WISC CHARACTERISTICS OF CLINIC-REFERRED

SUBGROUPS OF DISABLED LEARNERS

By

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ABSTRACT

The initial goal was to determine what proportion of a sample of disabled learners referred to a Neuropsychology Clinic would present with an isolated deficit in either reading or arithmetic rather than a more general handicap affecting both academic areas. Significantly low achievement on the WRAT, using local normative data, was used as criterion of a learning disability. Subjects were screened for primary psychiatric problems. Of the 109 subjects (25 female, 84 male; mean FSIQ of 100; mean age of 10.7 years) 23% had definite neurological indicators of brain damage, 39% had questionable and 40% had no indicators of brain damage.

Of the 109 disabled learners, 94 could be described as reading disabled and 82 as arithmetic disabled using conservative criteria generally accepted in the literature. However, there was considerable overlap between these two categories. Most subjects (86% of the reading disabled and 93% of the arithmetic disabled) were below the normal range in the second academic area and would more accurately be described as generally learning disabled. Relatively few subjects (17%) presented with single deficits in either arithmetic or reading. For the six subjects with an

arithmetic disability and normal reading achievement, spelling achievement varied from normal to significantly impaired. While these findings need to be replicated, they emphasize a need for careful reporting of pattern of academic deficit in studies of reading and arithmetic disabilities. Clinical category of neurological status did not discriminate between a subgroup with reading plus arithmetic disability (n=67), a subgroup with normal arithmetic but impaired reading (n=13), and a subgroup with normal reading but impaired arithmetic (n=6).

In the second part of the study, the potential of information contained in the WISC profile for both diagnostic purposes and for understanding the cognitive strengths and weaknesses of disabled learners was investigated for subgroups formed according to pattern of academic deficit.

Distributions of WISC Verbal-Performance discrepancies and of subtest scatter were not abnormal when the three subgroups were compared to the WISC and WISC-R standardization populations. These findings are contrary to common clinical assumptions of the diagnostic usefulness of these two WISC measures.

A principle components analysis of the WISC subtest scores supported the recategorization of the subtests into Conceptual, Spatial and Sequential factors, for clinic-referred disabled learners.

While no subgroup was consistently characterized by a particular pattern of factor scores, a hypothesis that subjects in a reading plus arithmetic disability subgroup (n=51) would present with a high incidence of a Spatial-Conceptual-Sequential hierarchy of factor scores was supported. Further, for 29 of the 30 subjects with this score pattern, the discrepancy between the Spatial and Sequential scores was greater than one standard deviation, suggesting the three factor division of subtests may be more meaningful for these disabled learners than the original Verbal-Performance dichotomy of the Wechsler scale.

Four of five subjects with a discrete arithmetic disability presented with a predicted factor hierarchy of Conceptual-Spatial-Sequential.

While a low Sequential score has generally been discussed in terms of reading disability, the results of a canonical correlation of WRAT Reading and Arithmetic with the Sequential factor subtests of Arithmetic, Digit Span and Coding, together with step-wise multiple regressions, supported a hypothesis that WRAT Arithmetic has a unique relationship with the Sequential factor not attributable to WRAT Reading.

However, while WISC Arithmetic accounted for most of the variance shared by WRAT Arithmetic and the Sequential subtests, only 49% of the 82 subjects significantly impaired on the WRAT calculations were also impaired on the WISC verbal arithmetic problems. These findings suggest the category of arithmetic disability might meaningfully be subdivided in terms of specific pattern of arithmetic skill impairment, as well as in terms of concomitant achievement in spelling and reading.

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INTRODUCTION

The potential of information contained in the Wechsler Intelligence Scale for Children (Wechsler,1949,revised 1974) for understanding the cognitive abilities of disabled learners and for differential diagnosis, has received considerable attention in the literature on learning disabilities. In the current study some of the issues in this research area will be examined for a sample of disabled learners referred to a Neuropsychology Clinic.

Before reviewing studies focusing on the WISC profiles of disabled learners some pertinent conceptual and methodological issues in the wider literature on specific learning disabilities will be discussed briefly. These issues include the conceptual basis for differentiating learning disabilities from the broad category of academic learning problems and some methodological difficulties involved in the attempt to identify and investigate this population. Of direct relevance to this study is a growing awareness of a need to search for meaningful subtypes within the heterogeneous categories of learning, reading, and arithmetic disabilities. This study is designed to examine some potentially useful dimensions for subdivision of learning disabilities within the context of research with the WISC and its revised version, the WISC-R.

The initial goal wil be to determine what proportion of cases referred with a learning disability will present with an isolated deficit in either reading or arithmetic, rather than a more general disability affecting both academic areas. Also of interest is the spelling achievement of subjects presenting with normal reading but impaired arithmetic. As well, subgroups differentiated according to pattern of academic deficit will be compared in terms of neurological status. pp;The subgroups will be formed using local normative data for the Wide Range Achievement Test (Jastak and Jastak, 1946,1965,1976,1978) as criterion of achievement in reading, spelling and arithmetic.

In the second part of the study, the WISC performance of the various subgroups of disabled learners will be investigated. A WISC measure of particular interest is the recategorization of WISC subtest scores as suggested by Bannatyne (1971,1974) and Rugel (1974a,b). As well, research on the Verbal-Performance Scale discrepancies and on inter-subtest scatter will be discussed.

The second chapter will introduce the hypotheses for the current study. The third chapter will describe the methods of data collection and analysis, and present the results. The fourth chapter will present a discussion of the findings.

Review of the Literature

Selected Issues in Learning Disabilities

Definition.

It is evident that a significant proportion of children in literate cultures fail to attain age-appropriate academic skills. Factors commonly associated with difficulty in academic learning include mental retardation, gross neurological defects, severe emotional disturbance, cultural deprivation and inadequate opportunity to learn (Benton,1975,Critchley,1970). There remains a subpopulation of learning impaired children whose underachievement is not accounted for by any of these factors. Numerous clinical reports describe children of normal intelligence, with no primary psychopathology, intact sensory acuity and adequate environmental circumstances, who nonetheless are seriously and chronically impaired in learning one or more academic skills (see Critchley,1970,Money,1962, Rabinovitch,1968). Since the first case studies of otherwise unexplained specific learning disabilities, some form of cerebral anomaly has been postulated, either genetic in origin (e.g. Hinshelwood,1917)) or due to brain damage incurred in the perinatal period (e.g. Kawi and Pasamanick,1959). Adults with known cerebral pathology can be selectively impaired in acquired academic skills. By analogy, it has been argued that children with specific learning disabilities could have a selective abnormality of structure or function in an otherwise intact brain. For example, Dejerine had reported adult cases of reading impairment ("dyslexia") subsequent to lesions of the left angular gyrus (1891,cited in Heilman and Valenstein,1979). In 1896, Morgan (cited in Hinshelwood,1917) described a boy who excelled at arithmetic but was severely impaired in reading. Morgan speculated that the specific impairment resulted from a lag in the development of the left angular gyrus. While some children with a specific reading disability (or "developmental dyslexia") learn arithmetic normally, in other cases the learning impairment includes arithmetic. As well, there are reports of children who have severe and unexplained difficulty in learning arithmetic but read normally (e.g. Rourke,1978). Arguing from neuropathological evidence in adults with acquired arithmetic disability ("dyscalculia"), Guttman (1937) proposed that anomalies in cerebral structure or function are the underlying causes of specific arithmetic disability ("developmental dyscalculia") in children. The value of argument by analogy with acquired disabilities in adults is limited by our lack of corresponding pathological information for developmental disabilities, as well as a dearth of knowledge about the neuropsychological substrates of learning in the developing brain. However, clinical reports and research findings have continued to support the hypothesis that for some children a severe underachievement in one or more areas of learning reflects malfunctioning in information processing that is intrinsic to the child. The terms "learning disability/specific learning disability/ disabled learner" are commonly used interchangeably to refer to this hypothetical population. Only disabilities that involve reading or arithmetic are of concern in the present study.

While a neurological basis for specific learning disabilities has not been established, it remains a widely held premise. It has been assumed that children with constitutionally determined learning disabilities can and should be separated from the larger population of subnormal learners. Developmental dyscalculia and dyslexia, both implicity and explicitly, have been conceptualized as unitary syndromes, with unique characteristics. However there is a disconcerting lack of consensus on basic issues, including definition, operational criteria, valid diagnostic correlates, incidence, etiology, prognosis and appropriate remedial techniques.

In recent years a vast body of literature has appeared under the rubric of "learning disabilities" but as yet little order or integration has been achieved within the proliferation of clinical and research findings. A common approach in research directed towards identification of the cognitive and physiological correlates of developmental learning disorders has been to look for measures which could discriminate between a group of learning disabled and a group of normal children. Specific academic disabilities have been found to be positively correlated with subnormal performance on a wide variety of perceptual, linguistic, motor and cognitive tasks as well as with abnormal neurological, electrophysiological and biochemical findings (see Benton,1975,1978,Knights and Bakker,1976). Indeed, reading disability has been associated with almost every deficit of higher cognitive functioning found in children (Mattis,1978). However, the correlations are modest and many reported findings are contradictory or not replicable. No single sign, or group of signs, has been established as reliably pathognomonic for either isolated reading disability or disability involving both arithmetic and reading. The relatively rare studies of arithmetic disability without concomitant dyslexia also have not delineated a unique profile though various neuropsychological correlates have been reported (Ackerman,, Dykman and Peters,1976, Rourke and Finlayson,1978,Weinstein,1978).

Definitional problems underlie much of the confusion and inconsistency in this area. While numerous definitions of the "learning disabled" or "reading disabled" and, on occasion, "arithmetic disabled" child have been offered, they have failed to provide satisfactory descriptions of the characteristics of these children. In practice, identification of a child with a specific learning disability remains a somewhat arbitrary process.

A typical definition of specific reading disability, or developmental dyslexia, is that formulated by the World Federation of Neurology:

> A disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and socio-cultural opportunity. It is dependent upon fundamental cognitive disabilities which are frequently of constitutional origin (Critchley,1970.p.11).

A similar definition of specific arithmetic disability, or developmental dyscalculia, is offered by Kosc:

> Developmental dyscalculia is a structural disorder of mathematical abilities which has its origin in a genetic or congenital disorder of those parts of the brain that are the direct anatomico-physiological substrate of the maturation of mathematical abilities adequate to age, without a simultaneous disorder of general mental functions(1974,p.47).

Kosc distinguishes developmental dyscalculia from arithmetic disability due to inadequate instruction, emotional disturbance, or subnormal intelligence.

In the absence of valid behavioral or biological markers these definitions operate by default. Difficulty in learning to read or to do arithmetic is presumed to be of constitutional origin if nothing else will account for it. However, whatever genetic or congenital factors might underlie specific learning disabilities, it is unreasonable to expect that these factors would not be operative when instruction is unconventional, intelligence inadequate, or sociocultural circumstances inopportune.

There is considerable debate in the literature as to the usefulness and validity of the attempt to identify a group whose learning problems are of constitutional origin (see Critchley,1970,Guthrie,1978,Mattis,1978, Rutter,1978,Taylor, Satz and Friel,1980). Rutter (1978) argues that in practical terms the World Federation of Neurology's definition of dyslexia is nonoperative. He presents evidence from an epidemiological survey in England (Rutter and Yule,1975) that on statistical, medical and educational grounds it is valid to distinguish between children whose reading level is well below that expected for their chronological age, but consonant with their I.Q. level ("general reading backwardness") and children whose achievement is low after taking both age and I.Q. into account ("specific reading retardation"). He reports that specific reading retardation occurred at a rate higher than would be expected in a normal achievement distribution, forming a "hump" on the lower end of the distribution curve. There was a higher ratio of boys to girls (3.3 to 1) in the specific reading group compared to the general reading group (1.3 to 1). The general reading group was associated with overt, definite neurological disorders (11.4 percent) and with "dubious" neurological abnormalities (25.3 percent) on a wide range of motor, praxis, speech and other developmental functions. In contrast the specific reading group did not show an association with definite, or "hard" neurological signs and to a lesser degree (18.6 percent) with "dubious" or "soft" signs (i.e., which can be due to either structural defects in the brain or developmental delay). The specific reading retardation group showed an association to a marked degree only with abnormalities of speech and language development. Despite a higher mean IQ, at follow-up at age 14, the specific group had made significantly less progress than the backward group in reading and spelling and significantly more progress in arithmetic, though both groups were still seriously impaired in all three subjects. In both of the reading impaired groups, the familial incidence of reading difficulties and delayed acquisition of speech was about three times that of the control group.

While Rutter's classification of specific reading retardation is made on an arbitrary statistical basis, it is clearly meaningful in terms of prognosis as well as on clinical grounds. The high male and familial incidence, as well as abnormalities of language development, are characteristic of groups that can be identified as dyslexic according to the World Federation of Neurology's definition. However, unlike the latter definition, Rutter's statistical differentiation does not carry any implication of an underlying neuropathological condition. In Rutter's survey specific reading retardation appeared to be multifactorially determined, varying according to such factors as characteristics of the elementary schools the children attend, the area of the country they live in, family size, socioeconomic status and temperamental characteristics. Yule and Rutter (1976) suggest that specific reading retardation may result from a relative failure in maturation of certain specific functions, or some neurological damage, or a lack of suitable environmental stimulation, or all three, and that these factors interact with educational, motivational and family variables. They argue that it is not possible to separate out a dyslexic population as defined by the World Federation of Neurology and that there is no evidence for the validity of a unitary syndrome of dyslexia.

Operational Criteria.

One consequence, both resulting from and contributing to the lack of concordance on the definition of the learning/reading/arithmetic disabled child is that operational criteria for selection of "disabled learner" subjects vary markedly between researchers, depending on their concept of a learning disbility. Samples vary widely in composition along dimensions such as age range, IQ range, indicators of brain damage or primary emotional disturbance, socioeconomic status, sample source, and in both the pattern and severity of the academic handicaps. Little has been clarified about the role played by these factors in studies of learning disabilities. However, it is evident that failure to control or investigate the effects of potential sources of variance can obscure research findings and invalidate comparisons between studies.

As example, Spreen (1976) has discussed the role that source of subjects can play in studies of reading failure:

> It has been a persistent finding in many studies that populations referred to a reading clinic tend to show more significant results on a variety of measures, from EEG to cognitive performance, while on the other hand findings tend to be marginal or not replicable if the population is drawn directly from the classroom without referral, i.e., is based on reading achievement tests only (p.450).

He suggests we may be dealing with a more serious "pathological" group in the highly selected clinic populations. School selected samples are often chosen solely on the basis of a reading score that is low for the child's chronological or mental age. Careful screening for nonorganic potential etiological factors is not always possible or attempted in survey studies whereas children referred to a learning disabilities clinic are more likely to have been at least roughly screened and to have received some remedial instruction. Children referred at the tertiary level to the neurologist and neuropsychologist are even more likely to present with a specific learning disability that is severe, chronic and "unexpected" in terms of apparent level of intelligence, and to present with indicators of cerebral dysfunction and/or a familial incidence of learning disability.

A common omission in reports of sample composition is a specific description of the area of academic deficit. Subjects with general academic deficits or single area deficits may be referred to interchangeably. Samples reported as "learning disabled" generally include a high proportion of children whose academic handicap extends at least to reading, but can include a fairly heterogeneous assortment of impairments in areas such as grapho-motor and visual-perceptual skills, and even activity level and social behavior, as well as spelling and arithmetic. Similarly, many samples are reported as "reading disabled" or as "arithmetic disabled" but very few of these studies have demonstrated that these children have a clearly isolated arithmetic or reading disability. There appears to be considerable overlap in studies discussing a disability in either reading or arithmetic, since the subjects tend to be handicapped in both areas when this information is reported. It is likely that much of the discussion of specific arithmetic disability and of specific reading disability in the literature in fact derives from studies of children whose handicap encompasses both academic areas. It is not clear what proportion of the learning disabled population have single or dual deficits in arithmetic and reading.

Some clinicians have reported that cases presenting with a discrete disability in reading (e.g. Rabinovitch,1968) or in arithmetic (e.g. Cohn,1971,de Quiros,1978) are the exception amongst children referred with learning disabilities.

