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READING DISABILITIES: AN INVESTIGATION OF SUBGROUPS

by

CORINNE SLATT CALLAN

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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Abstract

In the present study subgroups of reading disabled children were investigated on the basis of oral reading strategies and performance on psychological tests. The relationship between oral reading strategies and psychological test performance was also examined. Forty-one children with specific reading disabilities were selected for the study. The children attended regular classrooms and were in grades three to six.

A hierarchical clustering technique was used to determine if there were subgroups. Two sets of subgroups were differentiated, one set on the basis of oral reading strategies and the other on the basis of psychological abilities. Each set comprised five subgroups. Partial support for the relationship between reading strategies and psychological abilities was found, but membership in a particular subgroup based on reading data could not be predicted from membership in a subgroup based on psychological data. The findings of the study show the importance of viewing disabled readers as heterogeneous with respect to their psychological and reading characteristics. The limited predictive relationship between the reading and psychological data suggests that further research is needed to explore how accurately information about a child's psychological strengths and weaknesses can predict his/her reading strategies.

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I. INTRODUCTION

The term "learning disability" has become prominent in the field of special education over the past twenty years. The National Advisory Committee on Handicapped Children (1967) has offered the following definition of learning disability:

> Children with special learning disabilities exhibit a disorder in one or more of the basic psychological processes involved in understanding or in using spoken or written language. These may be manifested in disorders of listening, thinking, talking, reading, writing, spelling, or arithmetic. They include conditions which have been referred to as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, developmental aphasia, etc. They do not include learning problems which are due primarily to visual, hearing or motor handicaps, to mental retardation, emotional disturbance or to environmental disadvantage (cited in Myers & Hammill, 1976, pp. 3-4).

There are two major aspects to this definition. First, the concept of learning disability subsumes a heterogeneous group of disorders. Second, learning disabilities exclude learning difficulties which are primarily due to sensory deficits, mental retardation, emotional disturbance or educational or cultural disadvantage.

The term "specific reading disability" refers to one particular type of learning disability. A child can be classified as reading disabled if he or she has a serious difficulty in reading which cannot be adequately explained by any of the handicaps excluded in the definition of learning disability (Benton, 1975).

In the past the main paradigm for studying reading difficulty has been the comparison of able and less able readers on any one of a large number of variables. Thus, much of the research about reading difficulty has made the distinction between the reading disabled individual and the child who has a reading deficit with a different etiology. For example, investigators may not have controlled for IQ (e.g., Juels, 1980; Kolers, 1975) or environmental disadvantage (e.g., Allington & Fleming, 1978; Englert & Semmel, 1981).

Research in reading has been focused in three main areas: 1) an examination of subskills thought to be involved in the reading process itself; 2) an investigation of the psychological correlates of reading difficulty, and 3) an attempt to identify the neuropsychological correlates of reading difficulty. Researchers investigating the reading process argue that the effectiveness with which the child uses various cues in reading distinguish good from poor readers. For example, Benton (1975) and Mason (1976) stated that the ability to make effective use of graphic cues differentiates good from poor readers. Other researchers have maintained that the distinguishing factor is to be found in the ability to use contextual cues (e.g., Leslie, 1980; Levy, 1977). Still other investigators stress the integration of all cues as the skill that separates the two groups (e.g., Goodman, 1970; Weber, 1970).

The psychological variables that have been examined to distinguish between poor readers and normal controls have included memory and perceptual, psycholinguistic, and cognitive abilities. All of the variables have, in one study or another, been found to differentiate good from poor readers, although the results are not always consistent across studies (e.g., Lovell, Shapton, & Warren, 1964; cf., Werner, Simonian, & Smith, 1967). No one psychological deficiency has been found to account for all children with reading difficulties.

Several researchers have examined the behavioural correlates of reading disability (e.g., visual perception, motor and sensory abilities, and cognitive and linguistic performance) in order to infer the neurological status of reading disabled children (e.g., Rourke, 1978). This indirect approach to the study of the neurological antecedents of reading disability is based upon the discovered relationship between brain damage and poor performance on certain behavioural tasks (Benton, 1978).

In general, research involving reading problems and their psychological and neuropsychological correlates has failed to take into account the heterogeneity of reading disorders. Doehring (1978) recently pointed out that reading disability is not a unitary disorder, and that it is therefore necessary to develop a multiple-syndrome paradigm which classifies retarded readers into subgroups. The inconsistencies of previous studies may be largely due to the fact that researchers have tended to employ a single-syndrome paradigm.

Instead of searching for a unitary cause of reading disability, some researchers have recently begun searching for independent patterns of factors which underlie the disability. Most of this research has been concerned with the psychological or neuropsychological characteristics of retarded readers (e.g., Lyon & Watson, 1981; Petrauskas & Rourke, 1979; Satz & Morris, 1980). Several attempts have also been made to classify disabled readers on the basis of their reading skills (e.g., Boder, 1973; Doehring & Hoshko, 1977). Benton (1978) has pointed out that the relationship between subgroups based on psychological attributes and subgroups based on reading subskills is still unexplored.

In short, much previous research has been flawed by a single-syndrome paradigm which ignores the heterogeneity of reading disability. The single-syndrome paradigm may explain many of the inconsistencies of previous research. It is hoped that the emergence of a multiple syndrome paradigm, which distinguishes subgroups of disabled readers on the basis of patterns of abilities and deficits, will provide a deeper understanding of reading disability and a better theoretical basis for remediation.

Statement of the Problem

The present study is based upon a multiple syndrome paradigm. The study addresses a number of basic problems about the classification of reading disabled children into subgroups by considering both reading and psychological variables. Neuropsychological characteristics of disabled readers are beyond the scope of the present study and therefore, were not included. Four questions were investigated. First, can subgroups of disabled readers be distinguished on the basis of their subskill deficiencies in reading? Second, can subgroups of disabled readers be distinguished by patterns of psychological correlates of reading disability? Third, does a predictive relationship exist between psychological abilities and reading strategies? Finally, is there a correspondence between the members of the subgroups formed on the basis of psychological attributes and membership of those formed on the basis of reading subskills?

II. REVIEW OF THE RESEARCH: READING DISABILITY

Four areas of research pertaining to the present study will be examined critically. A review of the literature concerning the reading errors and strategies of disabled readers is given in the first section. Secondly, recent attempts to distinguish subgroups of disabled readers in terms of reading attributes are discussed. In the third section studies which investigate the psychological correlates of reading disabilities are examined. Finally, a review of research which identifies subgroups of disabled readers on the basis of their psychological characteristics is presented.

A. Reading Errors and Strategies

For many years researchers have tried to pinpoint the problems of disabled and other inefficient readers through an examination of their performance on reading tasks. Attempts have been made to characterize poor readers by the type of errors found in their performances and to infer their reading strategies from the errors they make.

The variety of subskills involved in reading is strongly emphasized by current investigators:

> The act of reading involves many component processes of different degrees of complexity, ranging from the visual discrimination of graphemes and recognition of the phonemic value of single consonants and vowels, through the recognition of single words, to the apprehension of meaningful word sequences taken as units (Benton, 1975, p.6).

The errors which poor readers make may arise in any of the component processes of reading. A classification of many of the errors identified by researchers is offered below.

1. Letter orientation reversals

The tendency to make single letter reversals (p-q; b-d) and rotations (p-b; q-d) was once thought to be a major characteristic of disabled readers (Weber, 1968) but is now viewed as being relatively uncommon (e.g., Benton, 1975). Liberman and her colleagues (1971) found that letter reversals are the most unstable reading error type when compared to others. Individual differences among poor readers are also large.

2. Faulty reading of vowels and consonants

According to Shankweiler and Liberman (1972), vowels are misread more often than consonants. Vowels are more orthographically complex and varied than consonants since different letter group combinations may represent one sound—(e.g., u = u, oo, ou, oe, ew).

