winded
2. Verbal memory	Good	Poor
3. Printing and writing	Very difficult; very reluctant to do this	Graphomotor difficulties in one subgroup
4. Level of severity	Comparatively mild--all cases of average intelligence	Most are functioning in the low average range (IQ 80 to 89), except for subgroup of average intelligence

B. If: a) Visual processing is quite good--with visual-motor and maybe visual memory weaknesses

b) Language expression and comprehension are weak; language more impaired than visual perceptual

c) Many cases need to be spoken to slowly because of verbal reception and comprehension problems:

Then case is likely to belong to one of the Language Disorder subtypes: LR or GL.

Decision Path A1 (continued)

Differences between these two types:

	LR	GL
1. VIQ level	VIQ: 74 to 103	VIQ: 55 to 78 (very low); VIQ/PIQ split quite large large (17 to 37)
2.	Very slow in thinking, processing, response and performance	
3. Auditory		
4. Verbal memory		
5. Dynamometer		
If any of above are average level	then: case could be LR because	below are in all these skill areas if GL

Decision Path A2 (see page 9 for summaries of relevant group characteristics)

Is verbal memory below average?

A) If YES: Case could belong to either of the following groups: LX or VP4M

B) If NO: Case would belong to one of the VP3A subtypes (See below for choice):

Differences between these two types:

	LX	VP4M
Language skills?	Obvious expressive language difficulties --often quiet and shy; word-finding problems	Some language weaknesses but language better than visual/non-verbal abilities
Visual perceptual/ non-verbal skills?	Generally good--maybe some visual-motor weaknesses	Problems in these areas are fairly serious

Decision Path A2 (continued)

B) Differences between the two VP3A subtypes:

	TYPE J	TYPE C
Auditory discrimination?	Good	Poor
Articulation and Graphomotor problems?	Yes	None

SECTION B

1. If PIQ is less than VIQ:

   Could belong to any of the following:
   VP1, VP2L, VP3A, VP4M, NV5, MNV

2. Are Similarities and/or Comprehension scores below average?

   If NO: Could belong to any of the following groups: VP1, VP2L, VP3A, VP4M, or Group A (NVS)

   If YES: Proceed to Decision Path B2 (See page 5)

   Therefore, proceed with Decision Path B1, as follows:

3. Is verbal memory below average?

   If NO: Could belong to group VP1, VP2L, VP3A, NV5 (Gp. A)

   If YES: Proceed to Decision Path B3 (see page 6)

4. Are there general sequencing problems?

   If NO: Could belong to either VP1 or NV5 (Gp. A)

   If YES: Could belong to VP2L or VP3A:
   Proceed to Decision Path B4 (page 7)

Decision Path B1 (continued)

Differences between these two types:

		VP1	NV5 (Gp. A)
1.	Both have visual/ spatial deficits	Ranging from mild to moderate	Major and serious deficits (VIQ/PIQ split is 12 - 26 pts.)
2.	Language good	Articulate--may have mild word-finding problems or difficulties following directions	Talkative--but subtle difficulties in content --perseverative; reasoning weak
3.	Reasoning	Logical reasoning good	Logical reasoning poor
4.	Auditory discrimination	Good	Poor

Decision Path B2

1. If Similarities and/or Comprehension scores are below average:
   Then case could belong to: Group G (NV5) or MNV.

2.	Is verbal memory poor?	If YES: Case would belong to Group H (MNV)	If NO: Then case could belong to Group G (NV5) of Group W (MNV)

Decision Path B2 (continued)

Differences between these two groups:

		Group G	Group W
1)	Similarities and Comprehension scores	Similarities Comprehension	Similarities Comprehension
2)	Visual-spatial/ non-verbal deficits	Not as serious as W	Serious
3)	Language	Within average range-- (vocabulary or verbal expression can sometimes be weak)	Chatty, rambling and lacking substance. Language difficulties are marked-- (both receptive and expressive)
4)	Logical reasoning, comprehension, Novel problem-solving	Not as evident as in W	Poor

Decision Path B3: IF VERBAL MEMORY IS BELOW AVERAGE:

Then case could belong to VP4M or Group H (MNV)

Differences between these two groups:

	VP4M	Group H (MNV)
Similarities and Comprehension scores	Both normal	Similarities and/or Comprehension

Decision Path B4:

4. Are there general sequencing problems? (See note,)

If YES: Case could belong to VP2L or VP3A

Differences between these two subtypes:

	VP2L	VP3A
Gross motor problems?	No	Yes

If no gross motor problems--(i.e. Group VP2L), then could be Group D, E or F

Differences between these three subtypes:

	D	E	F
Auditory Discrimination poor	No	Yes	Yes
Articulation/graphomotor difficulties	Yes	No	Yes

DESCRIPTIONS OF LANGUAGE DISORDERED SUBTYPES

AND CRITERIA FOR INCLUSION

LR Group: (Receptive-Expressive Language)

a) Language difficulties involve both verbal expression (naming, fluency, grammatical construction) and verbal comprehension. (Questions need repeating and re-explanation.)

b) VIQ ranges from approximately 74 to 103.

c) WISC-R Comprehension frequently below average.
Audit recep. on ITPA below average (verbal reception slow).

d) Visual processing varies. Difficulties with visual-motor skills (Coding , Beery). Trails , visual memory and figure-ground may be poor.

e) Problems in sequencing (generally).

f) Very slow in thinking, processing, responding and performance.

g) Verbal memory usually poor (but not always).

GL Group: (Global Language--Severe)

a) Very low scores on all language tests, as well as on WISC-R verbal tests.

b) VIQ very low (55 to 78) (Main difference between GL and LR).

c) PIQ average or above--large VIQ/PIQ split (17 to 37 points).

d) Verbal memory always poor .

e) Auditory discrimination poor .

f) Visual memory poor .

g) Dynamometer poor .

h) Visual processing usually fairly good, but problems in visual-motor skills; figure-ground perception poor .

i) Similarities and Comprehension usually both poor .

NB. Both above groups need to be spoken to slowly because of verbal reception and comprehension problems.

LX Group: (Expressive Language)

a) Language difficulties include expressive skills (word finding, naming, fluency, sentence construction poor).

b) Verbal responses either limited or circumlocutory and vocabulary weak .

c) VIQ is less than PIQ but VIQ still within average range.

d) Visual processing skills and visual memory generally good. (There may be some problems in visual-motor copying.)

e) Fairly quiet (not spontaneously talkative) and shy by nature, or else chatty, but circumlocutory.

f) Verbal memory (good or poor--varies).

g) Auditory discrimination (good or poor--varies).

h) Sequencing skills poor.

ML1 Group: (Mild Mixed-Language Disorder)

a) Similarities/Comprehension scores low.

b) Intelligence is in average range.

c) VIQ slightly less than PIQ (not much difference--mixed).

d) Gross motor average.

e) Verbal expression difficult: fluency; verbal responses limited; speech rate often slow (particularly when younger).

f) Visual processing: poor visual-motor; low scores on several WISC-R performance tests; figure-ground and spatial problems.

g) Verbal memory--average.

h) Articulation often poor; printing/writing very difficult (articulation/graphomotor).

i) Tend to be strong-willed, difficult children; some are active/restless; others are stubborn/resistant/disruptive.

ML2 Group: (Moderately Severe Mixed-Language Disorder)

a) Similarities/Comprehension scores low. Intelligence level varies. (Note under subgroups)

b) VIQ is greater than PIQ (not much difference--mixed).

c) Verbal expression difficult: fluency; word-finding; naming.

ML2 Group: (Moderately Severe Mixed-Language Disorder) ...continued

d) Thought patterns tend to be disorganized.

e) Talk a lot, but speech is circumlocutory, perseverative, long-winded.

f) Visual processing: skills are variable; range from poor visual-motor and drawing skills to general perceptual weaknesses.

g) Verbal memory below average .

h) Auditory discrimination poor . (Four exceptions.)

Subgroups:

i. Qa - Typical "Mixed" group:
VIQs 74 to 80; PIQs 77 to 88.
Auditory discrimination is good in four cases out of 13 in this group.

ii. Qb - Articultory-Graphomotor group (marked):
VIQs 73 to 100; PIQs 85 to 106.

iii. Qc - Generally slightly higher functioning group:
VIQs 80 to 94; PIQs 91 to 109.