To clarify discussion, the term "arithmetic disability" will be used here only in reference to an isolated handicap in learning arithmetic in the presence of normal ability to learn reading. However, unless otherwise indicated the term "reading disability" will be used interchangeably for a handicap affecting reading in the presence of normal ability to learn arithmetic, or for a more general pattern of academic handicap extending to both reading and arithmetic.

<u>Search for Subtypes</u>.

There is growing recognition that a serious conceptual error in this research area has been the failure to expect heterogeneity of basic defect within the class of children whose learning handicaps are dependent upon fundamental cognitive disabilities. Traditionally, developmental dyslexia has been conceptualized as a unitary condition with a specific constitutional basis (e.g., Hinshelwood,1917, Orton,1937,Critchley,1970). In the literature on dyscalculia, a similar trend can be found (e.g.,Cohn,1971,Rourke and Finlayson,1978,Weinstein,1978). As well, the broader category of specific learning disabilities has been conceptualized by some writers as having a common basic deficit (e.g.,Smith,Coleman,Dokecki and Davis,1977). However, the assumption of homogeneity of basic defect can be faulted on several grounds. Such an assumption is based on the analogy drawn between acquired and developmental disabilities. However, neither dyslexia nor dyscalculia constitute unitary syndromes even in brain-injured adults. In the adult brain the processes of reading and arithmetic can be disrupted by lesions at various loci and in qualitatively different ways (see Heilman and Valenstein,1979). For the young child it is reasonable to predict the ability to acquire these complex and multifaceted skills would be vulnerable to disruption by more than one form of functional or structural cerebral anomaly. Further, the unity of the skills subsumed under reading or arithmetic is questionable. Kosc (1974) reports that arithmetic skills develop unevenly in the normal child, and are not uniformly impaired in children considered to have a significant disability in some aspects of arithmetic. Gibson (1968) found various reading skills highly correlated in children who read normally, but not in disabled readers. Within the category of reading disability, available evidence on the role of a genetic factor in the etiology of some cases suggests that more than one mode of transmission is involved (Owen,1978). To summarize, it seems unlikely that constitutionally based reading or arithmetic disabilities would be homogeneous in etiology or in expression.

Commenting on the failure to find reliable correlates of specific reading disability, Applebee (1971) argues that the assumption of homogeneity of basic deficit has led to the use of research designs with mathematical models that are insensitive to complex data structure. Underlying heterogeneity of data will be obscured when analyzed with mathematical techniques appropriate to comparisons between homogeneous groups. The existence of subtypes within the categories of developmental dyslexia and dyscalculia would explain much of the contradictory results in this area. Studies using small samples might by chance find a difference between the learning disabled and control groups which is not obtained on replication. Large samples might be more consistent in showing statistically significant group differences but the overlap between controls and heterogeneous disabled learners would be considerable. Further, when characteristics of subtypes are averaged for group comparisons their true patterns of deficit would be obscured. Thus, it could be predicted that mean profiles of large groups of learning disabled children would not be characteristic of individual subjects.

In fact, there is considerable clinical evidence of heterogeneity within the categories of reading and arithmetic disability along several dimensions. It is possible that this heterogeneity is best viewed as quantitative variations along a multifactorial continuum.

That is, constitutionally based learning problems may not be behaviorally discrete from other learning problems. Alternatively, within this diversity there may be meaningful subtypes of specific learning disorders, with qualitatively different basic deficits and correlates and possibly with different prognoses and responses to intervention.

On the basis of clinical impressions, researchers have explored different approaches to subdivide specific learning/reading disabilities. Samples have been differentiated on a wide range of variables including linguistic and cognitive measures, visual information processing ability, patterns of reading and spelling errors, indicators of neurological dysfunction, familial incidence, response to remediation, and prognosis (e.g. Boder,1971,Denckla,1972, Kinsbourne and Warrington,1963,Mattis,French and Rapin,1975,Pirozzolo,1979). Some examples from the literature on the search for homogeneous subtypes will be given to provide background of specific interest to the present study, including research on cognitive variables, neurological status and pattern of academic deficit.

There is some evidence that the nature and number of the subgroups found in a sample will vary with the criterion variables used. As example, for reading disability samples, subgroups formed according to cognitive correlates commonly include a relatively large group with impaired performance on auditory-verbal measures, and a second group impaired on visual-spatial measures. Often a third group is reported with processing dysfunctions in both areas.

Denckla (1972) reports that only 30% of a consecutive series of 190 clinic-referred disabled learners could be differentiated into three "pure" syndromes, while the other 70% had a mixture of symptoms. Denckla used a broad range of measures, including a classical neurological exam, a gross motor test, a fine motor test, measures of language, visuo-spatial, perceptual and memory functions, as well as observation of specifics of behavior, strategy and control.

However, Mattis (1978) argues that many correlates of developmental dyslexia reported in the literature are incidental manifestations of central nervous system dysfunction. The most impressive attempt to identify independent syndromes using cognitive correlates (Mattis,French and Rapin,1975) is unique in the use of a contrast group of brain-damaged children who could read normally. In his 1975 study (Mattis et al.) deficits observed in the brain-damaged readers were considered irrelevant as causal factors of dyslexia. Dyslexic subjects were selected from a sample of children referred to a neuropsychology clinic. They had normal IQ, hearing and vision, and adequate opportunity to learn, and were screened for psychosis. Using only neuropsychological variables not impaired in the control group of brain-damaged readers 90 % of the 82 dyslexics could be placed into three distinct subgroups. The largest subgroup had a language disorder, the second, articulatory and graphomotor discoordination and the third, and smallest, a visualspatial perceptual disorder. The subgroups were found to be stable over time and to have distinct implications for remedial teaching (Mattis,1980). In a cross-validation study (Erenberg,Mattis and French,unpub.,cited in Mattis,1978) the three subtypes accounted for 77% of 163 dyslexics with a further 9% presenting with deficits characteristic of two of the original subgroups. Denckla (1977) also replicated the three subgroups with a clinic sample, as well as reporting a fourth subgroup with a sequencing disorder.

The dimension of neurological status has been used in the search for subtypes. Some caution is necessary in interpreting findings for this factor. The distinction between presence and absence of brain damage or dysfunction is not always clearcut since neurological impairment exists on a continuum from gross to barely detectable to normal. While some neurological indicators are considered "hard" or unequivocal signs of brain damage, other indicators are considered "soft" or equivocal signs of brain damage, and there is disagreement on the interpretation of the soft signs. Further, the absence of hard or soft signs does not establish the absence of cerebral abnormality of structure or function.

While clinic-referred samples in the reading disabilities literature are not generally differentiated according to presence or absence of neurological indicators, several clinicians have argued that children whose reading handicaps are a not unexpected correlate of known brain damage do not belong to the population of "specific reading disability" which has traditionally been conceptualized as primary, or not attributable to any known brain damage. At the same time, soft neurological signs have been strongly associated with cases considered to fall in the "specific reading disability" category, and many clinicians assume an underlying dysfunction in some aspect of cerebral processes (see Critchley,1970,Shankweiler,1964, Rabinovitch,1964).

When the dimension of neurological status was used to differentiate the dyslexic sample in the Mattis et al. study (1975) no difference was found between the 53 brain-damaged and 29 non- brain-damaged dyslexics in terms of critical cognitive deficits. This finding of no difference was replicated by Erenberg et al. (1976).

Ackerman, Peters, and Dykman (1971) also found no significant differences between subgroups with positive, equivocal or negative indicators of brain damage in a learning disabled sample, when the subgroups were compared in terms of cognitive abilities as measured by the WISC.

However the Ackerman et al. (1971) findings are weakened by the use of a sample heterogeneous in terms of academic deficit as well as by unreliable statistical procedures, using small subgroups.

Ingram, Mason and Blackburn (1970) suggest neurological status may be a significant dimension of subtype differences when disabled readers are first subgrouped according to pattern of academic deficit. They report 20 out of 82 clinic-referred disabled readers with a concomitant arithmetic disability had a significantly higher incidence of indicators of brain damage than did the 62 out of 82 with an isolated reading handicap and normal arithmetic skills. The single deficit subgroup also had a higher incidence of auditory-phonic synthesis errors when reading than did the dual deficit group.

In contrast to Ingram's findings, Rabinovitch (1968) reports that almost all clinic-referred disabled readers are impaired on arithmetic whether or not either soft or hard indicators of brain damage are present. The discrepancy in findings between the two studies may reflect sampling bias since many of Ingram's patients were initially referred to a speech clinic. While reading disability has often been associated with mild dysfunction in some aspect of language processing, reading problems seen with clinically evident developmental language disorders may not be representative of the specific reading population.

Rourke and his colleagues (Rourke, and Finlayson,1978,Rourke and Strang,1978) also differentiated clinic-referred disabled subjects according to patterns of academic deficit but found no significant differences between 15 dyslexics with normal arithmetic and 15 dyslexics with impaired arithmetic on a wide range of neuropsychological variables, including the WISC. However they did report significant differences between the two dyslexic subgroups and a subgroup with a specific arithmetic disability. Differences were obtained on measure of verbal, auditory- perceptual, visual-perceptual,psychomotor and tactile- perceptual skills.

Little attention has been given in the literature to the possibility of meaningful subtypes within the category of specific arithmetic disability. However, correlates reported for arithmetic disability have been somewhat inconsistent between studies, suggesting the possibilty of underlying homogeneous subgroups. As example, performance on the Wechsler Intelligence Scale for Children (1949) has been used as a measure of the cognitive correlates of arithmetic disability in several studies (Ackerman,Dykman and Peters,1976,Denckla,1972,Rourke and Finlayson,1978,Spellacy and Peter,1978) with conflicting results. WISC patterns common to some samples were not found for others.

While reading disability is almost invariably associated with some degree of underachievement in spelling, reports of samples with normal reading and a significant disability in arithmetic are discrepant with regard to level of achievement in spelling. Spelling ability may also be a useful factor to investigate for arithmetic disability. Both cognitive correlates and academic deficit patterns will be discussed further below, in the section on research with the WISC.

Another dimension which may be useful in the search for meaningful subgroups of arithmetic disability is the specific aspects of arithmetic skills that are impaired. Kosc (1974) reported that children identifiable as developmental dyscalculics are not uniformly impaired in all facets of arithmetic, and may even achieve normally in some areas of arithmetic. His dyscalculic sample was heterogeneous for impairment in reading. Support for Kosc's claim was reported by Weinstein (1978) for a school-selected sample with a specific arithmetic disability, and normal ability to read.

At present there is no basis for determining how many types might meaningfully be delineated within specific reading and arithmetic disabilities. It is probable that the various dimensions presently being used to form subgroups will be found to interact in complex ways with each other and with still other variables, including environmental factors. Though commonalities seem to exist between subtypes reported in the literature, this selective review of efforts to form subtypes indicates that there is also a great deal of inconsistency. A methodological weakness common to most studies of clinic- referred disabled learners is small subgroup size. Further work is needed to establish reliability and clinical validity of subtypes.

WISC Profiles of Disabled Learners

A number of researchers in specific learning disabilities have investigated the potential of the Wechsler Intelligence Scale for Children (1949,WISC;1974,WISC-R) for understanding the cognitive strengths and weaknesses of disabled learners, and as an aid to differential diagnosis. Most of these studies are concerned with samples characterized as reading disabled. Recently there have also been reports on the WISC profiles of children with specific arithmetic disability (Ackerman, Dykman and Peters,1976,Rourke and Finlayson,1978,Rourke, Young and Flewelling,1971). Different profiles of performance on the Wechsler Intelligence Scale have been associated with specific patterns of academic underachievement, as well as with performance on other neuropsychological variables. It has been suggested that these associations have implications for differential diagnosis, for formulation of appropriate remedial intervention, and even for determining hemispheric laterality of presumed cerebral dysfunction. However, as in other areas of the specific learning disabilities literature, findings have been inconsistent. Failure to expect heterogeneity of basic defect, and to control for possible sources of heterogeneity, has been a weakness of many studies focusing on the Wechsler Scale. Also, Kaufman (1976,1979) has argued that many researchers seem unaware of the psychometric properties of the test, and of what constitutes clinically abnormal performance on the WISC/WISC-R.

Of the available measures of children's cognitive abilities, the Wechsler Intelligence Scale for Children is the most widely used, in both clinical and research settings. The popularity of this assessment instrument derives from its sound psychometric properties, and from the valuable quantitative and qualitative data which it can provide. The WISC, and subsequently its revised form, the WISC-R, have been subject to more rigorous empirical investigation than any other psychometric instrument used with children. The WISC is intended to measure both verbal and nonverbal aspects of intelligence, and yields both a "Verbal" and "Performance" quotient, as well as a "Full Scale" intelligence quotient. This test is further subdivided into 12 subtests. The six Verbal Scale subtests are Information, Comprehension, Similarities, Arithmetic, Vocabulary and Digit Span. Digit Span is optional but is generally administered in studies of learning disabilities. The six Performance Scale subtests are Picture Completion, Picture Arrangement, Block Design, Object Assembly, Coding and Mazes. The Mazes subtest is rarely administered.

Verbal-Performance Scale Discrepancies.

Initial research interest focused on discrepancies between scores on the Verbal and Performance subscales. Investigators have been concerned with both the direction and the magnitude of the Verbal-Performance (VIQ-PIQ) discrepancy. It is evident from clinical and research findings that, for many individuals, comparison of the Verbal Intelligence Quotient (VIQ) and the Performance Intelligence Quotient (PIQ), gives a more meaningful estimate of cognitive functioning than would be gained from the Full Scale Intelligence Quotient (FSIQ) which is derived from the sum of the two subscale scores.

Numerous studies have reported reading disability and learning disability samples to be characterized by a PIQ greater than the VIQ. Though various interpretations can be found in the literature, this pattern has generally been considered to reflect a deficit in some aspect of language processing and/or a strength in dealing with visual-spatial material. While most research on VIQ-PIQ discrepancies has been concerned with reading disabled, or with less clearly defined learning disabled, samples, Rourke and his colleagues (Rourke and Finlayson,1978,Rourke,Young and Flewelling,1971) have investigated the VIQ-PIQ patterns of clinic- referred children with a specific arithmetic disability, as well as children impaired in both reading and arithmetic.

From a clinic-referred learning disabled population, Rourke, Young and Flewelling (1971) selected three subgroups, each with 30 subjects, based on the direction and magnitude of the VIQ-PIQ discrepancy. They found that the subgroup with PIQ greater than VIQ by at least 10 points, and the subgroup with a PIQ approximately equal to a VIQ (within 4 points), both had uniformly low scores on the Reading, Spelling and Arithmetic subtests of the WRAT. In contrast, a third subgroup with a VIQ greater than the PIQ by at least 10 points was characterized by an impaired group mean score on Arithmetic, but normal Reading and Spelling scores. It is not reported how many individuals conform to their subgroup pattern of performance in academic achievement.

Support for the Rourke, Young and Flewelling (1971) findings was obtained by Rourke and Finlayson (1978). In the latter study, three subgroups, each with 15 subjects, were selected according to patterns of academic deficit, and could then be differentiated according to the magnitude and direction of VIQ-PIQ discrepancies. A subgroup with uniformly low (WRAT) Reading, Spelling and Arithmetic, and a second with Reading and Spelling substantially lower than Arithmetic, were both characterized by a PIQ greater than the VIQ. For 29 of the 30 subjects, the PIQ was greater than the VIQ, while one subject had a PIQ equal to the VIQ. In contrast, in a third group with impaired Arithmetic but normal Reading and Spelling scores, all 15 subjects had a VIQ greater than the PIQ.

In both studies, the correspondences found between pattern of academic deficit and patterns of VIQ-PIQ discrepancy were consistent with subgroup performance on other neuropsychological variables. That is, relatively low performance on the auditory-verbal tasks of the Verbal scale correlated with poor performance on other measures of verbal and auditory-perceptual abilities, for the subgroups disabled in reading. Conversely, the subgroups with an isolated arithmetic disability were relatively low, both on the visual-spatial-motor tasks of the WISC Performance scale, and on other measures of these abilities. Rourke and Finlayson (1978) suggest that their results are consistent with a hypothesis (Rourke and Telegdy,1971) that WISC VIQ-PIQ discrepancies may reflect the differential integrity of the two cerebral hemispheres in older children (ages 9 to 14) with specific learning disabilities. They further argue that children with a specific arithmetic disability on the

WRAT have a relatively dysfunctional right hemisphere while children with a handicap affecting either reading and spelling; or reading, spelling and arithmetic, have a relatively dysfunctional left hemisphere. Some weaknesses with this line of argument will be raised below, in a discussion of a study by Rourke and Telegdy (1971). Inferences about cerebral integrity aside, the results of the Rourke and Finlayson (1978) study do suggest a strong correspondence between subtypes of academic deficit and the pattern of VIQ-PIQ discrepancy. However, their findings have not been consistently supported by other investigators.