3. Letter sequence reversals

It was once thought that letter sequence reversals were part of the same phenomenon as letter orientation reversals and were therefore a major characteristic of disabled readers (Weber, 1968). Studies have since found that they occur more frequently than letter orientation reversals and that together both types of errors make up only 12 to 25 percent of disabled readers' errors (e.g., Bennett, 1942; Shankweiler & Liberman, 1972). It has also been discovered that letter orientation reversals and sequence reversals are virtually unrelated (Liberman et al., 1971).

4. Omissions and additions of words

According to Benton (1975) these errors are characteristic of disabled readers, although he does not note the frequency with which these errors occur.

5. Excessive slowness in reading (word-by-word reading)

There is general agreement that poor readers take significantly longer than able readers to read words (e.g., Samuels, Begy, & Chen, 1976; Schvaneveldt, Ackerman, & Semlear, 1977), sentences (e.g., Kolers, 1975), and passages (e.g., Allington, 1978; Allington & Strange, 1977). Some researchers have attributed the slowness of poor readers to a letter-by-letter processing strategy in contrast to the ability of proficient readers to process larger units of letters (Biemiller, 1978; McCormick & Samuels, 1979). It has been commomly argued that dysfluency (i.e., word-by-word reading) prevents adequate retention of reading material (e.g., Benton, 1975; McCormick & Samuels, 1979; Perfetti & Hogaboam, 1975).

6. Failure to grasp the meaning of the passage

Traditionally, comprehension of a passage has been measured by the number of questions answered correctly on the passage. In recent years the analysis of oral reading errors has permitted the assessment of a reader's use of grammatical and semantic cues within a passage. The appropriate use of these contextual cues has been used as an indicator of the readers' understanding of sentences and passages. Many researchers have reported that poor readers pay little attention to the grammatical and semantic cues in a reading passage (e.g., Au, 1977; Goodman & Burke, 1973; Levy, 1977); however, other researchers have disputed this finding (e.g., Allington & Strange, 1977; Biemiller, 1979).

Many researchers have tried to explain the poor reader's patterns of errors by inferring his reading strategies from the errors. Studies such as Goodman and Burke's (1973) have analyzed oral reading errors such as substitutions, omissions, and additions for the degree of visual similarity between the errors and the text and for the contextual appropriateness of the errors made. By comparing the degree of graphic cue reliance to the appropriate use of contextual cues, researchers have made inferences about the poor readers' word attack skills. However, there has been much controversy about how the poor reader uses graphic and contextual cues.

One group of investigators claim that the unskilled reader relies more on graphic than contextual cues. This school of thought reflects LaBerge and Samuels' (1974) theory of automatic information processing in reading. According to LaBerge and Samuels' (1974) theory, the beginning reader's skills in decoding are not automatic, and this causes the reader to attend primarily to visuophonic cues and to neglect contextual cues. Later, when decoding becomes automatic, attention is freed for comprehension. Some researchers have found that LaBerge and Samuels' (1974) theory is applicable to poor readers. For example, Goodman and Burke (1973) found that poor readers made less effective use of contextual cues than able readers. Other researchers have reported similar findings (e.g., Au, 1977; Leslie, 1980; Levy, 1977).

In contrast to the above findings, some studies have suggested that use of contextual cues does not differentiate between good and poor readers (e.g., Allington & Strange, 1977; Biemiller, 1979; Koler, 1975). Other investigators have claimed that poor readers may rely on contextual cues to an even greater degree than good readers (e.g., Schaneveldt et al., 1977; West & Stanovich, 1978). Stanovich (1980) suggested that some poor readers may rely heavily on contextual cues in order to compensate for poor word recognition skills. It has also been maintained that poor readers depend on contextual cues for accuracy whereas good readers rely on contextual cues for fluency (e.g., Allington, 1978; Allington & Fleming, 1978; Allington & McGill-Franzen, 1978).

Studies which have dealt with poor readers' use of graphic cues have yielded inconsistent results. Several researchers have reported that poor readers rely more on graphic cues than do good readers (e.g., Au, 1977; Goodman, 1970; Leslie, 1980) but others have suggested that able and less able readers do not differ significantly in their reliance on graphic cues (e.g., Goodman & Burke, 1973, Levy, 1977). Still others have reported that good readers attend more to graphic information than poor readers (e.g., Allington & Strange, 1977; Juels, 1980). Researchers who reported the latter finding have argued that the proficient readers' greater attention to graphic details reflects an automatic and efficient decoding strategy (e.g., Stanovich, 1980). Thus, several investigators have found that good readers were more aware of graphemic patterns within words than poor readers (Kolers, 1975) and that they read significantly faster even though they attended more closely to graphic information (Allington & Strange, 1977). It has often been suggested that the efficiency with which cues are integrated may be what really distinguishes good from poor readers (e.g., Allington & Strange, 1977; Biemiller, 1979; Juels, 1980; Stanovich, 1980; West & Stanovich, 1978). However, it is not clear that a deficiency in the integration of cues can account for the difficulties of all poor readers.

Much of the literature on poor readers' use of cue systems does not differentiate disabled readers from others whose reading is inefficient. The inconsistencies found in the research may be largely due to the assumptions that all poor readers can be studied as a homogeneous group and that their reading problems are all due to one specific subskill deficiency. These assumptions are extremely doubtful given the diversity of poor readers' errors and the failure to identify any particular subskill deficit which will fully explain reading disorders. In fact, the success of recent attempts to identify subgroups of disabled readers through an analysis of their errors and strategies clearly demonstrates that the term "reading disability" designates a heterogeneous group of disorders (e.g., Boder, 1973). It is possible that studies which focus on the differences between subgroups of disabled readers will help to resolve many of the inconsistencies of previous research. For example, some disabled readers may be more efficient in processing graphic than contextual cues, while for others the reverse may be true. The research which has divided disabled readers into subgroups on the basis of their reading characteristics will be examined in the following section.

B. Subgroups of Disabled Readers Based on Reading Characteristics

An attempt to classify disabled readers on the basis of reading error type was made by Ingram, Mason, and Blackburn (1970). Ingram et al. (1970) predetermined their subgroups by establishing two categories of errors into which subjects would be classified -- audiophonic, and visuo-spatial. Audio-phonic difficulties were measured by an inability to analyze words into phonemes, to blend phonemes into words, and by confusion of vowel sounds and poor phonic knowledge of dipthongs. Visuo-spatial difficulties were identified by the tendency to make letter and word reversals, by the slow recognition of simple words, and by poor visual discrimination of words which were very similar in shape.

The study failed to offer a classification system into which homogeneous subgroups of disabled readers could be placed because sixty-six percent of the sample had problems in both error categories.

Like Ingram et al. (1970), Johnson and Myklebust (1967) based their subgroup classification system on personal observation. According to these researchers, one subgroup of disabled researchers were termed "visual dyslexics" because they could not retain an entire sequence of letters or learn from a global word approach. Instead, this group learnt individual sounds and blended them into words. The other subgroup, termed "auditory dyslexics", were deficient in sound-symbol integration and hence, were unable to develop phonetic skills. These children were only able to learn words as wholes and so had a limited sight vocabulary. Through independent observation of clinical populations, Boder (1973) identified the same two groups of disabled readers and added a third group who had the disorders of both groups.

A more objective approach to classifying subgroups of disabled readers has been through the use of the Q-technique of factor analysis. Doehring and Hoshko (1977) used such a technique in their study of subjects who attended a summer program for children with reading disabilities. The researchers were primarily concerned with the automatic processing of information, and used response latency as well as accuracy to determine areas of strength and weakness.

Different degrees of decoding deficiency were discovered among the children. Some had difficulty using the basic phonological code and also lacked an understanding of orthographic structure, while others had difficulty primarily in the use of orthographic structure. Still others' primary deficiency seemed to lie in the rapid oral reading of words and syllables. Unfortunately, none of the deficiencies were analysed for visual perception or comprehension difficulties.