DESCRIPTIONS OF VISUAL-PERCEPTUAL/NON-VERBAL SUBTYPES

AND CRITERIA FOR INCLUSION

VP1 Groups (Mild Visual-Perceptual-Motor Disorders):

a) Similarities and Comprehension both normal.

b) VIQ is greater than PIQ.

c) Articulation normal.

d) Verbal memory normal.

e) Gross motor varies.

f) Language basically good--ranges from very articulate speech through slightly fuzzy articulation to mild word-finding problems, and some difficulties following directions.

g) Visual processing varies--ranges from almost ALL scores low to just Object Assembly and Coding low. Visual memory is good in all cases.

Two groups:

a) Gross motor is normal.

b) Gross motor is poor.

VP2L Groups (Moderate Perceptual with Mild-Language Disorder:

a) Similarities and Comprehension both average.

b) VIQ is greater than PIQ.

c) Verbal memory normal.

d) Problems in visual perceptual/spatial and visual-motor skills.

e) Also mild language difficulties--naming, fluency, difficulty organizing thoughts and understanding verbal instructions.

f) General sequencing problems evident.

Divided into three groups: D, E and F.

Group D: 1) Auditory discrimination normal.

2) Gross motor skills normal.

Group D (contd.): 3) Visual processing: pictorial analysis generally good (Picture Arr. and Picture Compl.). Problems mainly spatial.

4) Language fairly good--some fluency and word-finding problems.

5) Difficulties with speech pronunciation and immature articulation. (Very like VP1 (a)--this is main difference.)

Group E: 1) Auditory discrimination poor .

2) Gross motor skills normal.

3) Visual processing: quite general, including both Block design and Object assembly, in many cases.

4) Sequencing problems.

5) Constructional and motor planning difficulties.

6) Articulation and pronunciation is normal (no problem).

7) Language: subtle problems; difficulty in understanding directions; defining word meanings; organizing thoughts; being verbally concise; finding words; in sentence construction.

Group F: 1) Auditory discrimination poor .

2) Gross motor skills normal.

3) Visual processing--quite general (as in E); visual memory good, in most cases.

4) Sequencing difficulties .

5) Problems in articulation and pronunciation.

6) Printing and pencil work very difficult.

VP3A Groups (Moderate Visual-Perceptual Disorder with Anomia and Gross Motor Problems:

a) Similarities and Comprehension both normal.

b) Verbal memory normal.

c) Gross motor deficits .

Group J: 1) Auditory discrimination normal.

2) Language reasonably efficient--chatty and talk freely; language use is adequate and these cases are quite fluent, but:

Group J: (contd.)
3) Problems with articulation and pronunciation (not severe).

4) Sequencing problems.

5) Visual difficulties include: problems with part/whole; very slow scanning and visual-motor difficulties (Bender, Coding, Block Design, Mazes, Frostig, Rey Osterreich, Ravens, Beery, Visual Closure--etc.

6) Visual memory normal.

7) Many with dysgraphia and poor printing.

Group C: 1) Auditory discrimination poor .

2) Language reasonably efficient--subtle problems with verbal expression; grammatical patterns immature; reluctance to expand responses; naming ; fairly quiet; difficulties with verbal responses on demand; sometimes rambling and circumlocutory.

3) No articulation difficulties.

4) Visual difficulties include: visual-motor mainly--Coding, Beery; also Object Assembly and Block Design (P. Arr. sometimes).

5) Visual memory normal.

In both the above groups, there is:
(a) a group with VIQ greater than PIQ, and
(b) a group with PIQ greater than VIQ.

VP4M Group (Moderate Visual-Perceptual Disorder with Expressive Language and Verbal Memory Problems:

a) VIQ is greater than PIQ.

b) Similarities and comprehension both normal.

c) Verbal memory poor .

d) Visual processing--fairly serious deficits (PIQ: 69 to 100).

e) Language--weaknesses in expressive skills (naming, word-finding, sequencing skills, in general), but better than visual/non-verbal abilities. Trouble following directions and can be quite talkative.

f) Cross motor skills vary.

g) Auditory discrimination varies.