Results from two other studies, also using WRAT scores as criteria of disability, do not consistently support a pattern of high VIQ, low PIQ as characteristic of specific arithmetic disability. Spellacy and Peter (1978) found three of seven clinic-referred children with arithmetic disabilities had PIQ greater than VIQ. A difference in subtest selection may explain their contradictory findings since Rourke and Finlayson (1978) used prorated subscale scores, omitting the Arithmetic and Comprehension subtests from the Verbal subscale, and the Digit Span subtest from the Performance subscale. Spellacy and Peter (1978) do not report prorating subscale scores.

A study by Ackerman, Dykman and Peter (1976) also failed to confirm the Rourke and Finlayson (1978) findings for a group with an isolated arithmetic disability. While figures for individual subjects are not given, a graph of the mean subtest score profile for nine arithmetic disabled children indicates a relatively flat WISC profile whether all eleven subtests are considered or only the eight used by Rourke and Finlayson. However, Ackerman's specific arithmetic group had a significantly lower mean FSIQ than Rourke's. Also, the 9 subjects in Ackerman's group are somewhat atypical disabled learners since 5 of the 9 were achieving normally in grade school.

However, results obtained for a second subgroup in the Ackerman, Dykman and Peter (1976) study provide some support for the Rourke and Finlayson finding. A subgroup that was impaired in written spelling as well as arithmetic presented with a mean profile on a graph of WISC subtest scores that was similar to the profile reported for Rourke and Telegdy's (1978) sample of arithmetic disability with normal spelling ability.

Further support for the WISC VIQ-PIQ pattern reported by Rourke and his colleagues, and also for a spatial deficit in children with developmental arithmetic disability is reported by Denckla (1977). In searching for discrete subgroups within a clinic-referred disabled learner sample she found a subgroup impaired on measures of visual-spatial skills including a uniformly low WISC PIQ, relative to the

VIQ. All children in this subgroup had an arithmetic disability. Oral spelling skills and reading were normal, but the subjects were impaired in written spelling.

Patterns of VIQ-PIQ discrepancies found for reading disabled samples have also been inconsistent. While a pattern of high PIQ, low VIQ characterizes a number of groups, other studies have not found this pattern. In 23 studies of disabled readers reviewed by Huelsman (1970), 12 of the 23 had reported a PIQ greater than the VIQ. In his own study of a school-selected sample, Huelsman (1970) found 62 of 101 disabled readers had a PIQ greater than the VIQ by one or more points. Looking at discrepancies of 15 or more points ($p<0.01$), 23 out of 101 subjects had a significantly high PIQ, and 21 a significantly high VIQ. Huelsman suggested looking for subtypes of disabled readers, with high VIQ, high PIQ, or approximately equal subscale IQ's.

Many of the studies reviewed by Huelsman (1970), as well as Huelsman's own study, suffer methodologically from such problems as small sample size, lack of, or inappropriate, control groups, and poor sampling procedures. It is often not clear whether adverse sensory, neurological, emotional or socioeconomic factors, or mental retardation were excluded; what degree of reading retardation is involved; or whether the disability extended to arithmetic.

A methodologically more satisfactory study done by Lyle and Goyen (1969) found VIQ-PIQ discrepancies were about equally distributed in either direction for a group disabled in reading and arithmetic, and for a control group of normal learners. Compared to the distribution for the WISC standardization population, the frequency of VIQ-PIQ discrepancies of abnormal magnitude was low for the disabled learner sample. Lyle and Goyen (1969) argue that the direction of the discrepancy between Verbal and Performance subscale scores is not a very sensitive index for disabled readers since the majority of their disabled subjects scatter below the normative mean standard score on subtests from both the Verbal and the Performance scales. They conclude their sample does not contain two syndromes of reading retardation, based on significant VIQ-PIQ discrepancies.

While no subgroups were evident in Lyle and Goyen's school-selected sample other investigators, using clinic-referred disabled readers, report that significant VIQ-PIQ differences can be used as a criterion to form meaningful subgroups. Kinsbourne and Warrington (1963) selected two groups of disabled readers with VIQ-PIQ discrepancies greater than 20 points. The highly significant discrepancies were in favour of the PIQ for Group 1, and the VIQ for Group 2. The direction of the VIQ-PIQ discrepancies was consistent with other neuropsychological measures, suggesting Group 1 had some form of linguistic deficit while Group 2 had a deficit in sequential ordering. All seven subjects in Group 2 had difficulty in mechanical arithmetic, while only two out of five in Group 2 showed this form of arithmetic impairment. Kinsbourne and Warrington suggest that the two groups represent syndromes of cerebral deficit, but consider that they probably represent only a minority within the population of retarded readers. A factor that obscures interpretation of their findings is a considerable difference in general level of intelligence for the two groups, evident from a table of VIQ and PIQ scores. That is, the neuropsychological deficits found for Group 2 may be a result of low intelligence and not have a causal relationship with reading impairment.

In a clinic-referred sample of 108 disabled readers Warrington (1967) investigated the frequency of these highly significant VIQ-PIQ differences relative to the distribution of VIQ-PIQ differences in the WISC standardization (Seashore, 1951). The disabled reader group had an excess of significantly low VIQs compared to the normative population (32% versus 5%) but a comparable number of low PIQs (6% versus 5%). Of the 24 disabled readers with a significantly low VIQ, 46% had a history of slow speech development, compared with 19% of the remainder of the sample.

From a clinic population of boys, ages 9 to 14, Rourke and Telegdy (1971) formed three subgroups of disabled learners, each with 15 subjects. Magnitude and direction of VIQ-PIQ discrepancy were the criteria for subgroup selection. The types of learning disabilities involved are not specified. Comparison of the subgroups on 25 measures of motor and psychomotor skills shows a consistent trend for the subgroup with high PIQ (PIQ at least 10 points higher than VIQ,) to perform better than the high VIQ group . The number of subjects that conform to this trend is not reported. Rourke and Telegdy (1971) interpret their results as supporting the hypothesis that VIQ-PIQ discrepancies reflect the relative integrity of the cerebral hemispheres. That is, a VIQ-PIQ discrepancy of 10 or more points in favour of the Verbal subscale would reflect integrity of the left cerebral hemisphere and dysfunction of the right hemisphere while a comparable discrepancy in favour of the Performance scale would reflect the reverse pattern. This conclusion can be faulted on methodological and theoretical grounds. Statistical comparisons in the Rourke and Telegdy (1971) study were inappropriate and did not protect the alpha level. The findings were not replicated by Wener and Templer (1976) or by Rourke, Dietrich and Young (1973) using a younger learning disabled sample. Moreover, it has not been established that the 25 neuropsychological measures used in the Rourke and Telegdy (1971) study are valid measures of the differential integrity of the cerebral hemispheres.

The hypothesis that the Verbal and Performance subscales correspond in a one to one fashion to left and right hemispheric functioning has not been supported by studies of children with known brain damage (see Boll,1981,Kaufman.1979). Further, VIQ-PIQ discrepancies that are statistically significant are not necessarily abnormal relative to the WISC and WISC-R standardization populations. As example, one in three (33%) children had a discrepancy of at least 10 points ($p<0.15$) which is the minimum criteria used by Rourke and his colleagues (Rourke and Finlayson,1978,Rourke and Telegdy,1971). One in four (25%) had a discrepancy of at least 15 points ($p<0.01$), which is the criterion used by Huelsman (1971).

Discrepancies of the magnitude used by Kinsbourne and Warrington (1963) can reasonably be considered abnormal since less than 14% of the normative sample had comparable VIQ-PIQ discrepancies (Seashore,1951,Kaufman,1976b).

The issue of statistical significance versus the frequency with which sizeable VIQ-PIQ discrepancies occur in the normal population has not been adequately investigated in studies of disabled learners. It is common clinical practice to consider a difference between the Verbal and Performance IQ scores that is statistically significant, to be a diagnostic indicator of a learning disability (see Kaufman,1976b). However, while a difference that is statistically significant may reflect a clinically important difference in the abilities measured by the Verbal and the Performance Scales, a statistically significant difference is not necessarily abnormal. It has not been demonstrated that abnormally large VIQ-PIQ discrepancies are characteristic of disabled learners. This issue was addressed by Lyle and Goyen (1969), as discussed above, and also by Anderson, Kaufman and Kaufman (1976). They report the mean VIQ-PIQ discrepancy for 41 heterogeneous disabled learners was significantly higher than the mean of the WISC/WISC-R standardization populations, but note considerable overlap in the distributions of the two samples. However the mean WISC-R IQ of this sample was 84, which is approximately one standard deviation below the normative population mean IQ, and it is possible that the learning handicaps of some subjects in the sample could be attributed to a low level of general intelligence. Results for this sample may not be representative of the children with learning handicaps not attributable to low intelligence. Further research is needed to determine whether learning disabilitiy populations or subgroups are characterized by abnormal distributions of VIQ-PIQ discrepancies.

To summarize the discussion of VIQ-PIQ discrepancies, the few studies of specific arithmetic ability have been inconsistent, but suggest a low PIQ is strongly associated with impairment in mechanical arithmetic. Neither learning disabled nor reading disabled samples have been consistently characterized by a low VIQ, high PIQ pattern. Highly significant VIQ-PIQ disrepancies in favour of the PIQ may be a meaningful correlate for a small subsection of the reading disabled population with a developmental language disorder (Kinsbourne and Warrington,1963,Warrington,1967). However, other studies suggest the frequency of abnormally large VIQ-PIQ discrepancies in disabled learner samples may not typically exceed that of the normal standardization population. Further, it must be concluded that the hypothesis that VIQ-PIQ discrepancies in learning disabled populations are diagnostic of differential hemispheric integrity is not tenable.

Subtest Scatter.

A number of researchers have questioned the usefulness of the Verbal/Performance dichotomy for interpreting the WISC/WISC-R profile of disabled learners. Kaufman (1979) notes that significant scatter of subtest scores within a scale may invalidate a VIQ-PIQ discrepancy. That is, a VIQ or PIQ score may mask the underlying pattern of cognitive strengths and weaknesses. He gives an example of a child with equivalent VIQ and PIQ scores suggesting comparable verbal and nonverbal scores. In this case, a single high score on Arithmetic elevated the VIQ, masking low scores on the other Verbal Scale subtests, while a single low score in Coding falsely lowered the PIQ, masking relatively good nonverbal spatial skills.

Considerable subtest scatter is often considered a significant correlate of learning disabilities (see Kaufman,1976a, MacIntyre,Keeton and Agard,1980,Sattler,1974,Waugh and Bush,1971). However, these claims appear to have been made without reference to the ranges for subtest scores found in the standardization populations. Anderson, Kaufman and Kaufman (1976) found that the scaled score ranges for 41 disabled learners did not differ significantly from the normative values. Again, interpretation of results are obscured by the sample characteristics, as discussed above.

An attempt has been made to identify a profile of subtest scores characteristic of disabled readers and, in some studies, of disabled learner groups. There is some evidence that the WISC subtest score profile for disabled learners is stable over time, and across age groups,levels of IQ and socioeconomic status.

Smith and his colleagues found that the mean subtest score profile for disabled learners was highly stable (pearson r=.94) over a seven month interval (Smith,1978), and independent of socioeconomic level (Zingale and Smith,1978). The majority of subjects in the two studies were impaired in reading (personal communication,Smith) though the sample was heterogeneous in pattern of academic deficit. Coleman and Rasof (1963) examined the WISC subtest standard score profile for a clinic-referred sample of reading disabled children and found the pattern did not vary with age or IQ level.

ACID (Arithmetic,Coding,Information,Digit Span) is an acronym for the four WISC subtests most frequently reported as low for disabled readers. Huelsman (1970) analyzed the rank ordering of mean subtest scores for 20 studies and found a consistent trend for disabled readers, with 100% of the groups low on the Arithmetic subtest, 95% low on Coding and 80% low on Information. Weaker trends were seen for two other subtests, with 60% of the groups low on Digit Span and 50 % high on Picture Completion. Little attention has been paid to the high Picture Completion scores but there has been much interest in the four low subtests, or ACID pattern . With his own school selected sample of 101 disabled readers, Huelsman (1970) found a greater trend towards low scores on the Information, Arithmetic and Coding subtests for the reading disabled than for the control group, using a criterion of three points (one standard deviation) below a subject's own mean. However the group trend was not applicable to individual disabled readers in his sample. Not one of the 101 disabled readers was low on all three subtests, only six subjects were low on two subtests and 64 were not significantly low on even one subtest.

In contrast to Huelsman's findings with a school selected sample, Stevenson (1980), using the WISC-R, found 65% of a clinic-referred sample of disabled learners had their lowest subtest scores in Arithmetic, Coding and Information. Stevenson did not have a control group and did not report the pattern or severity of academic deficit for her sample. Differences in criteria for "low" subtest standard scores may account for the striking differences between Huelsman's (1970) and Stevenson's (1980) results since the former's criteria were more stringent than the latter's. A second factor may be the sampling procedures used. Huelsman's sample was not referred, or screened for emotional disturbance or adverse socioeconomic influences or inadequate opportunity to learn, but was selected on the basis of achievement test scores only.

Recategorized Subtest Scores.

Several writers have cautioned against interpreting scores on single subtests as reflecting a particular strength or weakness. A strong clinical tradition exists that specific meanings can be assigned to these individual scores on Wechsler Intelligence tests. However, for most WISC subtests, variance unique to the subtest is low, never exceeding a third of the total variance. Subtest specificity is somewhat improved for the revised WISC-R but for both versions of the test, common, or shared variance usually exceeds unique variance (Cohen,1959,Sattler,1974). Kaufman argues that it is more appropriate to "search for shared hypotheses to explain significant strengths and weaknesses before settling for highly specific hypotheses (p. 13,1979b)."

In an effort to reduce measurement error and obtain more stable patterns of cognitive strengths and weaknesses a number of investigators have recategorized the subtest scores. Tests thought to have significant common variance have been grouped to yield "factor" or "category" scores. Some justification for the regrouping of subtest scores has come from factor analytic research with WISC/WISC-R normative data and with reading disabled samples, as well as from clinical observations.

While results differed somewhat according to the factoring technique used, Wechsler's original dichotomy of the scale along a verbal/nonverbal dimension has been supported by factor analytic research based on the WISC and WISC-R standardization populations. Silverstein (1969) concluded that only a verbal and performance factor were present for the WISC, corresponding to the original Verbal and Performance subscales, but other analyses suggest that three factors may be required to adequately describe the test structure of the WISC and the WISC-R. Investigators finding three factors in the data structure report a "verbal" and a "spatial-performance" factor as the first two factors extracted. The third factor had high loadings by the Arithmetic and Coding subtests at some ages and by Coding at all ages for the WISC (Cohen,1949) and by Arithmetic, Coding and Digit Span for the WISC-R (Kaufman,1979). While the first two factors have always been interpreted in cognitive terms, the third factor has been viewed in both behavioral and cognitive terms. Cohen (1949) suggests the third factor reflects the behavioral attribute of distractibility. However, while the subtests of Arithmetic, Digit Span and Coding are known to be vulnerable to distractibility or anxiety, it is also clear that a child must do more than pay close attention to do well on the tasks. Interpretations of the cognitive skills measured by the third factor include sequencing ability, short-term memory, symbolic processing and numerical ability (Kaufman,1979).

Based on clinical work with dyslexic children, Bannatyne (1971) suggested a recategorization of the WISC subtests that is roughly parallel to the three factor solutions found for the WISC/WISC-R standardization populations.