Although the studies examining decoding skills contribute important information to reading research, their treatment of word identification skills is limited. This is because they do not take account of context, which has an important effect on word recognition. The importance of context was demonstrated by Goodman's study (1965), which revealed that readers in the primary grades were more accurate when reading words in passages than when reading the same words in lists. However, in the research concerning subgroups of disabled readers, their ability to make use of contextual cues has not yet been examined.

C. Psychological Correlates of Reading Disability

The investigation of psychological factors in reading disabilty "aims to identify the more fundamental cognitive disabilities that are responsible for failure to learn to read and to provide guidelines for effective remediation"

(Benton, 1978, p. 469). The focus of this research is on "immediate" or behavioural correlates of specific reading disability rather than on "ultimate" or neurological correlates (Vellutino,1978).

Prior to the 1970s, the basic paradigm of most studies which examined these correlates was a comparison of normal and poor or disabled readers on one or a small number of tests. If a significant difference existed between reading ability groups, a causal relationship was inferred between the measure(s) and the reading difficulty. The paradigm was termed the "single-syndrome" paradigm (Doehring, 1978) because it implied that the term "reading disbility" represented a homogeneous dysfunction. One can distinguish four major areas of psychological factors associated with reading disorders within the paradigm: visual spatial development, verbal abilities, intersensory integration, and sequential processing.

1. Visual-Spatial Development

The association between reading disorders and visual perception deficits stems from the observation that children's reading often manifests the following errors: reversals in letter orientation (e.g., b-d; p-q) and letter sequencing (e.g., was-saw) and confusions of letter and word configuration (e.g., m-n; some-come). Investigators have assumed that these error types reflect an underlying perceptual deficit, and have administered measures of visual perception such as form discrimination, visual-motor integration and left-right discrimination in order to identify that deficit.

a) Visual Form Perception

Studies that have aimed at distinguishing good from poor oral readers on form perception have generally used measures such as the Performance Scale IQ and Performance Scale subtests from the Wechsler Intelligence Scale for Children-Revised (WISC-R) as well as the Bender Visual-Motor Gestalt Test (Bender-Gestalt) and the Developmental Test of Visual-Motor Integration (Beery's VMI Test). In general, some studies have found evidence for perceptual problems in poor or disabled readers (e.g., Lovell, Shapton, & Warren, 1964), but others have not (e.g., Werner, Simonian, & Smith, 1967). Factors that have been cited to explain these inconsistencies include a failure to control for IQ differences between groups (e.g., Richardson, Di Benedetto, Christ, & Press, 1980) as well as age differences between samples across studies (e.g., Sobotka, Black, Hill, & Porter, 1977; Satz, Rardin, & Ross, 1971).

Several investigators (e.g., Benton, 1975; Rutter, 1978) have concluded that visual perception difficulties are associated with reading difficulties in younger children but are not significant correlates of severe reading difficulties at older ages. Rutter (1978) maintained that older reading disabled children still have visual perception impairments relative to their peers, but that they may have developed sufficient skills in discrimination to learn to read. Rutter (1978) suggested that in the more advanced stages of reading, poor oral readers may learn to rely more on context than on individual letter or word processing.

Finally, it is likely that some of the variability found in studies is due to the fact that not all children with reading difficulty have perceptual deficiencies (see Lovell, Shapton, & Warren, 1964). The fact that Bannatyne (1971) found both spatially competent and incompetent disabled readers supports that view.

b) Visual-Motor Integration

In the studies reviewed above, measures of form perception included WISC-R Performance subtests, the Bender-Gestalt, and Beery's Visual-Motor Integration (VMI) Test. Although these tests do measure form perception, the fact that most also measure the coordination of visual perception with motor and conceptual operations has often been overlooked. The multiplicity of constructs measured by these tests may interfere with the predictability between performance on these tests and reversals in letter orientation and sequence (Park, 1978-79).

One aspect of visual-motor integration which has been studied apart from perception is the visual tracking of a stimulus. Studies have reported inefficient eye movements among disabled readers relative to normal readers in both reading and nonreading tasks (e.g., Rubino & Minden, 1973; Adler-Grinberg & Stark, 1978; Griffin, Walton, & Ives, 1974). While some researchers have concluded that erratic eye movements only reflect passage difficulty level (e.g., Goldberg & Arnott, 1970), Pavlidis (1981) has found that disabled readers display abnormal eye movements even when reading simple text.

c) Left-Right Discrimination

The tests used to measure awareness of left-right directionality have usually required the child to demonstrate his awareness of left and right with regard to his own body, the body of the examiner, and physical objects. The first ability is normally mastered by age 7, the second by age 8, and the third by age 11 (Belmont & Birch, 1963).

Most studies that have examined the relationship between the ability to make left-right discriminations and reading ability have reported a significant difference between at least some disabled readers and normal controls (e.g., Ginsburg & Hartwick, 1971; Lovell et al., 1964; Belmont & Birch, 1965); however, other studies have not (e.g., Spellacy & Peter, 1978; Balow, 1963). It seems that the strongest relationship between the two variables exists for severely disabled readers who have difficulty identifying right and left on their own bodies (Lovell et al., 1964; Belmont & Birch, 1965). Evidence reveals that left-right discrimination is related to intelligence (e.g., Coleman & Deutsch, 1964; Croxen & Lytton, 1971) and age (Benton, 1962; Sparrow & Satz, 1970). Variations with respect to intelligence and age in sample selection may have led to many of the inconsistencies across studies.

2. Verbal Abilities

Researchers concerned with the psychological correlates of reading disability have investigated the relationship between verbal abilities on non-reading tasks and reading achievement. Studies that have matched disabled and normal readers on Full Scale WISC IQs have found disabled readers to be inferior in Verbal IQ and superior in Performance IQ relative to normal readers (e.g., Belmont & Birch, 1966; Neville, 1961). The Low Verbal IQ-High Performance IQ discrepancy seems to be more highly related to poor reading achievement among older children around nine or ten years of age than among younger readers (e.g., Reed, 1967). Because Verbal IQ is a global measure of verbal functioning, some researchers have been interested in examining the performance of disabled readers on the subtests of the WISC Verbal Scale. Benton (1975) reported that disabled readers are likely to perform poorest on vocabulary level, range of information, and oral arithmetic reasoning, while comprehension of social situations and verbal reasoning are handled reasonably well.

A variety of other measures have been used to assess the verbal competence of poor readers. Among the most common variables which have been examined are auditory discrimination, phonemic analysis and synthesis, and word fluency.

a) Auditory Discrimination

Auditory discrimination between similar sounding words is important in the intial stages of the letter-sound association process. Wepman's Auditory Discrimination Test (Wepman, 1973) is a commonly used screening device which measures the capacity to distinguish between phonemes used in speech. The test requires examinees to determine whether word pairs are the same, or differ in a single phoneme (e.g., pat-pet). Wepman (1960) reported a significant relationship between reading scores and auditory discrimination. Other studies have supported this finding (e.g., Christine & Christine, 1964; Flynn & Byrne, 1970; Briuninks, 1969). Although norms on Wepman's test only range from five to eight years, several studies (e.g., Lingren, 1969; Goetzinger, Dirks, & Baer, 1960) have reported that the test also discriminates between older good and poor readers.

b) Phonemic Analysis and Synthesis

The ability to isolate the phonemes that make up a word and the ability to blend individual phonemes into whole words have been found to be important skills in the initial reading task (Williams,1980). These abilities are important in early reading because deciphering a new word requires first, that the word be broken into its component phonemes, and second, that the resulting units be recombined or blended. Golinkoff (1978) suggested that these auditory analysis and synthesis skills are separate abilities that ordinarily enter into a child's repetoire successively.