Divided into two subtypes:

1) Group B2 - Visual memory is good; verbal expressive difficulties include naming problems in particular.

2) Group B3 - Visual memory poor; many have articulation and graphomotor problems. Chatty and inclined to be clumsy.

Also a group where VIQ is less than PIQ:

In this group, there are difficulties in both areas, although visual-perceptual problems are clearly more serious than language difficulties. However, verbal scores on WISC-R tend to be slightly lower, in general, than performance scores (in which specific deficits have low scores)--hence, VIQ is less than PIQ.

NV5 Group (Moderate Non-Verbal Disorders:

a) VIQ is greater than PIQ;
b) Verbal Memory normal.

Divided into two subtypes, as follows:

1. Group A Typical Non-Verbal LD Type

a) Similarities and Comprehension both normal.

b) Auditory discrimination poor .

c) Visual/spatial processing--serious deficiencies; low scores on all or most of the performance subtests of the WISC-R, as well as other perceptual/motor measures, e.g. Ravens, Embedded figures, Beery, BURT, Visual closure, Frostig, 3-D Praxis, etc.

d) Arithmetic poor .

e) 12 to 26 point split between VIQ/PIQ.

f) Language usually quite articulate; cases are quite talkative (subtle difficulties re. content rather than expression).

g) Problems in logical reasoning.

h) Gross motor skills poor ; clumsy children.

i) Difficulty in learning to print; slow with pencil work or written work.

j) Visual memory poor in many cases.

2. Group G

a) Similarities poor and comprehension as well, in some cases.

b) Auditory discrimination poor .

c) Visual-spatial processing--serious deficits.
(Performance scores on WISC-R: 74 to 92.)

d) Language within average range, but conceptual thinking (Similarities test) low , in all cases.

e) Difficulties in verbal expression (naming , vocabulary limited).

f) Sequencing skills also weak, in many cases.

g) Articulation and graphomotor difficulties, in many cases.

h) Gross motor skills are normal.

Groups MNV (Severe Mixed-Non-Verbal Disorders) MIXED DISORDER

Divided into Two Subtypes:

1. Group W (Moderately Severe Mixed-Non-Verbal Disorders)

a) VIQ is greater than PIQ. (VIQ range 80 to 95; PIQ 74 to 88.)

b) Fairly serious non-verbal/visual-spatial deficits.

c) Similarities normal; Comprehension poor .

d) Verbal memory normal.

e) Gross motor skills vary

f) Auditory discrimination varies.

g) Language--talkative but rambling; perseverative responses; lacking substance. Language problems quite marked (both receptive and expressive difficulties).

h) Logical reasoning and novel problem-solving poor .
Reasoning and comprehension poor ; following directions poor .

i) Some cases with minor articulatory-graphomotor problems.

2. Group H (Severe Mixed-Non-Verbal Disorder) MIXED DISORDER

a) VIQ is greater than PIQ.

b) Severe non-verbal/visual-spatial problems in most areas; involves all performance tests, in some cases; in others, all except one or two. Also BURT, Embedded figures, etc.

c) Similarities or Comprehension (or both) below average .

d) Verbal memory poor .

e) Gross motor skills vary, but poor , in most cases.

f) Auditory discrimination varies, but weak in many cases.

g) Many have problems in sound patterns .

h) Language--can be quite chatty (and use verbal mediation for non-verbal tests), but there are some difficulties with language. Problems with word retrieval and verbal expression. Can sometimes be reticent.

i) Vocabulary use may be sophisticated BUT comprehension often lacking (talk is often lacking in substance)--reasoning problems.

j) Some articulatory-graphomotor problems, in a few cases.

APPENDIX C

Standardized Parent Interview

APPENDIX C

Standardized Parent Interview

I. Reasons for Referral: This section includes questions relating to the problems that led to the request for services, such as: Can you tell me what your main concerns about __(child's___name)__involve? How long have you had these concerns? What attempts have you made to deal with them to date?

The responses to these questions usually lead to requests for further elaboration as well as additional questions about specific concerns - e.g. What exactly are the teacher's complaints about his behaviour in the classroom? or Is she just having trouble with reading or does she have problems in other academic areas as well?