Bannatyne's category scores involve only nine of the 12 subtests. Subtests in his Conceptual category (Vocabulary,Similarities, Comprehension) require verbal skills. The Spatial category subtests (Picture Completion, Block Design,Object Assembly) involve visual-perceptual skills and the manipulation of objects in space. His Sequencing category originally included Picture Arrangement, Coding and Digit Span (Bannatyne 1971). Bannatyne claimed this recategorization of subtest scores was diagnostically useful in differentiating reading disability of genetic etiology from other types of reading disability. He found that children classified as genetic dyslexics had their highest scores on the Spatial category, intermediate in the Conceptual category and lowest in the Sequential category.

Rugel (1974b) reviewed data from 22 samples of disabled readers, and found the pattern of high Spatial and low Sequential category scores predominant. The eleven normal control groups available for comparison were not characterized by this hierarchy of category scores, though eight of the eleven control groups had their lowest score in the Sequential category. Rugel notes that the 22 samples reviewed are probably heterogeneous with respect to etiological factors including genetic influences, minimal cerebral dysfunction, emotional disturbance and cultural deprivation. He suggests that the category score hierarchy may characterize not only genetic dyslexics, but also impaired readers of any etiology.

It is possible that, within the heterogeneous population reviewed by Rugel (1974b), there is a subtype characterized by the Spatial-Conceptual-Sequential hierarchy of scores or alternatively, that more than one subtype is hidden within the data and finally, that no homogeneous subtype exists.

While the factor analytic research discussed above had been done with normal populations, Rugel (1974a) factor analyzed the WISC subtest scores from two samples of disabled readers. Together with the findings from his review study (1974b), Rugel's factor analyses support a three factor recategorization of subtests. However, Rugel's findings (1974a,b) indicated that the Picture Arrangement subtest was misplaced in the Sequential category proposed by Bannatyne (1968,1971) since it did not load with Coding or Digit Span in the factor analyses and was not significantly lower for disabled readers than for the normal reader groups. In Rugel's (1974a) factor analytic study, the Arithmetic, Coding and Digit Span subtests had their highest loadings on the third factor extracted for a clinic-referred sample of disabled readers. However, for the second sample of school-selected disabled readers, Digit Span did not load with Coding and Arithmetic. Rugel's findings led Bannatyne (1974) to replace Picture Arrangement with the Arithmetic subtest. The revised Sequential category includes the Arithmetic, Coding and Digit Span subtests.

Support for Bannatyne's hierarchy was reported by Smith, Coleman, Dokecki and Davis (1977) for a sample consisting of all children enrolled in 23 learning disabilities classrooms of a major metropolitan city. Bannatyne's predicted order of Spatial greater than Conceptual greater than Sequential category scores was manifest for the total sample as well as for both "high" IQ (n=132) and "low" IQ (n=76) subgroups, but not for a subset of the low IQ group labeled Educable Mentally Retarded. Altogether 43% of the total sample obtained the predicted category score pattern, while the proportion expected by chance occurrence was 17%. An unpublished analysis (personal communication, Smith), using only those children who obtained a Spatial-Conceptual-Sequential profile, produced a significant correlation between the Spatial-Sequential score discrepancy and the estimated degree of reading ability. Smith et al. (1977) suggest school-verified disabled learners are characterized by the same pattern of abilities that Bannatyne (1971) reported for genetic dyslexics and that Rugel (1974b) reported for the broad class of children with reading impairment. However several problems obscure interpretation of the findings. First, a control group of normal learners was not available for comparison. Second, while a majority of the subjects could be described as reading disabled the sample was highly heterogeneous in patterns of academic deficit (personal communication, Smith) and demographic characteristics were not adequately reported. It is unclear whether the 43% of subjects with a Spatial- Conceptual-Sequential profile are homogeneous or heterogeneous with respect to pattern of academic deficit, age, IQ or potential etiological factors. Further, since 57% of the sample did not manifest the predicted profile, it is inappropriate to conclude that the population of children in learning disability classrooms is characterized by the Spatial-Conceptual-Sequential hierarchy. A third issue is the composition of the Sequential category. As suggested by Bannatyne (1974), Arithmetic has replaced Picture Arrangement. However Digit Span was omitted by Smith et al. (1977). Thus where Rugel (1974b) reported support for Bannatyne's recategorization of subtest scores and the Spatial-Conceptual-Sequency hierarchy using the mean of the Picture Arrangement, Digit Span and Coding subtests for the Sequential category score, Smith et al. reported similar results using the mean of Arithmetic and Coding. Thus the Sequential category had only one subtest in common for the two studies.

Fuller and Friedrich (1974) established reading disability subgroups based on Rabinovitch's (1968) categories of reading disorders of Primary (genetic), Secondary (emotional disturbance,adverse socioeconomic influences) and Organic (brain damage) etiology. The three subgroups were compared using Bannatyne's (1974) revised category scores. None of the subgroups were characterized by the hierarchy of high Spatial, intermediate Conceptual and low Sequential category scores. Individual profiles within the subgroups were not reported. Fuller and Friedrich's results must be viewed with caution since their criteria for sample selection were not reported and the procedure used for assigning subjects to subgroups is highly questionable. Performance on the Minnesota Percepto-Diagnostic Test was used to infer etiology of reading disability. While subgroups formed on this basis may have differed on the visual-motor skills measured by the MPD it does not follow that they also differed in etiology of their reading problems.

Ackerman, Dykman and Peters (1976) investigated recategorized WISC scores for a clinic-referred learning disability sample. This is one of the few studies in the literature which subgroups disabled learners according to pattern of academic deficit. However the selection of subjects for the 1976 study is somewhat questionable. At follow-up, at age 14, some subjects originally categorized as "learning disabled" were categorized as "normal", while some subjects from the control group were placed in the "learning disabled" category . Graphs of the mean subtest scores for all nine subgroups, including two achieving at or above a normal level on the WRAT Reading, Spelling and Arithmetic subtests, show Sequential as the lowest recategorized score. The Sequential score was also lowest for most individual subjects in both "normal" and "learning disabled" groups. However Ackerman notes that for normal achievers Sequential was still average or better relative to the standardization population while for disabled learners Sequential was below average. The recategorized subtest score hierarchy of Spatial greater than Conceptual greater than Sequential (as reported by Bannatyne,1968) was evident only in the graph of subtest means for the subgroup with a dual deficit in reading and arithmetic. The profile for a subgroup with an isolated arithmetic disability is relatively flat. However this may be an atypical group since five of the nine subjects were classified as normal achievers in grade school. In contrast, the subgroup with normal reading but impaired arithmetic and spelling was relatively high on the Conceptual, (or verbal), factor and impaired on the Sequential factor. The Conceptual-Spatial-Sequential pattern is concordant with Denckla's (1972) findings for an arithmetic and spelling disabled group, and with Rourke and Finlayson's (1978) findings for a group with an isolated arithmetic disability. However, the number of individual subjects showing either of these hierarchies is not clear from available data.

An interesting finding, reported by Ackerman, Dykman and Peters (1976), is that most of the learning disabled subjects were impaired in performance on the WRAT Arithmetic subtest which measures computational skills for written problems, but were not impaired in performance on the WISC Arithmetic subtest which involves verbal problems presented orally. This finding suggests that written calculations and verbal problem solving may be differentially impaired in children labeled arithmetic disabled, or dyscalculic. Also, since Ackerman et al. (1976) report that most learning disabled subjects had a below-average Sequential score, the finding that most of these subjects were not impaired in Arithmetic raises the question of the unity of the Sequential factor.

Vance and Singer (1979) report a group mean profile of Spatial-Conceptual-Sequential for a sample of 98 disabled learners selected from classrooms. The number of individuals with this score hierarchy was 39%, while the proportion expected by chance would be 17%. However, several factors obscure interpretation of their findings. The nature of the academic deficits is not reported. There is no control group. The age range of the subjects is from four to 19 years, raising a question as to how the authors define a learning disability.

A study by Owen (1978), on the genetic aspects of dyslexia, lends some support to Bannatye's clinical observation that dyslexics with no clinical indicators of brain damage, and with a familial incidence of reading problems, were characterized by high scores on the Spatial subtest and low scores on the Sequential subtest. Owen's findings are reported for individual subtests, rather than for recategorized factor scores. A group of 20 dyslexics with a strong familial incidence of reading problems, were significantly poorer on Information, Arithmetic and Digit Span, and significantly superior on Picture Completion and Picture Arrangement, relative to normal controls. The dyslexic subgroup had superior spatial abilities and a high incidence of speech problems that seemed to be related to an inability to reproduce groups of patterns of auditory stimuli in correct order. The number of individuals conforming to the group profile is not reported.

Clarizio and Bernard (1981) compared a learning disabled sample (n=278) to groups labeled Educable Mentally Retarded (EMR) (n=141), Emotionally Disturbed (n=67), Otherwise Impaired (n=61), and Nonimpaired (n=294), using recategorized subtest scores. They report that the learning disabled sample was significantly different from the other four groups on the Sequential factor. However, four of the groups (excluding the EMR group) had a mean profile with the Spatial-Conceptual-Sequential hierarchy, and this profile was not effective in discriminating the learning disabled group from the other groups. This study can be faulted on several grounds. Criteria for a learning disability are not reported. The nature of the learning problems are not specified. The source of subjects in the Nonimpaired group is not given. The Digit Span subtest was not used, so that the Sequential score was prorated and is not necessarily comparable to results from studies using Digit Span as well as Arithmetic and Coding to derive a Sequential score.

The possibility that the Spatial-Conceptual-Sequential hierarchy occurs more often than chance for a number of populations is raised, not only by Vance and Singer's findings using a prorated Sequential score, but also by a Canadian study using a normal middle-class sample, screened for learning problems and emotional disturbance (Wersh and Briere, 1981). These 91 normal children presented with a subtest score mean profile corresponding to the pattern reported by Huelsman (1970) for disabled reader samples. The four lowest scores were on Information, Digit Span, Arithmetic and Coding, characterized as the ACID pattern, and the highest score was on Picture Completion. When mean subtest scores are used to derive recategorized scores the group presents with the Spatial-Conceptual-Sequential score hierarchy. However, differences between factor scores are small, and the number of individuals with this hierarchy is not reported. When the sample was subgrouped according to sex, the female (n=51) and male (n=40) subgroups both had a low Sequential score. However, only the male subgroup presented with the Spatial- Conceptual-Sequential hierarchy. Differences between the male and female profiles were small and may not be reliable. Nonetheless, the difference in male and female profiles raises the possibility that the Sequential pattern reported for many learning/reading disabled samples may be confounded with the high incidence of male subjects found in these samples.

In summary, findings for studies investigating the usefulness of recategorized subtest scores have been inconsistent and somewhat contradictory. The Spatial-Conceptual-Sequential hierarchy appears to be a significant correlate of learning/reading disabled groups. There appears to be an even stronger association between a low score on the Sequential factor and learning disabilities. Also there is some suggestion that disabled arithmetic groups are characterized by a Conceptual-Spatial-Sequential hierarchy. However most studies in this area can be faulted on methodological grounds including inadequate criteria for sample selection, heterogeneity of academic deficit or prorating of the Sequential score with the result that between study comparisons are obscured. It must be concluded that hypotheses regarding the prevalence and usefulness of the recategorized factor scores and, in particular, the Spatial-Conceptual-Sequential hierarchy of scores, have not been adequately tested.

While the studies in this area are methodologically weak, their results raise several questions about the recategorized scores. Does the correlation between learning disabled and reading disabled samples and the Spatial-Conceptual-Sequential hierarchy reflect an underlying subgroup? As example, Bannatyne (1971) initially reported this pattern as diagnostic for genetic (or non-brain-damaged) dyslexics. Owen's findings, though not entirely consistent with Bannatyne's predicted hierarchy, lends some support to the existence of a subgroup of dyslexics with some evidence of a genetic etiology, that is characterized by a WISC profile roughly comparable the high Spatial, low Sequential pattern. Alternatively, Ackerman, Dykman and Peters (1976) looked at academically subgrouped disabled readers and report that only the subgroup with a general deficit in reading and arithmetic was characterized by this pattern.

Other questions pertain to the unity of the Sequential factor, and the significance of a low Sequential score. Arithmetic replaced the Picture Arrangement subtest after Rugel's studies (1974a,b) but few studies done since then have used all three subtests (Arithmetic, Digit Span, Coding) to derive a Sequential score.

While low Sequential scores have generally been discussed in terms of reading disabilities, it is likely that many subjects in reading and learning disability samples are also impaired in arithmetic. Kaufman (1979a) reports clinic-referred subjects with an arithmetic disability can be expected to be down on the three Sequential subtests which all involve manipulation of numbers and suggests (1975) the possibility that the Sequential factor is a measure of numerical ability. However, Ackerman et al. (1976) report that while most of their disabled learners were impaired on the WRAT Arithmetic subtest, many were not impaired on the WISC Arithmetic subtest. Only the generally impaired group, with a deficit in both reading and arithmetic, show a significant impairment on WISC Arithmetic. Further, only this generally impaired subgroup is relatively low, as a group, on all three of the Sequential factor subtests. These results suggest that the three subtests may have different relationships to reading and arithmetic, as measured by the WRAT.

PURPOSE OF PRESENT STUDY

The present study is concerned with two different, but complementary, issues in research on specific developmental disabilities in learning arithmetic and reading. The first area of interest is the search for meaningful subtypes within the learning disabilities population. The second area to be investigated is the usefulness of information contained in the WISC profile for understanding and identifying specific arithmetic or reading disabilities. A sample of children that can be identified as learning disabled in reading or arithmetic, will be differentiated into homogeneous subgroups, according to their pattern of academic achievement. The performance of these subgroups on various WISC measures will be investigated, relative to earlier reports in the literature for disabled learners, and, where appropriate, to the performance of normal populations on the WISC and its revised version, the WISC-R.

The initial goal is to determine what proportion of a clinic-referred sample of disabled learners will present with isolated deficits in either reading or arithmetic, rather than with general learning handicaps affecting both academic areas.

A brief overview of the research on specific learning disabilities indicates that little consensus has yet been achieved in the attempt to investigate this population. It can be concluded that the lack of agreement on definition and identification of disabled learners has contributed to inadequate methodology, with operational criteria for sample selection varying widely between researchers. A related factor in the failure to account for potential sources of heterogeneity is the inappropriate asssumption of homogeneity of basic underlying deficit, that is shared by many researchers. Recently there has been increased interest in subgrouping learning disabled samples along various dimensions in a search for meaningful subtypes or syndromes.

Of particular concern to the present study, the specific pattern of academic strengths and weaknesses is rarely reported. Heterogeneity of academic deficit is likely to be a significant source of within- and between-study variance, and may obscure underlying order in the data. Also, while specific reading disability and specific arithmetic disability are discussed as separate entities in the literature, it appears that there is considerable overlap in the composition of samples. Very few samples have been reported with clearly isolated deficits in either reading or arithmetic disability. Further, the few reported samples with normal reading but impaired arithmetic are discrepant in level of achievement in spelling.

Another dimension of interest in the present study is neurological status. Clinicians have agreed that learning handicaps associated with definite neurological indicators of brain damage should be differentiated from those associated only with soft or equivocal indicators of brain damage, as well as from those with no clinically apparent indicators of brain damage. However, research findings are discrepant on the importance of this clinical distinction in terms of pattern of academic deficit, as well as in terms of critical cognitive correlates.

Statement of Hypotheses for Part I:Subgroups

Hypothesis 1: Subgrouping According to Pattern of Academic Deficit

Hypothesis 1 is an exploratory hypothesis. Based on the relative scarcity in the literature of reports of isolated deficits in either reading or arithmetic, it is expected that a clinic-referred sample of disabled learners will have fewer children with isolated deficits than with deficits in both academic areas.

Hypothesis 2: Spelling Achievement of Arithmetic Disabled Subgroup

Hypothesis 2 is an exploratory hypothesis based on the contradictory and limited findings in the literature. No prediction is made as to the level of achievement in spelling of children with normal reading but impaired arithmetic skills.

Hypothesis 3: Comparison of Subgroups on Neurological Status

Hypothesis 3 is an exploratory hypothesis based on the contradictory and limited findings in the literature. No prediction is made as to differences in neurological status of different subgroups.

A second focus of this study is the potential of information contained in the WISC profile for investigating the cognitive strengths and weaknesses of children with a developmental dyslexia or developmental dyscalculia.