While most of the research on phonemic analysis has been conducted on young children in the initial stages of reading (e.g., Hardy, Stennet, & Smythe, 1973; Wallach, Wallach, Dozier, & Kaplan, 1977), the research on phonemic synthesis has included older children as well. Two commonly used measures of phonemic synthesis are the Sound Blending and Auditory Closure subtests from the Illinois Test of Psycholinguistic Abilities (ITPA; Kirk, McCarthy, & Kirk, 1968). Both subtests require the child to translate phonemic units into whole words. Although subjects are sometimes older than the target population of the ITPA, researchers (e.g., Richardson et al., 1980) have reported that reading disabled children score well below the ceiling on these measures. In general, sound blending was found to be a distinguishing factor between reader ability groups in most studies (e.g., Golden & Steiner, 1969; Kass, 1966; Richardson et al., 1980); auditory closure differentiated between groups in some studies but not in others (e.g., Golden & Steiner, 1969; Kass, 1966; cf., Richardson et al., 1980; Wussler & Barclay, 1970).

c) Word Fluency

Word fluency has also been found to be less efficient among poor readers. One measure of word fluency requires the subject to name as many words as possible beginning with the letters F, A, and S in the time span of one minute per letter (Spreen & Benton, 1969). Older disabled readers have been found to perform significantly worse than normal readers on this measure (e.g., Satz, Rardin, & Ross, 1971; Spellacy & Peters, 1978). However, a significant difference between reader ability groups on this measure is not always found (e.g., Sobotka et al., 1977).

3. Intersensory Integration

Reading involves the translation of visual spatial stimuli into appropriate sound sequences. This decoding process requires the ability to perceive visual spatial patterns and auditory sequential speech patterns, as well as the ability to match the two patterns. Investigators interested in determining the factors responsible for poor decoding skills have examined the relationship between performance on auditory-visual matching tasks and reading ability. The initial research in this area was conducted by Birch and Belmont (1964, 1965). Their research paradigm of assessing children's abilities to match auditory tap patterns to visual dot patterns has been used, with various modifications, by many investigators (e.g., Beery, 1967; Warren, Anooshian, & Widowski, 1974). However, the construct validity of the Birch and Belmont (1964) task is highly questionable. Moreover, the task has been criticized on the grounds that crossmodal matching of meaningless nonverbal stimuli cannot be directly compared to the intermodal matching that occurs in reading (Pick, 1978).

One crossmodal matching task that uses verbal material is the Visual Aural Digit Span (VADS) Test (Koppitz, 1970).

The test uses sequences of digits to measure the effects of aural and visual presentations with oral and written modes of response. Koppitz (1975) found that three of the four subtest scores (Aural-Oral, Visual-Oral, Visual-Written) and the VADS total score significantly distinguished between a learning disabled group who could read and a similar group who could not. Results indicated that the Visual-Oral subtest had the highest correlation with reading ability. Tasks involving letter naming are even more closely related to reading than the VADS. Steinhauser and Guthrie (1974) found that scanning for a target phoneme, an operation which required the conversion of graphemes into sound, was a task uniquely difficult for disabled readers.

There is very little research on the direct association between crossmodal integration of verbal stimuli and reading errors per se. Nonetheless, Vernon (1977) hypothesized that deficits in this type of integration are one of the major causes behind poor readers' difficulty in grapheme-phoneme association. Support for Vernon's hypothesis comes from Doehring and Hoshko (1977). They reported that the subgroup of reading disabled children who had difficulty in auditory-visual association were rated by their teachers as requiring training in this area.

Vernon (1977) pointed out that deficiencies other than crossmodal integration may also cause poor grapheme-phoneme association. Poor reasoning ability and a deficiency in sequential memory could also interfere with the learning of patterns of letter sequences based on regularities between graphemes and phonemes. The relationship between sequential memory and reading skill will be discussed in the following section.

4. Sequential Processing

Many researchers have found reading disabled children to have a general sequencing deficit (e.g., Doehring, 1968; Bakker, 1972; Bannatyne, 1971; Rugel, 1974). The sequencing deficit of disabled readers has been investigated [illegible] a number of areas. For instance, researchers have found that disabled readers perform significantly worse than average readers in both reading and nonreading sequential oculomotor tasks (e.g., Griffin, Walton, & Ives, 1974; Pavlidis, 1981). Other evidence for a sequencing deficit among reading disabled children is frequently found in the Sequential pattern of the WISC-R (Digit Span, Coding, and Picture Arrangement). Rugel (1974) reviewed 22 studies which examined reading disabled children's performance on the WISC. He reported that out of the three WISC patterns (Spatial, Conceptual, and Sequential), their performance was poorest on the Sequential pattern in 18 of the 22 studies. Within the Sequential pattern, poor readers performed significantly worse than good readers on Digit Span and Coding but not on Picture Arrangement.

Rugel (1974) concluded that the sequential processing deficit comprised deficiencies in short-term sequential memory and attentional processes. The relationship between reading disability and these processes will be discussed below.

a) Short-term Sequential Memory Processes

The three most popular screening measures for diagnosing short-term memory deficits among disabled readers have been the Auditory and Visual Sequential Memory subtests of the ITPA (Kirk, McCarthy, & Kirk, 1968) and the Digit Span subtest of the WISC (Wechsler, 1949) or WISC-R (Wechsler, 1974). Studies differ greatly as to whether or not there exists a significant difference between disabled and normal readers on these measures (e.g., Rugel, 1974; Kass, 1966; Golden & Steiner, 1969).

Investigators interested in studying good and poor readers' ability to remember meaningful verbal material have found group differences on sentence repetition tasks (Waller, 1976; Richie & Aten, 1976). The process of sentence repetition is interpreted to be a complex one involving comprehension and expression of language as well as memory (Vogel, 1975). Performance on tasks of this nature has sometimes been contrasted to performance on digit span tasks or tasks of random word order in order to compare the dimensions of memory for meaningful and nonmeaningful material. Richie and Aten (1976) found that reading disabled children performed poorly on both types of tasks.

Difficulty in remembering both meaningful and nonmeaningful material can affect the acquisition of various reading skills. For instance, memory for discrete items plays an important role in learning grapheme-phoneme correspondences (Torgesen, 1978-79). Vernon (1977) hypothesized that memory for the sequence of items was crucial to learning the patterns of letter sequences and that the production of letter sequence reversals was related to difficulty remembering the visual shapes of words. Bakker (1970) provided evidence for the relationship between sequential memory and reading errors when he demonstrated that children who did poorly on tasks of temporal order processing made a large number of letter sequence reversals. Memory has also been associated with retaining the meaning of a sentence or a story. Poor readers who decode slowly are thought to have difficulty grasping the meaning of whole sentences because slow and laborious reading taxes the memory for connecting words and phrases (Vernon, 1977).

b) Attentional Processes

Researchers have related reading disabilities to shortened attention span and hyperactivity. Pavlidis (1981) stated that "some dyslexics are (also) accident-prone, hyperactive, easily distractible, with a low level of tolerance and very poor concentration" (p. 102). Hunter and Johnson (1971) provided evidence that disabled readers were significantly inferior to controls on the WISC Digit Span and Coding subtests and on a "tested attention" score (the sum of WISC Arithmetic and Digit Span subtests). Hunter and Johnson (1971) concluded that the poor performance of reading disabled children on WISC Digit Span, Arithmetic and

Coding subtests reflected an inability to focus upon stimuli for a sustained period.

Attention span has also been examined through the study of eye movements. Lefton, Lahey, and Stagg (1978) compared eye movement strategies used by adults, and normal and reading disabled children while they tried to match groups of letters. Results indicated that when attention had to be maintained for more than five seconds, the eye movement search patterns of reading disabled children became erratic and error rates rose steeply. The authors concluded that these children were unable to use a positive systematic sequential examination under sustained attention. Pavlidis (1979) also found that when disabled readers were asked to 'hold' their eyes for a few seconds on a light stimulus, they were unable to do so for more than a second or two.