II. School History: This section includes questions about the child's prior school experiences up until the present, starting from the earliest group situations (preschool or daycare), kindergarten, elementary school, and beyond. Parents are asked about:

a) Any difficulties in learning or the acquisition of academic skills in the early grades? Any problems in performance (i.e. getting the work done, completing work)? Subject areas in which they have usually done quite well? Any teacher comments in kindergarten about failure to grasp pre-academic skills, immaturity etc.? If a specific academic problem has already been discussed (e.g. reading difficulty), questions are asked about how this has been handled through school? What help has been provided (specific programme,if known)? Grades repeated, if any?

b) Any complaints about behaviour or problems relating to social interaction in the child's school experiences to date? This includes preschool and early group experiences.

c) Participation in sports or P.E.? School activities that are enjoyed? Friends and social life? Invited to birthday parties? A loner by choice? or rejected by peers? etc.

III. Developmental and Medical History: This section includes questions relating to the following main topics:

a) Adopted? At what age? If natural, pregnancy normal or complicated? and details are requested. Similarly, birth details- normal or with complications? If so, what? Full term, early or late delivery?

b) Neonatal status? Incubator? Breathing complications? Apgar rating?

c) Infancy: normal sleeping and eating patterns? easy, placid infant? or irritable. frequent crying. colicky? Cuddly or resists cuddling? Any problems?

d) Developmental milestones: Age when started to sit up, crawl, walk? Age of first single words spoken? First phrase or group of words? Any delays or problems with speech or motor development? Any difficulties with articulation? Speech therapy ever required? Any parental observations re. development? Was the child exploratory as a toddler, or when he became mobile? Or did he just sit and play with what was given to him? Activity level high, low or normal?

e) Medical History: Includes questions about any illnesses, accidents, hospitalizations or surgery during the child life? Allergies? Seizures? Blank spells? Tendency to colds, bronchitis, asthma? Medication? Ear infections? Ventilating tubes necessary (otitis media)? Any eye problems? Eneuresis or encopresis?

f) Vision and hearing: Have these been tested? Any difficulties? Audiological examination reports requested if this is problem. Does child wear glasses?

IV. Family and Home life: This section includes discussion about the family situation, and who constitutes the family.e.g. two parents? single parent? siblings? step-father or mother? etc. How does the child get along within the family or with siblings, etc.? Do both parents work? Any dissension or problems?

Child's behaviour at home: Is this a problem? If so, in what ways? (parent is asked to expand on this topic).

V. Child's Emotional Status: Are there any concerns about this? Is child withdrawn or unhappy? Nightmares? Temper tantrums? Emotional outbursts? Extremely shy? Unusually fearful? Shows signs of depression? Feels rejected by peers or always picked-on by others etc.?

VI. General: This section includes questions about the child's interests and hobbies; What does he enjoy doing? Also questions about parents educational level or school experiences. Any particular difficulties?

APPENDIX D

Parent Information Form

PARENT INFORMATION FORM

DATE:_____

I am attempting to put together as comprehensive a picture of your child as possible in order that I can better meet his/her needs. Therefore, I would appreciate your taking the time to complete this rather lengthy questionnaire.

GENERAL INFORMATION

Name of Child:_____ Age:_____ Sex:_____

Birthdate:_____ Natural:_____ Adopted:_____ Foster Child:_____

Child's Address:_____ Telephone:_____

Postal Code:_____

CURRENT FAMILY HISTORY

	Father	Mother
Name		
Address		
Phone Number		
Birthdate		
Birthplace		
Marital Status		
Previous Marriages (give dates)		
Occupation		
Grade completed		
Educational problems		
If yes, please specify		
Right or left handed		
General health		

If the referred child is not your natural child, please complete the following if known:

	Father (Natural)	Mother (Natural)
Occupation		
Education (grade completed in school)		
Educational problems		
If yes, please specify		
Right or left handed		
General health		

Please list child's brothers and sisters:

	Oldest	Next	Etc.		
Name					
Sex					
Birthdate					
Living at home					
In school					
Grade completed					
School problems					
If yes, please specify					
Right or left handed					
General health					

Who lives in the home besides child's parents, brothers and sisters?