In general, learning disabilities research focusing on the WISC has been inconsistent and contradictory. While some correlations have been found between various WISC characteristics and specific learning disabilities, no pattern of scores has been established as diagnostic for either the heterogeneous population of learning disabilities or for the subpopulations of reading or arithmetic disabilities. Conceptual and methodological weaknesses cited for the general body of research in learning disabilities can be found in the research focusing on the WISC. In the absence of consensus on definitions for learning/reading/arithmetic disabilities there has been little commonality in procedures for sample selection. Many studies in this area can be criticized for inadequately defined criteria for sample selection and for a failure to deal with potential sources of heterogeneity.

As well, a problem specific to this research area has been the failure to compare WISC patterns achieved by disabled learner samples to patterns achieved by the WISC/WISC-R standardization populations.

In the present study, questions arising from a review of this research area will be investigated for subgroups formed according to pattern of academic deficit.

Subgroups of interest are those with either a dual disability in reading and arithmetic, or a discrete disability affecting either reading or arithmetic.

Statement of Hypotheses for Part II: WISC Characteristics

Hypothesis 4: Magnitude of VIQ-PIQ Discrepancies

Hypothesis 4 is an exploratory hypothesis based on the contradictory and limited findings in the literature. It is expected that neither the total heterogeneous learning disabled sample nor the subgroups will differ from the WISC standardization population in frequency of VIQ-PIQ discrepancies of abnormal magnitude.

Hypothesis 5: Range of Subtest Scatter

Hypothesis 5 is an exploratory hypothesis, based on the contradictory clinical reports and limited research findings in the literature. It is expected that neither the total learning disabled sample nor the subgroups will have subtest scatter exceeding the normal range for the standardization population.

Hypothesis 6: WISC Factorial Structure

Hypothesis 6 is an exploratory hypothesis, based on the limited findings in the literature. it is expected that a principle components analysis of WISC subtest scores for this sample will yield a factor with high loadings by the Arithmetic, Coding and Digit Span subtests, as well as two additional factors, interpretable as "Verbal" and "Spatial" factors.

Hypothesis 7: Spatial>Conceptual>Sequential Hierarchy

Based on previous reports in the literature, it is expected that both the total sample of disabled learners and a subgroup with deficits in both reading and arithmetic will present with a mean profile consistent with the Spatial-Conceptual-Hierarchy.

It is further predicted that the number of individual subjects within the Reading plus Arithmetic subgroup with this pattern of recategorized WISC factor scores will be greater than expected by chance.

No prediction is made as to the recategorized pattern of a subgroup with normal arithmetic but impaired reading.

Hypothesis 8: Conceptual>Spatial>Sequential Hierarchy

Hypothesis 8 is an exploratory hypothesis, based on previous reports in the literature. It is expected that a subgroup with normal reading but impaired arithmetic will present with a mean profile consistent with the Conceptual-Spatial-Sequential hierarchy of recategorized WISC factor scores.

Hypothesis 9: Relationship of Sequential Factor to Reading and Arithmetic

Hypothesis 9 is an exploratory hypothesis based on the apparent complexity of skills involved in the Sequential factor subtests, as well as on findings in the literature.

The three Sequential subtests (Arithmetic, Digit Span and Coding) all require manipulation of numbers as well as freedom from distractibility, attention-concentration, symbolic facility, sequencing ability and short-term memory. As well, each of the three subtests has unique variance attributable to the specific task requirements.

Within the learning disabilities literature low Sequential scores have generally been discussed in relation to reading disability despite an apparent high incidence of arithmetic impairment in reading/learning disabled samples. However, limited research findings suggest low Sequential subtest scores are common for disabled learners in general, regardless of academic pattern. Most disable learners in a study by Ackerman, Dykman and Peters (1976) had relatively low Sequential scores, but graphs of mean subtest scores for learning disabled subgroups suggest the subtests of the Sequential factor have different associations with different patterns of academic handicap.

It is expected that WRAT Reading and Arithmetic will both have significant relationships to the Sequential factor.

It is further expected that the relationship between WRAT Arithmetic and the Sequential factor will have unique variance not accounted for by the relationship between WRAT Reading and the Sequential factor.

Hypothesis 10: Relationship of WISC Arithmetic to WRAT Arithmetic

Hypothesis 10 is an exploratory hypothesis, based on reports in the literature that various facets of arithmetic can be differentially impaired in children considered to be dyscalculic and specifically on a study (Ackerman,Dykman and

Peters, 1976) reporting disconcordance between achievement on WISC verbal arithmetic problems, orally presented, and WRAT mechanical calculations, which are in written format. It is expected that children impaired on the WRAT Arithmetic subtest will not necessarily be impaired on the WISC Arithmetic subtest. No prediction is made about the WRAT Arithmetic performance of children impaired on WISC Arithmetic, or about the concordance of the two arithmetic scores for the various subgroups.

METHOD

Subjects

Subjects were selected from the files of the Neuropsychology clinic at the University of Victoria. Children seen for neuropsychological assessment at the clinic are almost always referred with a learning problem. Referrals tend to be made when the learning difficulty has proven to be severe, chronic and resistant to remediation. Generally cerebral dysfunction is either known or suspected to exist. The child is usually seen by a neurologist before coming to the clinic.

Rarely, the learning problem of a child referred to the clinic is found to be secondary to a motivational or psychiatric problem. Children assigned to either the "Normal" or "Psychiatric" classification were excluded from consideration for subject selection.

Most children seen for assessment are placed into one of three clinical classifications according to the presence or absence of 'hard' or 'soft' neurological signs (Gaddes,1981).

1. **Brain Damage:** Children assigned to this group usually present with one or more hard neurological signs, considered to be conclusive evidence of brain tissue damage or dysfunction. Children may also be assigned to this category if they present with three or more soft neurological signs, in which case brain dysfunction is strongly indicated but not proven to exist.
2. **Questionable Brain Damage:** In the individual case the distinction between presence and absence of brain damage is not always possible. The presence of one or more soft neurological signs is considered to raise the possibility of brain damage. Some soft signs, such as slight asymmetry of tonus or reflex, barely perceptible hemiparesis and minimal athetosis, are mild forms of hard signs. These soft signs tend to be difficult to elicit and unreliable. Some soft signs, such as nystagmus and tremor, may or may not result from pathological neurological factors. A third group of soft signs may reflect "developmental delay" as well as brain damage, and include speech retardation, motor incoordination, motor overflow and extinction or suppression of double simultaneous tactile recognition.
3. **Learning Disability:** Children are assigned to this category when they present with a specific learning

disability in the absence of hard or soft neurological indicators.

In the present study, criteria for inclusion included:

1. classification in either the Brain Damage, Questionable Brain Damage or Learning Disability categories
2. age at time of assessment between 8 and 14 years (using cut-off criteria of 7 years, 6 months and 14 years, 5 months)
3. intelligence within the normal range as measured by a FSIQ of 85 or higher
4. achievement scores available for reading, spelling and arithmetic on the WRAT.

The above criteria were met by 133 children from the clinic files.

To facilitate presentation of findings, the procedure and results will be presented separately for the two areas of interest.

Procedure for Part I: Subgroups

Using scores on the Reading, Spelling and Arithmetic subtests of the WRAT as operational criteria of academic achievement, the selected sample of 133 clinic-referred children was differentiated according to level and pattern of academic achievement. Several factors influenced the choice of scores on the WRAT measure of skill in reading, spelling and arithmetic . It was the achievement test most frequently administered to children meeting the first three criteria for selection (neurological status, level of intelligence, age). The WRAT test manual reports good reliability for this instrument. Also, the WRAT has been one of the most frequently used measures of academic achievement in clinical and research settings concerned with learning disabilities (Keogh,Major,Reid,Gandara and Omari,1980).

However, many clinicians in the Victoria area have considered the American based WRAT norms inappropriate for local children, overestimating level of performance relative to their peers. To obtain an estimate of the range of performance normal for Victoria area elementary children, a normative study was undertaken in cooperation with the Greater Victoria school board (see Appendix B).

Normative data obtained for 149 children in the age range of 7.7 to 9.6 years were used to establish categories of achievement level along a continuum from normal to mildly impaired to significantly below the normal range:

1. **Significantly Impaired:** scores falling at least 1.5 standard deviations below the mean standard score achieved by the Victoria sample
2. **Mildly Impaired:** scores falling at least 1.0 standard deviations below the mean standard score achieved by the Victoria sample

3. **Average:** scores less than 1.0 standard deviations below the mean standard score achieved by the Victoria sample.

Table 1 gives cutoff scores for these four categories in both Victoria normalized standard scores and in the original standard scores as derived from tables in the WRAT test manual. Scores falling in category 1 were used as an arbitrary criterion for a significant learning handicap, while scores falling in category 3 were considered to represent achievement within the normal range.

TABLE 1

WRAT Standard Score Cut-offs for Level of Achievement Based on Victoria Normative Data

Achievement Level	Victoria Equivalent	Reading	Spelling	Arithmetic
Significantly Impaired	-1.5 SD	0-103	0-99	0-90
Mildly Impaired	-1.0 SD	104-108	100-103	91-95
Average	>-1.0 SD	109 or >	104 or >	96 or >

All subjects meeting the criterion for significant learning handicap in either reading or arithmetic scores on the

WRAT were retained for further investigation as a sample of disabled learners.[1] Within this disabled learner sample, further subdivisions were made according to level and pattern of academic achievement. Of the various subdivisions possible along these dimensions, three subgroups were selected for most further analyses.

A reading plus arithmetic disability subgroup was formed using the criteria of achievement significantly below the Victoria mean on both reading and arithmetic scores on the WRAT.

A reading disability subgroup was formed using the criterion of achievement on WRAT Arithmetic within the normal range for the Victoria normative sample, and achievement significantly below the Victoria mean on WRAT Reading.

An arithmetic disability subgroup was formed using the criterion of achievement on the WRAT reading within the normal range for the Victoria normative sample, and achievement significantly below the Victoria mean on WRAT Arithmetic.

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[1] Raw data for the disabled learner sample is presented in Appendix A.

Results for Part I: Subgroups

Hypothesis 1: Subgrouping According to Pattern of Academic Deficit

The hypothesis that a clinic-referred sample of disabled learners would present with relatively few cases of a clearly isolated handicap in either reading or arithmetic was supported.

Of the 133 children selected from the clinic files 121 cases were below the normal range of achievement in reading or arithmetic.

Using an achievement level at least 1.5 standard deviations below the mean as the criterion for a significant learning disability, 109 (89.95%) of the initially selected sample could be classified as significantly disabled in learning reading and/or arithmetic. This heterogeneous "learning disability" sample (n=109) was then further subgrouped according to presence of single or dual deficits in reading or arithmetic:

1. **Significant Disability in Reading:**
   Of the 109 learning disabled children in the clinic sample, 94 could be classified as reading disabled. Spelling was at least mildly impaired in 90 out of 94 (96%) and significantly impaired in 85 out of 94 (90%) of the disabled readers.

When this group was subdivided according to level of arithmetic achievement,

a) 81 out of 94 (86%) were also at least mildly impaired in arithmetic skills (i.e. at least 1 S.D. below the Victoria mean).

b) 67 out of 94 (71%) had a dual deficit, with a significant disability in arithmetic (i.e. at least 1.5 S.D. below the Victoria mean).

c) 13 out of 94 (14%) had arithmetic scores in the normal range.

2. **Significant Disability in Arithmetic:**

Of the 109 learning disabled children in this clinic sample, 82 could be classified as arithmetic disabled.

When this group was subdivided according to level of reading skill,

a) 76 out of 82 (93%) were also at least mildly impaired in reading skills (i.e. at least 1 S.D. below the Victoria mean)

b) 67 out of 82 (82%) had a dual deficit with a significant disability in reading (i.e. at least 1.5 S.D. below Victoria mean level of performance)

c) 6 out of 82 (7%) had reading scores in the normal range.

To summarize, of 109 cases with a significant learning disability, 90 (83%) presented with at least a mild impairment in the second academic area and 64% with a significant handicap in both subjects. Only 19 (17%) presented with a clearly isolated disability in either arithmetic or reading.

Most further analyses of the data included only three of the above subdivisions of pattern of academic deficit, as well as the total sample of disabled learners, where appropriate. The selection was made in order to obtain subgroups clearly distinct in terms of a general or discrete pattern of significant dyslexia and/or dyscalculia. The three subgroups of interest are reading plus arithmetic disability (n=67) (see subdivisions 1.a and 2.b above); reading disability (n=13) (see subdivision 1.3 above); and arithmetic disability (n=6) (see subdivision 2.3 above).

<u>Hypothesis 2: Spelling Achievement of Arithmetic Disabled Subgroup</u>

No predictions were made as to level of spelling achievement for subjects disabled in arithmetic, but with normal reading. Of the 109 disabled learners, six had normal reading but were significantly handicapped in arithmetic. Of the six, two subjects had spelling scores within the normal range of achievement, one subject was mildly impaired, and two were significantly impaired in spelling.

Hypothesis 3: Comparison of Subgroups on Neurological Status

Subgroup sizes were not appropriate for univariate analyses of the relationship between subgroup membership and clinical category of neurological status. However no trends were apparent in an inspection of the proportion of subjects in each of the clinical categories of Brain Damage, Questionable Brain Damage, and Learning Disability for the various subgroups, including the total disabled learner sample (n=109), the reading plus arithmetic disabled subgroup (n=67), the reading disabled subgroup (n=13) and the arithmetic disabled subgroup (n=6). The figures for the reading plus arithmetic subgroup are highly comparable to those for the total sample of disabled learners. Table 2 gives the percentage of subjects in each of the three clinical categories of neurological status for the total sample and three subgroups.

TABLE 2

Neurological Status

Percentage of Disabled Learner Sample and Reading plus Arithmetic Disability, Reading Disability and Arithmetic Disability Subgroups in the Three Clinical Categories of Neurological Status

Group	n	Brain Damage (N=25) (pct)	Questionable Brain Damage (N=39) (pct)	Learning Disabled (N=40) (pct)
DL sample	109	22.9	35.8	41.3
RAD subgroup	67	22.4	29.9	47.8
RD subgroup	13	15.4	46.2	38.5
AD subgroup	6	50.0	33.3	16.7

Supplementary Analyses

For descriptive purposes, post hoc analyses were performed for the total disabled learner sample (n=109), the reading plus arithmetic disabled subgroup (n=67), the reading disabled subgroup (n=13) and the arithmetic disabled subgroup (n=6) on several attribute variables of interest, including age, sex and Full Scale, Verbal and Performance IQ.

Age.

The four groups were similar in distributions of ages, with means ranging from 10.3 to 11.0 years. Table 3 gives the means, standard deviations and ranges of ages for the sample and the three subgroups.

Sex.

The ratio of female to male subjects was highly similar for the total learning disabled sample (1:3.4) and the reading plus arithmetic disabled subgroup (1:3.6). These ratios are comparable to the ratios of 1:3 or 1:4 commonly reported in the literature for learning or reading disabled samples. The ratio of 1:1.2 obtained for the subgroup with an isolated reading disability is atypical for reading disabled samples, but may be unreliable due to the small

TABLE 3

Means, Standard Deviations and Ranges of Ages

for Disabled Learner Sample and Reading plus Arithmetic Disability, Reading Disability and Arithmetic Disability Subgroups

Group	n	Mean	Standard Deviation	Range
DL sample	107	10.7	1.9	7.5-14.5
RAD subgroup	67	11.0	2.0	7.6-14.1
RD subgroup	13	10.3	2.2	7.6-14.5
AD subgroup	6	10.5	1.0	9.0-11.7

number of subjects (n=13). The arithmetic disabled subgroup had one female and five male subjects (see Table 4). Again, results are unreliable with such a small number of subjects.

FSIQ, VIQ, PIQ.

Full Scale IQ for the total disabled learner Sample (n=109) ranged from 85 to 123, with a mean of 100. The distribution of FSIQ for this sample closely approximates that obtained for the WISC standardization populations. Table 5 gives FSIQ, VIQ, and PIQ means and standard deviations for the sample and three subgroups.

Two of the 109 subjects in the disabled learner sample had been given the revised WISC-R (1974), while the other 107 subjects had been given the WISC (1949).