D. Subgroups of Disabled Readers Based on Psychological Characteristics

The studies reviewed in the previous section compared able and less able readers on one or several dependent variables. While many studies reported significant differences between reader ability groups' performance on these variables, others failed to find any such differences. Inconsistencies were also found within studies in that some poor or disabled readers performed poorly on a test while others did not. Thus, it seems clear that at the lower level of performance in reading, subjects are heterogeneous with respect to psychological attributes.

The fact that so many different variables are correlated with reading disability has led researchers to try to identify subgroups of disabled readers, defined in terms of distinctive patterns of psychological deficits. Relevant research will now be examined.

1. Nonstatistical Classifications

One approach to classification is the clinical inferential approach. This method involves subdivisions of the data that are based on clinical diagnostic judgements and direct observation of interrelated test scores (Lyon & Watson, 1981). Mattis, French, and Rapin (1975) used this approach when they isolated independent clusters of deficiencies in reading disabled children. Subgroups were determined from a wide range of test variables. The largest proportion of disabled readers (39%) had primary disorders in language development, with anomia (i.e., word finding difficulty) as the critical factor. Other characteristics in the syndrome included deficiencies in listening comprehension, speech/sound discrimination and in short-term memory for sentences. The second pattern or syndrome, found almost as frequently as the first (37%), comprised speech dysarticulation (including poor sound blending) and gross and fine motor dyscoordination. The third syndrome, representing the smallest proportion of disabled readers (16%), was characterized by a marked disorder of visuo-spatial perception.

Denckla's (1977) study examined children who had some form of minimal brain dysfunction and serious difficulty in reading and spelling. Based on clinical inferential classification, three syndromes were identified. A language disorder group accounting for 65% of the sample was subdivided into three subgroups consisting of disorders of anomia, dysphonemic sequencing (i.e., repetitions characterized by phonemic substitutions and missequencing) and a combination of the two. Mattis et al.'s (1975) articulatory-graphomotor dyscoordination pattern was replicated, but included only 12% of the sample. Denckla (1977) also isolated a syndrome of verbal memorization disorder (10%) which included impairment in sentence repetition and verbal paired-associate learning. These syndromes accounted for 92% percent of the sample. Unlike Mattis et al.(1975), Denckla (1977) did not find a pure visuo-spatial group. Although Mattis agreed with Denckla's (1977) subdivisions of the language deficit he found that the visuo-spatial syndrome was still viable in a later study (1978) of disabled readers' syndromes. Inconsistencies across studies weaken the reliability of the subgroup classifications which are based on the clinical inferential approach. However, sample differences in the studies reviewed make direct comparison difficult.

2. Statistical Classifications

The statistical approach to classification is generally preferred over the clinical inferential approach because the use of complex multidimensional measures makes it difficult or impossible to determine the true structure of the data without the use of statistical techniques (Satz & Morris, 1980). Both the Q-technique of factor analysis and cluster analysis techniques have been used in research concerning the classification of disabled readers. Studies using cluster analysis will be presented first, followed by research which classified subjects on the basis of the Q-technique.

Satz and Morris (1980) administered tests of language (WISC Similarities, Verbal Fluency) and perceptual abilities (Beery's VMI Test, Recognition Discrimination) to 89 11-year-old learning disabled boys. A number of different clustering techniques were used as a reliability check for the five subtypes which emerged. Results indicated that the five subtypes were replicated in terms of profile elevation, pattern, and sample sizes. The titles used to describe these subtypes were global language impairment; specific language impairment in naming (Verbal Fluency); mixed language and perceptual impairment; visual-perceptual-motor impairment, and no impairment. Although the stability of the classifications was high, the study was flawed by its use of only four variables as the basis for grouping subjects. If a greater number of processes had been sampled, the deficiencies of the fifth subgroup may have been revealed.

Another study which used the cluster analysis technique to classify reading disabled children into subgroups was that of Lyon and Watson (1981). In this study, a group of 100 reading disabled children between 11 and 12.5 years of age was given a test battery of eight language, memory, and perceptual measures. Subjects were also given a test of reading recognition and reading comprehension (Peabody Individual Achievement Test). Both raw scores and standard scores yielded the same six subgroups in independent cluster analyses. Subgroups 1 and 2 had mixed deficiencies across language, memory, and perceptual measures, but the deficits of the former subgroup were more severe than those of the latter. In addition, Subgroup 1 children had negligible sight vocabulary and poor word attack skills, corroborating Boder's (1971) observation that children with combined auditory-visual deficits are likely to achieve only minimal proficiency in reading skills. Subgroup 3 children had language-based deficits, while Subgroup 4 had deficiencies in visuoperceptive abilities. The fact that Subgroup 4 had the largest membership (34%) supports recent findings (Mattis et al., 1975; Mattis, 1978; Satz & Morris, 1980) that visuoperceptive disorders are a primary area of deficiency for older reading disabled children. Subgroup 5 was characterized by an inability to remember and correctly sequence auditory information. Subgroup 6 had a normal diagnostic profile on the psychological tests. Lyon and

Watson (1981) suggested that the reading difficulty of children in Subgroup 6 may be due to social, motivational, or pedagogical factors rather than to some inherent defect.

Lyon and Watson (1981) compared the subgroups on word recognition and reading comprehension skills. Significant differences among the six subgroups were found for both skills.

Decker and Defries (1981) gave a test battery to a large number of disabled readers and their siblings and parents, and to matched control families. The test scores were factor analysed and three ability dimensions emerged which measured reading achievement, spatial reasoning and coding speed. Disabled readers were then classified according to how individual profiles grouped together on these dimensions. The advantage of restricting the number of tests to a few highly independent factors was that the reliability of test variables was increased (Satz & Morris, 1980). Reliable variables were expected to yield a more reliable classification system (Satz & Morris, 1980). Four subgroups emerged from the three ability dimensions: reading and spatial/reasoning disabilities; reading and coding/speed disabilities; reading, spatial/reading and coding/speed disabilities, and reading disability alone. Because the test battery did not measure verbal abilities, the significance of these subgroups is limited. The limitations of the study are emphasized by the finding that fifty percent of the disabled readers were classified in the 'reading disability alone' subgroup. Many of the children in this subgroup may have had no measured psychological deficit because of the absence of tests of verbal abilities.

Petrauskas and Rourke (1979) used the Q-technique of factor analysis in order to group seven- and eight-year-old disabled readers on the basis of their performance on neuropsychological measures. The analysis yielded five subgroups, only three of which were found to be reliable.

Subgroup 1 included the largest number of subjects and was characterized by poor verbal skills and well-developed visual-spatial abilities. The second subgroup was marked by linguistic sequencing deficiencies. Subgroup 3's primary deficit was in concept formation where verbal coding was involved (Matching Pictures Test). While each subgroup had distinguishing characteristics, all subgroups had deficiencies in verbal fluency and sentence memory tests.

Fisk and Rourke (1979) investigated children with general learning disabilities at three age levels (9-10 yrs.; 11-12 yrs.; 13-14 yrs.) in order to determine which subgroups could be replicated across age levels. Three patterns of deficiencies were found across the three age levels. The first subgroup had linguistic and sequencing problems similar to Petrauskas and Rourke's (1979) second subgroup. In addition, the subgroup was impaired on tasks of finger localization and fingertip writing. Subgroup 2 resembled Petrauskas and Rourke's (1979) first subgroup, with deficient linguistic skills and well-developed visual-spatial abilities. Subgroup 3 had a marked deficiency in identifying numbers written on the fingertips as well as moderate linguistic and sequencing problems. This third subgroup seemed to be a variation of the first, and did not include the 9- to 10-year-olds.

The studies using the Q-technique method of classification are limited by poor sample coverage. Low coverage was the result of the elimination of subjects with substantial loadings on more than one factor or with no substantial loadings on any factor. Another limitation of all the studies reviewed in this section is that they have been primarily concerned with the neurological attributes of disabled readers and therefore the relationship of the subgroups to patterns of reading deficits has been neglected.