_____

_____

HEALTH INFORMATION

Pregnancy History

Were there any problems during pregnancy, for example water retention, severe nausea, vomiting, bleeding, high blood pressure, toxemia? Yes _____ No _____. If yes, please specify_____

_____

Was there contact with any infectious disease during pregnancy? Yes _____ No _____. If yes, please specify _____

_____

Were any medications taken during pregnancy? Yes _____ No _____. If yes, please specify

_____

Birth History

How long was labour and delivery?_____

Were there any complications during labour or delivery? (For example, breech birth, forcep delivery, caesarian section) Yes _____ No _____. If yes, please specify_____

_____

Was baby born on time, early, or late? If early or late, please specify by how many weeks or months_____

Baby's condition at birth (please underline)

Breathed immediately Cried immediately Required oxygen

APGAR rating, if known _____

Were there any problems in the first week? (For example, required incubator, feeding difficulties, jaundice (yellow skin), etc.) Yes _____ No _____. If yes, please specify

_____

Were there any birth defects, however unimportant you consider them? Yes _____ No _____.

If yes, please specify _____

_____

Early Developmental History

Infancy

Sleeping difficulties: Yes ____ No ____

Irritability and Colic: Yes ____ No ____

Feeding difficulties: Yes ____ No ____

If yes to any of the above, please specify_____

_____

_____

_____

Motor Development

Age, in months, if known, or state whether development was slow or average:

Sitting _____months

Crawling _____months

Standing _____months

Walking _____months

General motor coordination Good _____ Average _____ Poor _____

Speech Development

Age, in months, if known, or state whether development was slow or average:

First sounds (babbling) _____months

Words _____months

Sentences _____months

Toilet Training:

Age, if known:	Day	Night
Bladder	_____months	_____months
Bowel	_____months	_____months

Right or left handed _____

Level of activity: High _____ Average _____ Low _____

Did you have any special concerns about this child's behaviour in infancy that have not been covered above? Yes ____ No ____. If yes, please specify _____

_____

_____

Was professional help sought for any early developmental problems? Yes ____ No ____.

If yes, please specify_____

_____

Medical History

Has your child had any severe illnesses, accidents, hospitalizations, or operations?

Yes _____ No _____. If yes, please specify_____

_____

_____

Does your child have allergies? Yes ____ No____. If yes, please specify _____

_____

Has your child had convulsions or seizures or blank spells? Yes____ No ____. If yes, please specify_____

Has your child had eye problems? Yes ____ No ____. If yes, please specify _____

_____

Does your child require glasses? Yes ____ No ____. If yes, please specify_____

_____

Has your child had ear problems at any time? Yes ____ No ____. If yes, please specify

_____

Was hearing affected? Yes ____ No ____. If yes, please specify_____

_____

Has your child had any eating problems (For example, unusual food preferences or eating patterns) Yes ____ No ____. If yes, please specify _____

_____

Has your child been on medications at any time? Yes ____ No ____. If yes, please specify_____

Has your child ever received special kinds of therapy (For example, Play, Occupational, Physio, Speech or Psycho Therapy?) Yes ____ No ____. If yes, please specify _____

_____

_____

Would you describe your child as being in good general health? Yes ____ No ____. If no, please specify _____

_____

Has your child had a physical examination in the last six months? Yes ____ No ____.

BEHAVIOUR

Check when present:

	nervous habits	demands attention
	unusual fears	day-dreaming
	soiling	over-activity
	bedwetting	frequent tiredness
	rocking	easily upset
	head banging	argumentative
	breath holding	cries easily
	excessive neatness	lying
	irritability	stealing
	aggressive	shyness
	destructiveness	jealousy
	temper tantrums	tenseness
	mood swings	nervousness
	impulsiveness	lack of confidence
/	unpredictability	stubbornness

	worries excessively
	lonely
	unhappy
	self-critical
	suspicious
	feels misunderstood
	feels unliked or unwanted
	talks to himself
	prefers to be alone
	nightmares
	sleep disturbance
	clumsiness
	accident prone
	short attention span

When you tell your child to do something, does he obey you? always ____, most of the time____, seldom ____.