TABLE 4

Percentage of Female and Male Subjects

for Disabled Learner Sample and
Reading plus Arithmetic Disability,
Reading Disability, and Arithmetitic
Disability Subgroups

Group	n	Females (n=25) (pct)	Males (n=84) (pct)	Total=109
DL sample	109	23	77	
RAD subgroup	67	22	78	
RD subgroup	13	46	54	
AD subgroup	6	17	83	

TABLE 5

FSIQ, VIQ, PIQ, Means and Standard Deviations

for Disabled Learner Sample and Reading plus Arithmetic Disability, Reading Disability and Arithmetic Disability Subgroups

Group	n	FSIQ mean (SD)	VIQ mean (SD)	PIQ mean (SD)
DL sample	109	100.0 (10.5)	98.2 (12.0)	102.1 (12.3)
RAD subgroup	67	97.49 (9.9)	107.53 (10.2)	103.00 (11.4)
RD subgroup	13	107.5 (9.5)	110.1 (9.8)	103.5 (16.5)
AD subgroup	6	103.0 (11.8)	105.3 (11.9)	100.0 (10.2)

Procedure for Part II: WISC Characteristics

Hypothesis 4: Magnitude of VIQ-PIQ Discrepancies

The size of the discrepancy between the Verbal Scale IQ and Performance Scale IQ, regardless of sign, was computed for each subject. For the total learning disabled sample (n=109) and for each of the three subgroups, the distribution of VIQ-PIQ discrepancies was compared to that obtained by the WISC and WISC-R standardization populations using a Kolmogorov Goodness of Fit Test. The null hypothesis was retained if the alpha level was less than 0.05.

Hypothesis 5: Range of Subtest Scatter

For each subject, the range of scores for the eleven WISC subtests was computed by subtracting the lowest from the highest subtest scaled score. For the learning disabled sample (n=109) and for each of the three subgroups, the mean and standard deviations of the subtest score range was compared to that obtained by the WISC-R standardization population.

Hypothesis 6: WISC Factorial Structure

A restricted sample of subjects with scores available for eleven of the 12 WISC subtests (excluding Mazes) was used for this analysis. WISC subtest scores for the restricted sample of 82 disabled learner subjects were submitted to a principal component analysis with ones in the diagonal, using the SPSS (1975) factor analysis subprogram. From the initial unrotated principal component solution, factors were retained for rotation using the criteria of Bartlett's Test of Sphericity, as well as the criterion of eigenvalues greater than one. Bartlett's Test of Sphericity is a test of the hypothesis that, before extraction of each successive component, the residual correlation matrix is an identity matrix. The three factors retained from the initial principal component solution accounted for 60% of the total variance for the subtest scores. The subtest scores were submitted to a series of oblique-factor rotations (-.6 to 1.0), as well as to a varimax orthogonal-factor rotation, with three factors extracted for each rotation. The best solution was determined by conforming to simple structure: the factor pattern with the highest number of loadings <.15 (hyperplane count) and with the fewest number of variables loading >.30 on more than one factor (factorial complexity). Using the simple structure criteria, the Varimax orthogonal solution was retained for interpretation. Variables with a factor loading of at least .5 (25% shared variance) were considered to contribute significantly to a factor.

<u>Hypotheses 7 & 8: Recategorized Subtest Factor Scores</u>

Recategorized Spatial, Conceptual and Sequential factor scores were computed for the 85 subjects in the disabled learner sample (78% of 109) with scaled subtest scores available for the nine subtests. As suggested by Bannatyne (1974) and Rugel (1974a,b), the Spatial score was computed as the sum of the scaled scores obtained on the Picture Completion, Block Design, and Object Assembly subtests. The Conceptual score was computed as the sum of the scaled scores on the Comprehension, Vocabulary and Similarities subtests. The Sequential score was computed as the sum of the scaled scores obtained on the Arithmetic, Digit Span and Coding subtests.

The expected probability for a given factor score hierarchy is 16.6%, or one out of 6 possible factor score patterns.

To test the expectation of Hypothesis 7 that the number of individual subjects in the reading plus arithmetic disability subgroup presenting with the Spatial>Conceptual>Sequential hierarchy of recategorized factor scores would be greater than expected by chance, the obtained frequency of the Spatial>Conceptual>Sequential hierarchy was compared to the expected frequency of occurrence using the Chi-Square test for goodness of fit for subjects in the reading plus arithmetic subgroup (n=51;76%) with scores available for all nine WISC subtests used in calculating recategorized factor scores.

In one case where the factor score pattern was concordant with the predicted pattern but two of the three factor scores were of equal value, the subject was retained in the Spatial>Conceptual>Spatial category for the Chi-Square analyis.

A Kolmorogov goodness of fit test was performed for a restricted sample of the reading disabled subgroup (9/13) with scores available for all nine WISC subtests used in calculating recategorized factor scores.

To test Hypothesis 8 that more subjects than would be expected by chance would present with the Conceptual>Spatial>Sequential hierarchy a Kolmorogov goodness of fit test was performed for a restricted sample of five subjects with scores available for all nine WISC subtests used in calculating recategorized factor scores. For one of the five arithmetic disabled subjects a pattern of Conceptual=Spatial>Sequential was considered to correspond to the predicted Conceptual>Spatial>Sequential pattern.

<u>Hypothesis 9: Relationship of Sequential Factor to Reading and Arithmetic</u>

Several analyses were performed to investigate the exploratory hypothesis that WRAT Arithmetic and WRAT Reading would have different relationships to the WISC Sequential factor, using the 100 subjects with scores available for the three Sequential factor subtests. A canonical correlation (SPSS subprogram Cancorr, 1975) was performed between scores on WRAT Reading and Arithmetic and scores on the Arithmetic, Digit Span and Coding subtests of the Sequential factor.

For both WRAT Reading and WRAT Arithmetic, step-wise multiple regressions (SPSS subprogram Regression, 1975) were computed using the three Sequential factor subtests as predictor variables.

<u>Hypothesis 10: Relationship of WISC Arithmetic to WRAT Arithmetic.</u>

To investigate the concordance between impairment on the WRAT Arithmetic and WISC Arithmetic subtests, two analyses were done.

Subjects with significant impairment in WRAT Arithmetic (n=82) were selected for the first analysis, using a WRAT Arithmetic score at least 1.5 standard deviations below the Victoria sample mean as a criterion of significant disability. Using a scaled score on the WISC Arithmetic subtest at least one standard deviation below the WISC normative mean as criterion of significant impairment on WISC Arithmetic, the number of concordant subjects (i.e. significantly impaired on both arithmetic measures) and the number of disconcordant subjects (i.e. significantly impaired on WRAT Arithmetic; performance within average range for WISC Arithmetic) was tabulated for the 82 subjects, as well as for the six subjects in the arithmetic disability subgroup.

Subjects with a significant impairment on WISC Arithmetic were selected for the second analysis. Using the same criteria for significant impairment used in the first analysis, the number of disconcordant subjects (i.e. significantly impaired on WISC Arithmetic, performance within average range on WRAT Arithmetic) was tabulated for the 45 subjects.

Results for Part II: WISC Characteristics

Hypothesis 4: Magnitude of VIQ-PIQ Discrepancies

The hypothesis that neither the total disabled learner sample nor the subgroups formed according to pattern of academic deficit would differ from the standardization population in frequency of VIQ-PIQ discrepancies of abnormal magnitude was confirmed. Neither the sample or any of the subgroups presented with an excess of discrepancies either in favour of the Verbal or the Performance Scale or when VIQ-PIQ discrepancies were compared in terms of absolute value.

Two of the 13 subjects (15%) with an isolated reading disability (n=13) had VIQ-PIQ discrepancies of a magnitude obtained by 1% of the normal population. However, the distribution for this subgroup was not significantly different from the distribution for the normative population. Table 6 compares the parameters of the distribution of the absolute values of the VIQ-PIQ discrepancies for the standardization population to the absolute values obtained for this clinic sample and three subgroups.

Hypothesis 5: Range of Subtest Scatter.

The hypothesis that the magnitude of subtest scaled score scatter for the sample and subgroups would not be signifi-

TABLE 6

Distributions of VIQ-PIQ Discrepancies

for Disabled Learner Sample and Reading plus Arithmetic Disability, Reading Disability and Arithmetic Disability Subgroups

Group Absolute Value of VIQ-PIQ	WISC/WISC-R Normative Populations (pct)	DL sample (n=109) (pct)	RAD sample (n=67) (pct)	RD sample (n=13) (pct)	AD sample (n=6) (pct)
>=					
34	1	3	0	15	0
30	2	5	3	15	0
26	5	7	8	15	0
22	10	12	10	15	0
19	15	17	15	15	0
<=					
18	85	83	84	85	100

cantly greater than the mean of 7 obtained by the WISC-R normative population was confirmed. Mean scores for the sample and subgroups ranged from 4.6 to 5.7.

Hypothesis 6: WISC Factorial Structure

The prediction that a principal components analysis of WISC subtest scores for this sample of disabled learners would yield a factor with high loadings by the Arithmetic, Digit Span and Coding subtests, as well as two additional factors interpretable as "Verbal" and "Spatial" factors was confirmed. Three interpretable orthogonal factors, accounting for 60% of the variance, were extracted. Table 7 presents factor loadings for the Varimax principal components analysis.

The first factor, with significant loadings by all five subtests on the WISC Performance Scale, including Object Assembly, Picture Completion, Picture Arrangement, Block Design and Coding was readily interpretable as a "Spatial" factor. The second factor, with significant loadings by four of the six Verbal Scale subtests, including Information, Comprehension, Similarities and Vocabulary, was readily interpretable as a "Verbal" factor.

The third factor, with high loadings by the Arithmetic, Digit Span and Similarities subtests and a loading by Coding (.49) that closely approached the cut-off criteria of .50, corresponds to the third factor reported in the literature for normal children and clinic- referred disabled readers. With the exception of the significant loading by Similarities, the subtests loading on the third factor correspond to

TABLE 7

Varimax Principle Components Matrix for WISC Subtests

WISC Subtest	Factor 1	Factor 2	Factor 3
Information	.00	.59	.44
Comprehension	.10	.77	-.01
Arithmetic	-.14	.27	.70
Similarities	.38	.50	.53
Vocabulary	.40	.66	.24
Digit Span	-.10	.01	.85
Picture Completion	.70	.05	-.09
Picture Arrangement	.62	.12	.01
Block Designs	.60	.32	.08
Object Assembly	.83	.04	-.16
Coding	.56	-.45	.49

the recategorized Sequential factor (Bannatyne,1974,Rugel 1974a,b).

Hypothesis 7: Spatial>Conceptual>Sequential.

The hypothesis that the restricted disabled learner sample (85/109) and the restricted reading plus arithmetic subgroup (51/67) would present with a mean profile corresponding to the Spatial>Conceptual>Sequential pattern of recategorized scores was confirmed. The mean factor scores for this subgroup were 33.2 (Spatial); 29.8 (Conceptual); and 23.7 (Sequential).

The second prediction that the number of individual subjects in the reading plus arithmetic subgroup (51/67) presenting with the Spatial>Conceptual>Sequential hierarchy would be greater than expected by chance was also confirmed (Chi-Square, $df=5, p<0.0001$). Of the 51 subjects in the restricted sample of the reading plus arithmetic subgroup, 59% (30/51) were concordant for the Spatial>Conceptual>Sequential hierarchy.

The 9 subjects in the restricted reading disbility subgroup had a mean profile of Conceptual>Spatial>Sequential (37.7;34.7;31.6). Three individual subjects presented with this hierarchy of scores, while three presented with the Spatial>Conceptual>Sequential hierarchy. These two patterns did not occur significantly more often than would be expected by chance .

Supplementary Analyses

Clinical Significance.

For the 30 reading plus arithmetic disabled subjects found to present with the Spatial>Conceptual>Sequential pattern, a post hoc analysis was done to determine the number of subjects that also had a clinically meaningful difference between the Spatial and Sequential factor scores, using the criterion of at least one standard deviation (a nine point score discrepancy) suggested by Kaufman (1979). It was found that 29 of the 30 subjects (97%) presenting with the predicted hierarchy had a clinically significant difference, suggesting the recategorized factor score profiles obtained by these subjects could be useful in understanding their cognitive strengths and weaknesses.

Neurological Status.

A second post hoc analysis was done in order to explore the relationship between neurological status and frequency of the Spatial>Conceptual>Hierarchy pattern for the Reading plus Arithmetic subgroup. Bannatyne (1971) reported that dyslexics with no neurological indicators were typically characterized by this score pattern in contrast to dyslexics with definite or questionable indicators of brain damage.

Results for the 51 Reading plus Arithmetic Disabled subjects for whom recategorized scores could be computed do not support Bannatyne's claim. For this subgroup, 50% of the 10 subjects in the Brain Damage clinical category of neurological status, 56% of the 16 subjects in the Questionable Brain Damage category, and 64% of the 25 subjects in the Learning Disability category presented with the Spatial>Conceptual>Sequential hierarchy. For this group of subjects, the factor pattern did not discriminate between categories of neurological status.

Sex.

To explore the possibility that the Spatial>Conceptual>Sequential hierarchy would occur more frequently for male than for female subjects a post hoc analysis was done for the 43 Disabled Learner subjects presenting with a Spatial>Conceptual>Sequential pattern. Of the 85 subjects in the restricted Disabled Learner sample, 52.9% (36/68) of the male subjects, and 41.2% (7/17) of the female subjects presented with the factor hierarchy. Of the 43 subjects presenting with this pattern, 86% of the males and 81% of the females had discrepancies between the Spatial and Sequential factor scores of a magnitude considered clinically meaningful by Kaufman (1979a) (i.e. a minimum of one standard deviation). For this sample, the Spatial>Conceptual>Sequential pattern does not seem to differentiate between male and female subjects.

Hypothesis 8: Conceptual>Spatial>Sequential

The exploratory hypothesis that a subgroup with normal reading but impaired arithmetic would present with a mean profile with the Conceptual>Spatial>Sequential hierarchy of recategorized WISC factor scores was confirmed. The mean factor score profile for this subgroup was 37.6 (Conceptual), 33.8 (Spatial) and 24.8 (Sequential). Of the five subjects in this subgroup for whom recategorized factor scores could be computed, four were concordant for the predicted pattern of factor scores. This frequency is significantly greater than would be expected by chance (Kolmogorov, $p<0.05$).

Supplementary Analysis

Clinical Significance.

For the four Arithmetic Disabled subjects presenting with a factor score pattern consistent with the predicted Conceptual> Spatial>Sequential hierarchy, a post hoc analysis was performed to determine the number presenting with a discrepancy between the Conceptual and Sequential factor scores of a magnitude considered clinically meaningful by Kaufman (1979a). Three of the four subjects had discrepancies greater than one standard deviation.

A post hoc analysis was done to determine the number of subjects in the sample and three subgroups with Sequential as the lowest factor score. Sixty-five of disabled learners (60%), 41 (81%) of the reading plus arithmetic subgroup, 6 (66%) of the reading disabled and 6 (100%) of the arithmetic disabled subgroup had their lowest score on the Sequential factor.

Hypothesis 9: Relationship of Sequential Factor to Reading and Arithmetic

The prediction that WRAT Reading and WRAT Arithmetic would have significant relationships to the three subtests in the Sequential factor was confirmed. As well, support was found for the hypothesis that the relationship between WRAT Arithmetic and the Sequential factor subtests would have unique variance not accounted for by WRAT Reading.

A canonical correlation between the two WRAT subtests and the three Sequential subtests (Chi-Square, $p<0.01$) yielded two significant roots, accounting for 35% and 12% respectively, of the common variance between the two sets of variables. Standardized canonical coefficients for the two canonical roots are given in Table 8. For the first root, the canonical coefficients suggest much of the variance common to the two sets of variables is accounted for by WRAT Arithmetic and WISC Arithmetic. For the second root, the canonical coefficients suggest much of the residual shared variance is accounted for by WRAT Reading and the WISC Digit Span subtest.

Step-wise multiple regressions, using the three Sequential subtests as predictor variables for WRAT Arithmetic and for WRAT Reading provide support for the relationships suggested by the canonical correlation. The multiple regression between WRAT Arithmetic and the three WISC subtests yielded a multiple correlation of .583, or 34.0% shared variance. Of the three WISC predictor variables, the Arithmetic subtest accounted for 88.5% of the variance accounted for in WRAT Arithmetic. Digit Span and Coding made non-significant contributions to the prediction equation.