Only one study known to the present author has attempted to establish a link between reading disabilities and neuropsychological characteristics by statistical methods. Doehring, Trites, Patel, and Fiedorowicz (1981) first used the Q-technique to identify subgroups of reading skills and deficits. The tests used were the same as those employed in an earlier study by Doehring and Hoshko (1977). The 1981 study used neuropsychology clinic children as subjects, while the 1977 study used children attending a summer reading program. Despite these differences, the subgroups were very similar in both studies. Group one was characterized by exceptionally poor oral syllable reading.

Group two was distinguished by an intermodal association deficit and group three, by difficulty in responding to sequences of letters as units. Although both studies reported that a quarter of the sample had substantial loadings (>.40) on more than one factor, only the later study classified those subjects with mixed disabilities. This finding challenges other researchers' (e.g., Fisk & Rourke, 1979; Petrauskas & Rourke, 1979) assumption that subjects with substantial loadings on more than one factor should be disregarded in the search for homogeneous subtypes.

Doehring et al. (1981) also administered tests of language abilities, cognition, and neuropsychological skills to their sample. A Q-technique of factor analysis was conducted in order to determine if nonreading deficit subgroups could be associated with subgroups of children with reading skill deficiencies. The results, however, were complex and did little to advance an understanding of the reading difficulties originally defined by the Q-technique. Doehring et al. (1981) suggested that the use of tests which more directly assess reading skills might help clarify the characteristics of disabled readers.

E. Conclusions

The studies which have been reviewed in this chapter provide evidence for the heterogeneity of reading skill deficiencies and psychological variables associated with reading ability. There is a need to directly assess reading skills and to use statistical classification procedures for determining subgroups of children with reading skill deficiencies. There is also a need to assess a variety of psychological abilities and to ascertain if patterns of these abilities can be linked to patterns of reading skill deficiencies. A study which attempts to meet these needs is described in the following chapter.

III. THE STUDY

The research reviewed in the preceding chapter provided support for the hypothesis that there are subgroups of reading disabled children which are distinguished on the basis of their performance on psychological and neuropsychological tests. However, this researcher could locate no research utilizing objective statistical methods to classify disabled readers on the basis of oral reading strategies. Furthermore, researchers have only begun to explore the possibility of predicting oral reading strategies from the psychological profiles of disabled readers.

The present investigation was conducted in order to: (1) determine if disabled readers could be classified into subgroups based on their oral reading strategy; (2) determine if subgroups identified in (1) could be predicted from their patterns of performance on psychological measures.

The disabled readers identified for the present investigation met the following criteria of specific reading disability:

1. Primary academic difficulty in reading;
2. Normal or corrected visual and auditory acuity;
3. No evidence of emotional disturbance or environmental deprivation;
4. Verbal and/or Performance IQ greater than or equal to 90;
5. A discrepancy of one year or more between oral

instructional reading level and expected grade placement (i.e., grade placement appropriate for chronological age). This operational definition of reading disability is based on the criteria proposed by Tallal (1980). In addition to the above criteria, the restriction that all subjects came from homes where English was the primary language was imposed so that children whose reading problem was a result of lack of familiarity with the English language would be excluded from the sample.

A. Selection Criteria for Subject Identification

Children selected for study were attending grades three to six. All children received instruction in a regular classroom. However, most had received and/or were receiving remedial reading instruction in a resource room as well. A diagnosis of oral reading difficulty was considered to be more reliable for children within this grade range than for children in grades one and two because children in the earlier grades were considered to be still acquiring basic decoding skills. Children were initially chosen on the basis of their previous grades' scores on the Edmonton Public School Board (EPSB) test for reading and mathematics and on their third or sixth grade IQ scores on the Canadian Cognitive Abilities Test (CCAT). Because children selected for the present study were those with a specific learning disability in reading, children with math difficulties were excluded from the study. Thus, a potential subject was identified when a child obtained a reading grade score at or below the 15th percentile level and a mathematics grade score at or above the 40th percentile level. Subjects selected were also required to have an IQ score equal to or above 90 on the Verbal and/or Nonverbal IQ scale of the CCAT.

Following this initial screening procedure, the current academic performance of the children was verified with the classroom teacher before a decision to include them in the study was made. Occasionally the academic performance of children selected for study on the basis of the EPSB test was considered by the classroom teacher not to be below grade level. These children were therefore excluded from the study. In several cases additional children who were described by their teachers as poor in oral reading but average in math were included in the list for potential investigation.

Once parental permission had been obtained for the child to enter the study, subjects were screened by the present investigator to ensure that their oral reading was indeed at least one year below expected grade level. The Diagnostic Reading Scales-Revised Edition (Spache, 1972) were used to provide this documentation. At this point, several children were found to be reading at grade level and were excluded from the study. Subjects were given the WISC-R to ensure that Verbal and/or Performance IQ was at least 90.

In short, final selection of 41 subjects was conducted on the basis of teacher judgement of the child's oral reading and math abilities, confirmation on a standardized reading test that his oral reading instructional level was at least one year below expected grade level, and a Verbal and/or Performance IQ greater than or equal to 90.

Subjects ranged in age from eight years, five months to thirteen years, three months. There were seven subjects in grade three, sixteen in grade four, eleven in grade five, and seven in grade six. The average Performance Scale IQ on the WISC-R was 106.7, slightly higher than the average Verbal Scale IQ of 100.3. However, the difference was not statistically significant. Fifteen subjects had repeated at least one grade. The sample consisted of 22 males and 19 females. A description of the subjects by IQ and chronological age is provided in Table 1.

Table 1
IQ, Grade Placement, and
Chronological Age of Subjects

Descriptive Variables	N	Mean	SD	Range
WISC-R IQ:				
Verbal Scale IQ	41	100.3	10.3	77-120
Performance Scale IQ	41	106.7	11.7	85-131
Full Scale IQ	41	103.5	9.9	84-121
Chronological Age[1]:				
Grade 3	7	112.0	9.0	101-122
Grade 4	16	119.5	7.9	110-137
Grade 5	11	132.5	10.2	124-156
Grade 6	7	146.6	9.0	135-159

[1] Reported in months

As a whole, the sample appeared to be slow and inaccurate readers with adequate skill in comprehension. Spache's test assesses comprehension by asking a number of questions which require primarily convergent-type answers at the end of each passage. Degree of reading retardation (i.e., the difference between expected grade placement and oral reading instructional level) ranged from one to three years. The average degree of reading retardation for grade six subjects was 2.6 grades in contrast to 1.6 grades for grade three subjects. This difference does not signify a more severe level of reading disability among grade six than among grade three subjects because at both grade levels subjects were reading at approximately half the grade level expected of them. Description of the subjects' reading achievement levels is provided in Table 2.

Table 2
Levels of Reading Achievement

Reading Variables	N	Mean	SD	Range
Degree of Reading Retardation:				
Grade 3	7	1.6	0.6	.9-2.5
Grade 4	16	1.7	0.8	.9-3.1
Grade 5	11	1.9	0.8	1.2-3.0
Grade 6	7	2.6	0.5	2.2-3.3
Reading Rate:[1]				
Grade Placement	41	78.8	21.6	28-113
Instructional Level	41	97.0	23.2	36-137
Comprehension:[2]				
Grade Placement	41	74.9	18.3	25-100
Instructional Level	41	85.8	11.5	57-100

[1] words read per minute
[2] the percent of questions correctly answered on the passage read.

B. The Test Battery: Reading Assessment

The test battery included a reading assessment and a psychological assessment. The reading test that was designed to provide a comprehensive assessment of word attack skills will be examined in this section.