When your child does not obey you, what do you do? (check all appropriate): repeat demand ____, send him to his room ____, spank ____, ignore him ____, take away a privilege ____, try to reason with him ____, other _____

_____

_____

How does your child get along with brothers and sisters?_____

_____

How does your child get along with other children? _____

_____

Does your child have close friends? _____

_____

What activities is your child interested in? _____

_____

What does your child do well? _____

_____

What activities, if any, does your child tend to avoid? _____

_____

Was professional help sought regarding any behavioural problem? Yes ____ No ____. If yes, please specify _____

_____

EDUCATION

Please list schools (including Day Care, Preschool, and Kindergarten) in order of child's attendance:

Name of School	Age	Grade	Special Class or Regular	Best Subjects	Favourite Subjects	Most Difficult Subjects	

Please comment on any special concerns you have regarding your child's progress in school:

_____

_____

_____

_____

OTHER INFORMATION

Has your child ever been separated from the family? Yes ____ No ____. If yes, please specify age at time of separation _____, duration _____, reason _____

_____

_____

Has there been any recent or past major family events or problems, such as death, serious illness or accident? Yes ____ No ____. If yes, please specify _____

_____

_____

Do you have any thoughts or feelings about your child's difficulties, what they might relate to or stem from?

_____

_____

_____

_____

Do both parents share these views? Yes ____ No ____. If no, please specify _____

_____

_____

_____

_____

10.

Any additional comments you would like to add _____

Signature of person(s) filling out form

APPENDIX E

Letters to School Principals and Parents of Normal Control Volunteers

Letter to School Principals

Dear_____,

I am writing in order to request your help with a research project, with which I am currently engaged, in order to complete the requirements for a PhD degree at the University of Victoria. The design of my study involves the need to find approximately 30 control subjects, between the ages of 7 and 16, who are without any learning disabilities, behavioural problems or social difficulties.

Such children would need to be identified by their teachers as "average or above average learners" without any of the problems mentioned above. The teacher would then send home with each selected student a letter to the parents, explaining the project and asking if their child would like to volunteer as a subject for this study. A sample of this letter is enclosed for your information.

Other than this, no further involvement from the school would be required, and nor would there be any disruption of class time for the participating students. I would contact those parents who gave their permission and arrange for the student to come to my office on a Saturday or during a holiday break, where I would administer the test battery which would provide me with the necessary data. The testing process involves nothing coercive or unpleasant for the child and, in fact, most children find it an interesting and enjoyable experience.

Thankyou for your consideration in this matter,

Yours truly,

Barbara M. Peter, M.A.
Registered Psychologist, B.C.

BMP/cp
encl.

Letter to Parents of Volunteer Subjects (Controls)

Dear _____,

As a graduate student at the University of Victoria, I am currently engaged in a research project to complete requirements for a PhD degree. The study design necessitates seeking some 30 children between the ages of 7 and 16, who are without any learning difficulties, behavioural or social problems, and who would be willing to participate in this study as "normal control" subjects.

Your child has been recommended by his/her teacher as fulfilling these requirements, and I am writing to ask whether _____ might be interested in volunteering for this project, with your permission.

Participation in this project would involve two or three individual sessions (5 to 6 hours in total) during which I would administer to them a battery of language, perceptual, motor, memory and academic tests, in order to obtain the necessary data. The testing process is very informal, non-coercive and non-threatening. Most children find it an interesting and enjoyable experience. I should also explain that it would not involve any disruption of the regular school day for your child. With your permission, I would arrange for your child to come to my office on a Saturday or during a holiday break.

I am also offering each volunteeer a small payment for their time and cooperation in this project, at the going rate of $2.00 per hour.

If you and your child are interested and willing to participate in this research project, I would be glad if you would phone me at the above number, and we can arrange times that would be mutually suitable for the testing sessions. Also, please feel free to phone me if you are not sure but would like further information about this project.

Thankyou for your anticipated cooperation,
Yours sincerely,

Barbara M. Peter, M.A.
Registered Psychologist, B.C.

Criteria for Selection of Control Subjects

Should be:

1) Between the ages of 7 and 16
2) Identified by their teachers as functioning at average or above average levels academically,
3) Without any problems in learning, behaviour, social or emotional functioning - i.e. there are no "concerns" about them, which the teacher might wish to bring to the attention of parents or school counsellors.