The multiple regression between WRAT Reading and the three WISC predictor variables yielded a multiple correlation of .393, or 15.4% shared variance. Of the three predictor variables, the Digit Span subtest accounted for 99.4% of the variance accounted for in WRAT Reading. Arithmetic and Coding made non-significant contributions to the prediction

Since the criterion variables in the two multiple regression equations (WRAT Arithmetic and WRAT Reading) are not orthogonal, it could be expected that some of the variance accounted for by the predictor variables in the two equations would overlap (that is, be attributable to the shared variance of WRAT Arithmetic and Reading). However, since

TABLE 8

Canonical Correlation for WRAT Reading and Arithmetic with Sequential subtests

Root	Eigenvalue	Canonical Correlation	Wilk's Lambda	Chi-Square	D.F.	p
1	.34	.59	.57	53.18	6	.000
2	.12	.35	.88	12.69	2	.002

Coefficients for Canonical Variables of the Second Set

	Canonical Variate 1	Canonical Variate 2
Arithmetic	.84	-.48
Digit Span	.16	1.07
Coding	.31	-.26

Coefficients for Canonical Variables of the First Set

WRAT Reading	.14	1.02
WRAT Arithmetic	.96	-.38

the multiple correlation between WRAT Arithmetic and the three WISC subtests is substantially greater than that for WRAT Reading, it can be concluded that there is a unique relationship between WRAT Arithmetic and the Sequential subtests that is not shared by WRAT Reading. Further, for this disabled learner sample, the WISC Arithmetic subtest accounts for most of the variance shared by the Sequential subtests and WRAT Arithmetic, while the Digit Span subtest accounts for most of the variance shared by the Sequential subtests and WRAT Reading.

Hypothesis 10: Relationship of WISC Arithmetic to WRAT Arithmetic

The expectation that subjects presenting with significantly impaired performance on the written calculation problems of the WRAT Arithmetic subtest would not necessarily also be impaired in level of performance on the verbal, orally presented, problems of the WISC Arithmetic subtest was confirmed. Of the 82 subjects in the disabled learner sample (n=109) with a significantly low score on WRAT Arithmetic, 49% were also significantly impaired on WISC Arithmetic, while 51% showed some dissociation between achievement level on the two measures of arithmetic skills. However, only 17 of the 82 subjects had WISC Arithmetic scores at or above the subtest scaled score mean of 10.

For the subgroup with an isolated arithmetic disability, one of six subjects scored at the mean for the WISC Arithmetic subtest, while five scored below the mean. Three of the six subjects were significantly impaired on both arithmetic measures.

When subjects were selected on the basis of significant impairment on WISC Arithmetic, 40 (89%) of the 45 subjects were also impaired on WRAT Arithmetic. Of the remaining five subjects, all scored below the normative mean.

DISCUSSION

Pattern of Academic Deficit

General or Discrete Disabilities

The expectation that relatively few children in a clinic-referred sample of disabled learners would present with a single deficit in reading or arithmetic was confirmed. Of the 109 subjects identified as significantly learning disabled in at least one of the two academic areas, only 17% presented with a clearly isolated disability in either arithmetic or reading. Using local normative data for the WRAT achievement test, it was determined that 83% of the disabled learners were at least mildly impaired in the second area, and 62% had a significant impairment in both arithmetic and reading.

Out of the 109 subjects, 94 could be classified as dyslexic, or significantly impaired in reading, while 82 could be classified as dyscalculic, or significantly impaired in arithmetic, using operational criteria of impairment comparable to those commonly reported in the literature discussing reading disability and arithmetic disability. However, most of the subjects within each category were also below the average range of achievement in the second academic subject.

Further, the six subjects with normal reading achievement and impaired arithmetic were not homogeneous in level of spelling achievement. The level of spelling skill was on a continuum from normal to severe impairment.

While findings for this highly restricted clinic sample must be interpreted with caution, they are consistent with the relative scarcity in the literature of reports of isolated arithmetic or reading disabilities. It seems likely that most children reported as either reading disabled or arithmetic disabled are, in fact, achieving below the normal range in both academic areas, and would more accurately be described as disabled in reading plus arithmetic. Since the specific pattern of academic difficulty can be expected to be a significant dimension of variance in the search for critical correlates of learning disabilities, these findings emphasize the need for researchers to report sample characteristics in terms of pattern of academic strengths and weaknesses. Samples comparable to those commonly reported as arithmetic disabled or as reading disabled, should be differentiated into general and discrete learning disabilities. As well, the pattern of impairment identified in the present study as an isolated arithmetic disability might be more meaningfully investigated, in future studies, if subjects were subgrouped according to spelling achievement.

Statistical comparisons between a generally impaired reading plus arithmetic subgroup (n=67), a subgroup with a clearly isolated reading disability (n=13) and a subgroup with a clearly isolated arithmetic disability (n=6) were not appropriate due to small sample sizes. However, no association between clinical category of neurological status and pattern of academic deficit was apparent in an inspection of the data. These results do not support Ingram's report (1970) that definite clinical indicators of brain damage are more highly correlated with a general learning handicap, including both reading and arithmetic, than with an isolated reading deficit.

WISC Characteristics

VIQ-PIQ Discrepancies and Inter-subtest Scatter

Neither the total sample of disabled learners, nor any of the three subgroups, had a significant excess of cases with VIQ-PIQ discrepancies of a magnitude that was abnormal for the WISC and WISC-R standardization populations. This finding is discrepant with Warrington's (1967) report that a sample of clinic-referred disabled readers had an excess of abnormal discrepancies in favour of the PIQ, relative to the normative distribution, but is consistent with Lyle and Goyen's (1969) findings for a school-selected group disabled in reading and arithmetic, and with Anderson, Kaufman and Kaufman's (1976) findings for a heterogeneous learning disabled sample.

Similarly, the mean range standard score scatter for the WISC subtests, for the sample, and for the more homogeneous subgroups, was less than that obtained for the WISC-R standardization population.

No support was found for the common clinical assumptions (see Kaufman,1976a,b) that Verbal-Performance IQ discrepancies and inter-subtest scatter are useful diagnostic indicators of a learning disability.

Recategorized WISC Factor Scores

Results of a principal components analysis support clinical impressions that a third factor is needed to account for the WISC test structure, for groups of disabled learners. The factor structure found for this sample is comparable to that reported by Rugel (1974) for clinic-referred disabled learners and supports the modified three factor recategorization of nine of the WISC subtests into Conceptual, Spatial and Sequential factors (Bannatyne,1974,Rugel,1974a,b).

Consistent with earlier findings for heterogeneous learning disabled studies and with Ackerman, Dykman and Peters' (1976) report for a subgroup with a dual deficit in reading and arithmetic, both the total disabled learner sample, and the reading plus arithmetic subgroup, had a mean profile of recategorized subtest factor scores with Spatial greater than Conceptual greater than Sequential. The number of subjects in the reading plus arithmetic subgroup (59%) presenting with this pattern was significantly greater than the frequency that would be expected by chance.

Further, a post hoc analysis indicated that for 99% of the 30 individuals that had the predicted score hierarchy, the difference between the high Spatial and the low Sequential factor scores was of a magnitude that can be considered clinically meaningful (Kaufman, 1979). That is, in interpreting the WISC profiles, a more accurate understanding of the pattern of cognitive strengths and weaknesses might be obtained using the three factor scores than by using the Verbal and Performance Scale IQs. For this group of disabled learners, the original Verbal-Performance Scale dichotomy appears to be less valid than a three factor division of subtests.

Contrary to Bannatyne's (1971) report that the Spatial-Conceptual- Sequential factor score pattern could be used to differentiate dyslexics with no neurological indicators (and presumed genetic etiology) from dyslexics with hard or soft signs of neurological dysfunction, a post hoc analysis did not indicate a relationship between clinical category of neurological dysfunction and incidence of the hierarchy.

A post hoc comparison of the proportion of female and male subjects from the total sample presenting with the Spatial-Conceptual-Sequential pattern did not support the possibility raised by a study with normal Canadian children (Wersh and Briere,1981) that the frequency of the Spatial-Conceptual-Hierarchy in disabled learner samples was an artifact of the high incidence of male subjects. In the present study, 53% percent of the male subjects, and 41% of the female subjects, presented with this hierarchy. For approximately 80% of both the males and females with this pattern, the discrepancy between the high Spatial and the low Sequential factor scores could be considered clinically meaningful (Kaufman,1979a).

However, in view of the small numbers of subjects in the three neurological categories presenting with a Spatial-Conceptual-Sequential hierarchy, and the small number of female subjects in the sample,the findings for both of these analyses must be considered unreliable.

Thirty-three percent of the reading disabled subgroup presented with the Spatial-Conceptual-Sequential hierarchy but this frequency was not significantly greater than that expected by chance for the 13 subjects in this group.

For the arithmetic disabled subgroup, the predicted excess incidence of a Conceptual-Spatial-Sequential hierarchy was confirmed. Factor score patterns for four of the five subjects included in this analysis were concordant with the Conceptual-Spatial-Sequential pattern, while the fifth pattern was discrepant by a negligible difference in scores. As well, for three of the concordant subjects, the difference between the high Conceptual and the low Sequential factor scores was of a magnitude that suggests (Kaufman,1979) a clinically meaningful difference in the cognitive abilities measured by the factor scores.

These findings are consistent with the mean factor score pattern of Conceptual-Spatial-Sequential reported for an arithmetic plus spelling disabled group by Ackerman Dykman and Peters (1976). Since the Conceptual factor score is considered comparable to the Verbal IQ score, while the Spatial factor score compares to the Performance IQ (Kaufman,1979), the findings for arithmetic disability in the present study are consistent with reports that an arithmetic disabled subgroup (Rourke and Finlayson,1978), and an arithmetic plus spelling disabled subgroup (Denckla,1972), were uniformly low on the Performance IQ, relative to the Verbal IQ. Findings in the present study are also consistent with the hypothesis that a dysfunction in some aspect of visual-spatial processing is associated with an isolated disability in arithmetic, as defined by performance on the calculation problems of the WRAT.

The present findings, together with previous reports in the literature, suggest that disabled learner subgroups of reading plus arithmetic disability, and of arithmetic disability, are differentially associated with specific WISC profiles. However, while 59% of the reading plus arithmetic subgroup presented with a clinically significant Spatial-Conceptual-Sequential hierarchy, 41% did not present with this pattern, and there was some overlap with the isolated reading disability subgroup. Conversely, while the majority of the arithmetic disabled sample were homogeneous in terms of factor score pattern, the Conceptual-Spatial-Sequential pattern was also found for some subjects in the two reading disabled subgroups. Thus, neither the Spatial-Conceptual-Sequential pattern, nor the Conceptual-Spatial-Sequential pattern, is diagnostic of a particular pattern of academic impairment.

Sequential Factor

For the majority of subjects in the reading plus arithmetic disability, and the arithmetic disability, subgroups that presented with the predicted factor score patterns, the difference between the highest and the lowest factor scores was of a magnitude that may reflect clinically meaningful differences in the cognitive skills that are measured by the three factors. However, further research is needed to establish the significance and clinical usefulness of the Spatial-Conceptual-Sequential and the Conceptual-Spatial-Sequency patterns.

A number of explanations have been offered in the literature for the significance of high or low scores on the three factors and of specific score hierarchies (Kaufman, 1979a). For the Sequential factor, the various explanations of the possible dimensions common to the three subtests include ability to manipulate numerical symbols, short-term memory, freedom from distraction and sequencing ability. However, it has not been established that low scores on the Sequential subtests reflect impairment on a common dimension either for disabled learners in general or for any subgroup. There may be subgroups of disabled learners for whom a low Sequential score reflects a common critical cognitive or behavioral deficit. Alternatively, the prevalence of low Sequential scores in disabled learner samples may simply reflect the vulnerability of the complex Sequential subtests to disruption along many dimensions and may not arise from a common dysfunction.

In the present study a majority of subjects in the three subgroups (81% of the reading plus arithmetic; 66% of the reading; and 100% of the arithmetic disability subgroups) had their lowest factor score on the Sequential factor. Since a low Sequential score is associated with all three patterns of academic deficit, performance on the Sequential score may not have a direct relationship with the learning impairment. Alternatively, different patterns of academic deficit may have different relationships to the three Sequential subtests.

A canonical correlation and multiple regressions between WRAT Arithmetic and WRAT Reading as criterion variables and WISC Arithmetic, Digit Span and Coding as predictor variables supported the expectation that performance on the three WISC subtests would be differentially related to achievement in WRAT Arithmetic and Reading for a heterogeneous sample of disabled learners. The analyses indicate that WISC Arithmetic accounts for much of the variance common to WRAT Arithmetic and the Sequential subtests while Digit Span accounts for much of the variance common to WRAT Reading and the Sequential subtests.

Dissociation of Skills Within an Academic Area

The generalizability of most of the findings for the present sample to other clinic-referred disabled learners is restricted by the use of achievement on the WRAT as operational criterion of a significant disability in reading, spelling or arithmetic. Using the WRAT, an individual's pattern of academic achievement was assessed by performance on tests of oral sight vocabulary, written spelling skills and written calculation skills. However, reports in the literature indicate level of achievement on different aspects of a general skill area may be discrepant for an individual disabled learner. As example, children impaired on written spelling may be able to spell orally (Denckla,1971), and children with normal achievement on a measure of sight vocabulary may have difficulty on a measure of reading comprehension. Also, children that are impaired on the same academic measure might have markedly different kinds of errors (see e.g. Boder,1971). In the present study, only half of the 82 subjects significantly impaired on the WRAT written calculation problems were also significantly impaired on the WISC orally presented verbal arithmetic problems. This result supports reports by Kosc (1974) and Weinstein (1978) that children identifiable as dyscalculic may show significant dissociation between level of achievement on various aspects of arithmetic skill. It may be useful to explore subgrouping of disable learners along a wider range of measures of reading, spelling and arithmetic strengths and weaknesses than those included in the WRAT.

In conclusion, while the findings for this clinic sample need to be replicated, they support the increasing recognition of the heterogeneity of subjects within the categories of learning, reading and arithmetic disability along dimensions that may be relevant to an eventual understanding of critical cognitive correlates and appropriate modes of intervention.