Spache's Diagnostic Reading Scales-Revised Edition (1972) was first used to provide an index of oral reading frustration level. Frustration level was reached when reading errors exceeded the cutoff point which was recommended by the test author for each passage. The cutoff point was determined by a performance of one standard deviation or more below the mean found for normal readers for the oral reading of the passage. The reading error types used to determine frustration level were as follows: Omissions, Additions, Substitutions or Mispronunciations, Repetitions, Reversals, and Words Aided. Oral reading instructional level was reached when the total number of errors did not exceed the cutoff point. A detailed description of Spache's (1972) error categories is presented in Appendix A.

The Diagnostic Reading Scales also provided the basis from which to assess subjects' word attack skills. The oral reading analysis consisted partly of quantitative scores determined by the frequency with which each error category occurred, and which were expressed as percentages of the total number of errors made by the subject. It should be noted that more than one error type could occur in one word.

The error categories used in the present study were developed by the author from currently used oral reading tests (e.g., Diagnostic Reading Scales, 1972; Gray's Oral Reading Test, 1963) and a pilot study conducted by the author. It was decided to combine error categories from a number of sources because it appeared that no one oral reading test provided a comprehensive and reliable classification of errors (Hood, 1975-76; Weber, 1968). Thus, a compilation of error categories derived from various reading tests was used in a pilot study, which was then refined on the basis of the data obtained. Operational definitions of the error types used to analyze subjects' oral reading strategies are provided below.

1. Quantitative Scales

a) Additions: whole word additions

b) Omissions: whole word omissions

c) Structural Analysis errors: (i) substitution errors due to the omission, addition, or substitution of endings such as er, est, s, ed, ing and n (e.g., America-American; flowers-flower); (ii) substitution errors due to the omission, addition or substitution of suffixes (e.g., ly, less, tion), prefixes (e.g., re, mis, non) and possessives ('s); and (iii) errors due to the contraction of words that are not contracted in the text (e.g., was not-wasn't), or errors due to the expansion of words eliminated in a contraction (e.g., can't-cannot). Structural analysis errors do not include additions to the text that involve contractions (e.g., was-wasn't), nor do they include endings lost or gained in cases such as a real-really, flowers-the flower, a buyer-the buyers.

d) Grapheme-Phoneme errors: substitution errors within which there is the substitution or omission of a single vowel or consonant sound (e.g., freight-fright; seem-see). Grapheme-phoneme errors also include the addition of a sound that should remain silent (e.g., whistle-whistle). Single sound substitutions which are due to changes in structural analysis are not recorded as grapheme-phoneme errors, but as structural analysis errors (e.g., likes-liked; has-had).

e) Letter Orientation Reversals: substitution errors due to letter orientation reversals (b-d; p-q) and/or rotations (b-p; d-q; u-n).

f) Letter Sequence errors: substitution errors due to letter sequence reversals involving parts of words (e.g., form-from) or whole words (was-saw). Substitution errors due to letter sequence reversals must involve the same letters as the target word, with the exceptions that letters may be added to the ending of the substitution errors (e.g., of-for;for-from) and/or that there may be a change in vowel sound (e.g., calm-claim). Letter sequence errors do not include letter sequence reversals where letters are omitted in the substitution (e.g., from-of; from-for).

g) Scanning errors: errors which occur when a whole line of text is missed; a whole line of text is repeated; a word is read which is directly above or below the word that should have been read; or word order, or order of word endings, is reversed (e.g., in only-only in; John Paul's-John's Paul).

h) Repetitions: errors which are due to the repetition of two or more complete words when the same words are repeated.

i) Words Aided or Mumbled: words which are aided after ten seconds of no vocalization or when aid is requested, or words mumbled in such a way as to prevent the examiner from recording a graphemic translation of the mispronunciation.

j) Nonsense Words: substitution errors which are not meaningful in the English language.

In addition to these error categories expressed in quantitative terms, qualitative scores derived from Goodman and Burke (1972) were used to assess the degree to which each error was visually similar and linguistically appropriate in relation to the text. Scanning errors, Repetitions, and Words Aided or Mumbled were excluded from evaluation on these scales. The scales employed by Goodman and Burke (1972) and the modifications made to them for the present study are listed below.

2. Qualitative Scales

On each of the four qualitative scales (i.e., Visual Similarity, Grammatical Relationship Patterns, Meaning Change, Degree of Correction) each subject is given a percentage score based on his/her sum of scores divided by the maximum score that is possible to attain on that scale. For example, the maximum score that a subject can attain on the Visual Similarity scale if a total of eight errors is being considered is 4x8=32. If a subject received a total score of 24 on these eight errors, his Visual Similarity Scale score would be 24/32=75%. The total number of errors excludes scanning errors, repetitions and words aided or mumbled.

a) Visual Similarity: The criterion of visual similarity used by the author is similar to Goodman and Burke's (1972) in that errors are evaluated according to the degree of visual similarity between the error and the text. Goodman and Burke (1972) assess the degree of similarity by breaking down each word into three portions -- beginning, middle, end -- and judging the degree of similarity between the reader's response and the target word. However, in the present study the reader's response and the target word are compared letter by letter. A letter-by-letter comparison of errors and target words provided a more reliable scoring procedure since the terms beginning, middle, and end were not adequately operationalized by Goodman and Burke (1972). The scale used was adapted from Pflaum's (1979) Phonic Similarity scale. Errors received a score ranging from 0 to 4 as follows:

0 = No letters shared;

1 = Response contains 1 to 25 percent of target word's letters;

2 = Response contains 26 to 50 percent of target word's letters;

3 = Response contains 51 to 75 percent of target word's

letters;

4 = Response contains 76 to 100 percent of target word's letters.

b) Grammatical Relationship Patterns: Errors are evaluated according to the interrelation of Degree of Correction, Grammatical Acceptability and Semantic Acceptability. According to Goodman and Burke (1972), these three scales can be interrelated "to produce patterns which give insight into how concerned the reader is that his oral reading sounds like language" (p. 71). A description of the Degree of Correction, Grammatical Acceptability, and Semantic Acceptability scales precedes a demonstration of the integration of the three scales into one scoring system.

(i) Degree of Correction: Errors are evaluated according to the degree to which an error is corrected by the reader (Goodman & Burke, 1972). Errors received one of the following codes:

N - No attempt at correction is made.

P - An unsuccessful attempt at correction is made, or a correct respone is abandoned.

Y - The error is corrected.

(ii) Grammatical Acceptability:

Errors are evaluated acording to the degree to which the reader's errors are grammatically acceptable within sentence and passage (Goodman & Burke, 1972). A nonsense word can be scored as being grammatically acceptable if it maintains the grammatical structure of the target word (e.g., chirped

-chippered). Each error assessed received one of the following codes:

N - The error occurs in a sentence which is not grammatically acceptable.

P - The error occurs in a sentence which is grammatically acceptable but is not acceptable in relation to prior and subsequent sentences in the text. Or the error is grammatically acceptable only within the sentence portion that comes before or after it.

Y - The error occurs in a sentence that is grammatically acceptable.

(iii) Semantic Acceptability: Errors are evaluated according to the degree to which the reader's errors are understandable or meaningful within sentence and passage. Semantic acceptability is dependent on grammatical structure and should never be marked higher than grammatical acceptability (Goodman & Burke, 1972, p. 60). Nonsense words are always scored as semantically unacceptable. Each error assessed received one of the following codes:

N - The error occurs in a sentence which is not semantically acceptable.

P - The error occurs in a sentence which is semantically acceptable but is not acceptable in relation to prior or subsequent sentences in the text. Or the error is semantically acceptable only with the sentence portion that comes before or after it.

Y - The error occurs in a sentence which is semantically acceptable.

According to Goodman and Burke (1972), errors which are evaluated by the Grammatical and Semantic Acceptability scales should be judged within the context of the entire sentence, with all uncorrected errors included. This procedure was found to be unsatisfactory in the present study because errors were frequently being penalised as a result of the linguistic inappropriateness of other errors which occurred in remote parts of the same sentence. Therefore, it was decided that an error would be penalised as a result of the linguistic inappropriateness of another error only if both occurred within the same clause.