Appendix A

RAW DATA FOR DISABLED LEARNER SAMPLE

CAT = Clinical category of Neurological Status:
(1) Brain Damage
(2) Questionable Brain Damage
(3) Learning Disability

SEX = (0) Female
(1) Male

VIQ = Verbal Scale Intelligence Quotient

PIQ = Performance Scale Intelligence Quotient

FSIQ = Full Scale Intelligence Quotient

AGE = Age at time of testing

R = WRAT Reading Standard Score, from test manual

S = WRAT Spelling Standard Score, from test manual

A = WRAT Arithmetic Standard Score, from test manual

S#	CAT	SEX	VIQ	PIQ	FSIQ	AGE	R	S	A
1	1	1	99	110	104	7.5	85	92	95
2	1	1	87	111	99	7.8	85	87	86
3	1	1	79	94	85	9.9	86	84	89
4	1	1	104	86	95	10.1	92	89	96
5	1	1	97	74	85	10.0	97	101	93
6	1	1	100	110	105	10.4	90	85	86
7	1	1	84	100	91	9.9	65	65	71
8	1	1	94	78	85	9.6	97	92	86
9	1	1	113	114	115	11.4	122	99	82
10	1	1	116	107	113	11.7	111	103	80
11	1	1	108	83	96	12.2	98	103	87
12	1	1	84	90	85	12.5	78	75	74
13	1	0	90	100	94	10.0	95	85	86
14	1	0	100	108	104	10.9	91	91	86

15	1	0	121	79	101	12.6	108	110	74
16	2	1	118	127	123	9.1	97	96	96
17	2	1	86	118	101	9.4	83	86	87
18	2	1	92	113	102	9.6	97	107	95
19	2	1	94	99	96	9.5	90	82	92
20	2	1	108	97	103	10.3	83	72	91
21	2	1	109	101	106	9.7	98	96	95
22	2	1	116	127	123	11.0	100	93	87
23	2	1	123	108	117	11.2	105	97	87
24	2	1	114	107	112	13.3	80	77	108
25	2	0	85	96	89	8.1	78	88	88
26	2	0	108	125	117	10.3	96	101	109
27	2	0	80	101	89	9.7	97	98	92
28	2	0	123	89	107	9.7	99	98	97
29	2	0	85	89	85	10.8	100	101	81
30	2	0	89	101	94	11.7	92	89	76
31	3	1	91	104	97	9.4	102	96	78
32	3	1	91	97	93	9.4	105	96	87
33	3	1	86	114	99	8.5	104	96	68
34	3	1	106	108	107	9.6	95	75	95
35	3	1	124	118	123	9.8	99	107	89
36	3	1	104	106	105	10.9	104	97	81
37	3	1	94	97	95	11.6	80	68	78
38	3	1	119	121	122	12.5	106	83	77
39	3	1	123	115	121	14.5	82	69	107
40	3	1	91	103	96	14.1	83	80	82
41	3	0	100	111	106	7.6	97	90	102
42	3	0	99	114	107	9.0	69	75	84
43	3	0	111	120	117	9.4	92	94	99
44	3	0	113	104	109	9.7	95	92	83
45	3	0	79	96	85	13.8	74	68	73
46	3	0	109	127	119	13.8	81	81	84
47	2	1	91	94	92	12.9	94	85	71
48	1	1	89	104	96	13.5	86	74	73
49	2	1	97	107	102	8.9	95	96	105
50	3	1	104	122	114	12.5	80	78	90
51	1	1	123	115	121	9.5	84	84	92
52	3	1	106	113	110	9.8	69	71	86
53	1	1	106	79	93	9.8	73	65	77
54	3	1	95	121	108	9.7	67	75	89
55	1	1	100	76	88	13.8	105	104	89
56	2	1	96	107	101	8.2	98	85	88
57	1	0	101	92	96	8.4	87	107	98
58	2	1	85	87	85	7.9	82	90	89
59	1	1	97	99	98	14.0	94	81	66
60	2	1	84	94	88	12.2	78	65	71
61	1	1	91	92	91	8.0	93	88	82
62	3	1	115	99	108	10.5	114	97	83
63	3	1	109	94	102	10.1	98	56	88
64	2	0	90	87	88	11.2	73	75	79
65	2	1	92	122	107	7.9	82	82	77
66	2	0	81	92	85	9.5	84	78	74
67	2	1	104	122	114	12.7	73	65	80
68	3	0	100	101	101	7.6	94	92	98

69	3	1	79	107	91	10.1	65	60	60
70	2	1	104	108	107	10.7	79	75	93
71	3	1	77	97	85	14.1	79	75	70
72	3	1	96	92	93	10.9	91	85	86
73	2	1	89	104	96	8.0	68	76	79
74	3	1	87	92	88	13.1	91	75	68
75	3	1	87	99	92	11.5	99	103	76
76	3	1	100	117	109	12.3	84	65	73
77	1	1	86	87	85	10.4	109	97	86
78	3	1	104	110	107	13.7	99	77	75
79	3	1	97	115	107	10.6	67	66	76
80	2	1	94	97	95	13.0	78	68	78
81	3	1	110	122	117	10.7	83	85	91
82	2	1	95	104	99	9.8	108	92	86
83	2	1	105	103	104	9.0	120	104	90
84	3	1	101	92	96	11.6	81	68	71
85	3	1	84	96	88	8.3	75	76	76
86	2	0	97	90	93	10.0	110	112	78
87	3	1	99	114	107	13.0	80	72	70
88	2	1	125	72	100	13.0	88	92	103
89	2	1	87	97	91	14.0	72	73	75
90	2	1	89	97	92	9.0	94	90	87
91	3	1	97	106	101	11.0	82	81	79
92	3	1	91	90	90	10.0	73	74	73
93	3	1	87	108	97	10.0	55	56	57
94	3	0	106	93	100	13.0	100	108	80
95	3	0	97	113	105	13.1	73	72	80
96	2	0	92	90	91	9.8	76	88	95
97	3	1	89	87	87	12.5	68	57	66
98	2	1	82	92	85	13.0	76	72	68
99	3	1	85	105	93	13.2	73	75	83
100	3	1	105	115	110	9.9	90	86	95
101	3	1	107	93	101	11.6	99	83	105
102	2	1	84	93	87	13.6	80	74	70
103	1	0	94	105	99	9.5	89	84	89
104	2	1	90	108	98	9.2	71	86	90
105	3	1	97	101	99	7.6	77	68	86
106	1	0	87	106	96	12.6	96	85	82
107	2	1	99	89	93	9.3	92	94	93
108	3	1	123	109	119	8.5	99	89	89
109	2	1	98	98	98	13.4	105	101	75

WISC SUBTEST STANDARD SCORES:

INF = Information
COM = Comprehension
ARI = Arithmetic
SIM = Similarities
VOC = Vocabulary
DIG = Digit Span

PIC = Picture Completion
PIA = Picture Arrangement
BLD = Block Designs
OBA = Object Assembly
COD = Coding

Missing Value = -1

S#	INF	COM	ARI	SIM	VOC	DIG	PIC	PIA	BLD	OBA	COD
1	11	8	11	10	12	7	13	10	10	12	12
2	6	12	8	6	10	6	12	10	12	12	-1
3	9	8	5	4	8	6	12	9	12	9	4
4	10	12	12	12	11	6	10	7	12	5	6
5	13	6	9	6	9	14	9	5	7	2	8
6	10	11	10	12	9	8	17	10	4	16	10
7	5	6	8	11	6	8	11	13	10	11	5
8	11	7	10	10	10	6	9	7	7	6	5
9	13	10	9	13	13	14	13	13	16	9	10
10	11	17	10	15	13	9	12	11	10	15	5
11	14	8	13	11	9	12	7	10	9	5	7
12	9	5	7	6	7	10	11	11	6	7	9
13	10	10	9	7	6	8	14	7	12	-1	10
14	9	10	10	10	12	9	18	6	12	11	9
15	11	15	11	17	12	14	8	9	9	5	4
16	13	13	9	15	13	12	15	12	13	17	12
17	8	7	7	8	11	6	15	12	12	15	9
18	9	6	13	9	10	6	11	11	13	13	11
19	7	11	8	11	11	6	10	10	11	9	9
20	9	12	11	14	12	9	11	10	10	8	9
21	11	9	10	12	14	12	12	10	14	10	5
22	11	13	7	15	14	15	17	15	13	13	11
23	14	12	12	16	13	15	15	6	13	12	10
24	12	14	14	14	9	10	13	12	11	10	9
25	7	8	9	7	6	9	6	11	11	11	8
26	10	7	13	14	12	11	14	13	14	13	14
27	7	8	4	6	8	8	10	11	7	9	14
28	11	15	10	17	13	15	10	8	10	-1	8
29	7	10	7	6	8	8	8	10	6	9	6
30	9	6	6	13	10	5	13	10	7	12	9
31	14	7	7	11	6	8	11	7	11	15	9
32	11	10	7	8	7	8	12	9	11	-1	8
33	8	6	6	10	11	6	14	11	8	15	12
34	11	8	10	14	10	12	6	14	12	13	11
35	11	13	15	16	14	-1	11	14	15	-1	10
36	11	9	11	12	13	8	13	12	11	12	6
37	6	7	9	12	10	10	10	12	10	9	7

38	9	18	10	15	16	10	18	10	15	14	8
39	16	16	11	16	15	8	10	10	18	15	8
40	9	9	8	8	9	8	13	10	11	10	8
41	8	7	10	15	10	10	15	11	9	12	11
42	7	13	7	15	12	5	14	15	11	10	10
43	11	9	10	15	14	12	15	8	14	16	11
44	11	12	12	13	14	10	10	14	9	8	12
45	6	6	4	11	7	5	11	8	7	12	9
46	11	14	9	13	9	12	12	12	16	17	12
47	7	10	9	11	8	7	9	11	7	11	8
48	8	6	6	8	13	8	15	11	7	12	8
49	8	7	12	13	8	9	14	10	14	-1	6
50	8	11	13	13	11	8	18	12	12	14	10
51	15	18	10	14	18	6	11	15	12	13	10
52	10	16	8	13	11	8	10	14	12	14	9
53	13	15	11	10	11	6	9	9	7	6	4
54	10	8	6	14	13	4	14	15	12	13	11
55	10	8	12	10	8	12	9	4	7	5	8
56	7	6	9	14	9	11	15	12	12	6	10
57	10	6	8	13	13	11	8	8	10	8	10
58	7	8	10	6	7	7	11	8	8	8	6
59	9	12	7	12	11	6	11	10	9	9	10
60	6	5	7	11	10	5	12	8	12	9	5
61	7	8	7	9	13	7	8	8	14	-1	5
62	17	9	7	16	17	8	10	14	10	11	4
63	8	17	4	10	10	8	10	10	9	9	8
64	6	10	8	9	8	9	7	7	9	10	8
65	5	9	6	11	15	7	16	14	11	14	11
66	8	10	4	6	4	10	9	-1	8	-1	8
67	12	11	10	13	11	7	16	14	12	15	9
68	8	11	11	10	-1	10	12	7	10	-1	12
69	6	5	6	4	10	8	11	-1	12	13	8
70	10	11	11	11	12	8	13	15	14	-1	6
71	4	6	6	8	8	9	11	7	10	9	11
72	8	10	7	11	11	9	13	9	9	8	5
73	7	15	5	7	9	6	15	10	12	10	6
74	5	11	5	9	11	7	-1	10	10	11	6
75	8	12	6	9	8	5	12	9	11	9	8
76	8	13	9	12	12	6	14	13	14	12	9
77	6	8	7	7	-1	11	9	6	11	10	6
78	10	8	10	14	9	12	12	16	9	11	9
79	11	10	7	9	15	5	19	11	12	15	4
80	6	10	9	9	10	10	9	12	9	10	8
81	13	8	11	13	13	11	13	15	14	13	11
82	12	10	5	10	10	8	12	10	12	13	7
83	10	10	9	13	14	9	10	10	12	13	7
84	7	10	7	11	12	14	10	12	10	-1	3
85	5	11	7	7	8	-1	16	10	9	7	8
86	14	7	7	9	12	8	11	7	9	8	8
87	9	9	9	13	14	5	14	-1	13	15	8
88	11	16	15	14	14	14	9	8	4	2	7
89	8	9	8	9	7	7	11	10	11	12	5
90	8	7	7	10	9	8	11	6	13	10	8
91	8	11	7	11	13	8	14	9	12	10	9

92	7	8	8	9	12	8	10	-1	9	11	5
93	7	10	4	10	11	6	10	10	13	13	9
94	9	9	10	13	13	12	8	11	8	10	8
95	11	-1	7	12	10	8	12	12	15	-1	8
96	7	12	8	11	6	-1	10	10	7	9	7
97	7	-1	6	12	8	-1	8	11	11	-1	3
98	5	4	7	9	8	10	9	11	11	-1	5
99	9	7	10	5	7	5	11	14	9	14	6
100	9	14	6	12	13	6	15	14	12	14	6
101	10	11	13	12	10	-1	10	9	11	10	6
102	8	6	5	9	9	-1	9	8	6	12	10
103	10	8	5	10	12	-1	12	14	9	11	8
104	10	-1	10	10	9	3	12	14	12	11	7
105	6	10	9	14	9	6	12	10	10	12	7
106	6	-1	8	9	8	9	11	10	12	11	11
107	10	13	7	9	10	5	7	10	10	10	5
108	11	14	9	19	16	-1	13	12	12	13	7
109	10	10	8	11	10	4	13	11	11	10	4

Appendix B

WRAT NORMS FOR VICTORIA ELEMENTARY SCHOOLS

Normative data for the WRAT (Jastak and Jastak,1978) Reading, Spelling and Arithmetic subtests were obtained in the spring term (February to May) 1981, from three elementary schools chosen to be approximately representative of Victoria socioeconomic conditions.[2] At each of the three schools 25 children were selected from each of grades 1, 3, and 5, using alternate names on class lists as criterion for selection. Children in special classrooms and children who had failed a grade were omitted from the sample. Testing of one grade three subject was discontinued due to circumstances external to the testing situation. In all, 224 children were tested. Since children in grade 1 are below the age range of subjects used in the present study, only the results for the 149 grade 3 and grade 5 children will be discussed below.

Mean age at time of testing was highly comparable across schools, for both the grade 3 and 5 samples. Ages ranged from 7.7 to 9.6 years for the combined grade 3 sample and

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[2] The normative study was carried out with the cooperation of the Greater Victoria School Board which provided funding for the data collection. The author is grateful to Dr. Glen Pope for his cooperation and support.

from 10.1 to 11.8 for the grade 5 sample.

A Z test was used to compare mean standard scores achieved by the Victoria children to the mean standard score of 100 reported in the WRAT test manual for the American standardization sample. The Victoria mean standard scores were significantly higher than 100 for grade 3 Reading, Spelling and Arithmetic and grade 5 Reading and Spelling ($p<0.05$). The mean standard score for the grade 5 Arithmetic subtest was not significantly different from the WRAT test manual mean of 100 (see Table 9)

TABLE 9

Z Test for Means of Victoria WRAT Standard Scores

	Standard Scores Derived From WRAT Test Manual				
WRAT	grade	n	mean	z	p
Reading	3	74	118.0	10.32	*
	5	75	114.2	8.19	*
Spelling	3	74	113.0	7.46	*
	5	75	111.0	6.32	*
Arithmetic	3	74	103.8	2.19	*
	5	75	100.8	.44	n.s.

*$p<0.05$
(WRAT normative mean=100)

Standard deviations for the Victoria sample were compared to the standard deviation reported for the standardization population. Using a Modified Chi-Square Test, (Wonnacott and Wonnacott,1972) Victoria standard deviations were significantly smaller ($p<0.05$) for the distribution of Reading, Arithmetic and Spelling scores, for both the grade 3 and grade 5 samples (see Table 10).

TABLE 10

Modified Chi-Square Test for Standard Deviations of Victoria WRAT Standard Scores

Standard Scores Derived From WRAT Test Manual					
WRAT	grade	n	standard score	Test of Critical Points	p
Reading	3	74	9.55	.405	*
	5	75	7.63	.259	*
Spelling	3	74	10.62	.501	*
	5	75	9.70	.418	*
Arithmetic	3	74	6.16	.168	*
	5	75	9.79	.423	*

*$p<0.05$

(WRAT normative SD =15)

Normalized standard scores for the Victoria sample were derived using the percentile ranks of the subjects' test manual standard scores (see Tables 11,12,13)

TABLE 11

Victoria Norms for WRAT Reading

Normalized Standard Scores	Percentile	Grade 1 n=75	Grade 3 n=74	Grade 5 n=75
155	100	155	138	130
119	90	140	130	125
113	80	131	127	120
108	70	124	123	119
104	60	118	121	116
mean 100	50	115	118	115
96	40	110	114	112
92	30	106	113	110
88	20	98	109	108
-1 SD 85	16	97	(109)	107
81	10	93	105	106
-1.5 SD 70	7	92	103	103
-2 SD 70	2	86	101	95

TABLE 12

Victoria Norms for WRAT Spelling

Normalized Standard Scores		Percentile	Grade 1 n=75	Grade 3 n=74	Grade 5 n=75
	155	100	150	154	133
	119	90	131	126	124
	113	80	123	121	120
	108	70	120	119	116
	104	60	115	114	112
mean	100	50	113	113	111
	96	40	110	110	108
	92	30	105	107	106
	88	20	103	104	101
-1 SD	85	16	102	(104)	(101)
	81	10	95	100	99
-1.5 SD	78	7	93	98	(99)
-2 SD	70	2	88	94	93

TABLE 13

Victoria Norms for WRAT Arithmetic

Normalized Standard Scores		Percentile	Grade 1 n=75	Grade 3 n=74	Grade 5 n=75
	155	100	125	119	127
	119	90	120	111	114
	113	80	117	108	109
	108	70	114	(108)	106
	104	60	(114)	105	104
mean	100	50	110	104	101
	96	40	108	102	98
	92	30	105	102	96
	88	20	104	99	92
-1 SD	85	16	101	98	91
	81	10	99	96	88
-1.5 SD	78	7	98	93	86
-2 SD	70	2	84	90	83

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