To determine the overall Grammatical Relationship Pattern of each error, all were assigned to one of four categories according to the pattern they exhibited in Degree of Correction, Grammatical Acceptability, and Semantic Acceptability. These categories are listed in Table 3.

The reader's skill in using Grammatical Relationship Patterns was scored as follows:

0 = Weakness (i.e., fails to use grammatical or semantic cues)

1 = Partial Strength or Overcorrection (i.e., fails to use semantic cues successfully, or corrects errors which are already grammatically and semantically acceptable)

2 = Strength (i.e., uses grammatical and semantic cues appropriately)

Table 3
Grammatical Relationship Patterns

STRENGTH a+b+c[1]	PARTIAL STRENGTH a+b+c	WEAKNESS a+b+c	OVER CORRECTION a+b+c
Y+N+N	N+Y+N	N+N+N	Y+Y+Y
Y+P+N	N+Y+P	N+P+N	P+Y+Y
Y+Y+N	P+Y+N	N+P+P	
Y+P+P	P+Y+P	P+N+N	
Y+Y+P		P+P+N	
N+Y+Y		P+P+P	

[1]a = Degree of Correction
b = Grammatical Acceptability
c = Semantic Acceptability

c) Comprehension Patterns: Errors are evaluated according to the interrelation between Degree of Correction, Semantic Acceptability, and Meaning Change. These three scales "produce a pattern which gives insight into whether there has been meaning loss" (Goodman & Burke, 1972, p. 75). A description of the Meaning Change Scale precedes a demonstration of the integration of the three scales into one scoring system.

(i) Meaning Change: Errors are evaluated according to the degree of the child's digression from the basic intent of the author. Unlike the Grammatical and Semantic Acceptability Scales, no other errors in the sentence are read when assessing the degree of meaning change in the error being coded (Goodman & Burke, 1972). Errors are scored according to the following criteria:

N - No change in the basic intent of the author is involved.

P - There is a minor shift in the author's focus without altering the basic intent of the author.

Y - There is an extensive shift in the basic intent of the author.

To determine the overall Comprehension Pattern of each error, all were allocated to one of three categories according to the pattern they exhibited in Degree of Correction, Semantic Acceptability, and Meaning Change. The three categories are listed in Table 4.

Table 4
Comprehension Patterns

NO LOSS a+b+c[1]	PARTIAL LOSS a+b+c	LOSS a+b+c
Y+Y+N	N+P+P	N+N+P
Y+P+P	N+Y+P	N+N+Y
Y+P+Y	P+Y+N	N+P+Y
Y+N+Y	P+Y+Y	P+N+Y
N+Y+N	N+Y+Y	P+P+Y
N+P+N	P+N+P	
Y+P+N	P+P+P	
Y+N+N	P+Y+P	
N+N+N	P+P+N	
Y+Y+P	P+N+N	
Y+N+P		
Y+Y+Y		

[1] a = Degree of Correction
b = Semantic Acceptability
c = Meaning Change

The reader's skill in using Comprehension Patterns was scored as follows:

0 = Loss of Comprehension

1 = Partial Loss of Comprehension

2 = No Loss of Comprehension

d) Degree of Correction: In the present study, Degree of Correction was used as an independent category as well as part of Grammatical Relationship Patterns and Comprehension Patterns. When using Degree of Correction as an independent category, the codes N, P, and Y were assigned the numerical values of 0, 1, and 2, respectively. A summary of the measures and scoring method used for oral reading analysis is provided in Appendix B.

Other measures provided by the Diagnostic Reading Scales included Reading Rate (measured by words read per minute) and Passage Comprehension. The Passage Comprehension score was the percentage of questions answered correctly on any given passage.

C. The Test Battery: Psychological Assessment

The psychological measures and the processes which they are thought to assess are listed below.

1. Visual-Spatial Development
   a. WISC-R Nonverbal Measures (Wechsler, 1974):
      Block Design
      Picture Completion
      Object Assembly

Picture Arrangement

Coding

Performance Scale IQ

b. Developmental Test of Visual-Motor Integration (Beery & Buktenica, 1967)

c. Purdue Perceptual Motor Survey (Roach & Kephart, 1966); Ocular Pursuits Tests:

Convergence

Tracking

d. Left-Right Discrimination (Laurendeau & Pinard, 1970)

2. Verbal Abilities

a. WISC-R Verbal Measures (Wechsler, 1974):

Information

Comprehension

Similarities

Arithmetic

Vocabulary

Verbal Scale IQ

b. Wepman's Auditory Discrimination Test -- Form 1A (Wepman, 1973)

c. ITPA (Kirk, McCarthy, & Kirk, 1968):

Auditory Closure

Sound Blending

d. Word Fluency (Spreen & Benton, 1969)

3. Intersensory Integration

   a. VADS Test (Koppitz, 1977):

      Aural-Oral Subtest

      Visual-Oral Subtest

      Aural-Written Subtest

      Visual-Written Subtest

      VADS Total

   b. Sound [illegible] Association (Spache, 1972)

   c. Symbol [illegible] Association (Spache, 1972)

4. Sequential Processing

   a. WISC-R Subtests:

      Digit Span

      Arithmetic

      Coding

   b. VADS Test

   c. Sentence Repetition (Spreen & Benton, 1969)

   d. Attention:

      Davids' Rating Scale of Hyperkinesis (1971):

      Hyperactivity

      Short Attention Span

      Variability

      Impulsiveness

      Irritability

      Explosiveness

      Davids' Total

D. Procedure

Subjects were tested individually by the present author. Subjects were first required to read passages from Spache's Diagnostic Reading Scales. A series of passages read in succession from frustration to instructional level would probably have caused fatigue in the reader and would have resulted in an inaccurate measure of instructional level. Therefore, subjects were given a mixed sequence of difficult and easier passages, interspersed with the administration of psychological tests, until reading instructional level was determined. Because the investigator wished to obtain a reliable sample of each child's types of reading errors and reading strategies, alternate-form passages from the Diagnostic Reading Scales were sometimes given to subjects to read. Thus, while instructional and frustration reading levels were always determined by subjects' performances on Form A, Form B was used when it was necessary to obtain a larger sample of reading errors. Testing stopped when a minimum of 40 oral reading errors was produced by each subject and instructional level was attained.

All oral reading was tape recorded to provide a check on the Examiner for the accurate recording of errors. The recording also permitted the Examiner to time each child's reading rate outside of the testing situation so that a potentially anxiety producing factor was eliminated. Reading errors were recorded and analyzed according to the coding sheet illustrated in Appendix C. Following the reading of each passage, subjects were asked related comprehension questions.

The psychological tests were administered in a constant order within two testing sessions. The writer did not administer the WISC-R when the child had been given the test within the previous year and-a-half by school psychologists. The order in which the tests were given is listed below:

WISC-R
Symbol-Sound Association
Word Fluency
Wepman's Auditory Discrimination Test
Sound Blending
Auditory Closure
VADS Test
Developmental Test of Visual-Motor Integration
Sound-Symbol Association
Sentence Repetition Test
Ocular Motor Control
Left-Right Discrimination

The final measure used in the study was the Davids' Rating Scale for Hyperkinesis (Davids, 1971). Following assessment of each child, classroom teachers rated their student's activity level on the Davids' scale.

E. Questions for Investigation

The present study was designed to investigate the following questions:

1. Can subgroups of disabled readers be determined on the basis of a statistical analysis of reading strategies? If so, what are the distinguishing features of these subgroups?
2. Can subgroups of disabled readers be determined on the basis of a statistical analysis of psychological characteristics? If so, what are the distinguishing features of these subgroups?
3. Can reading strategies be predicted from psychological abilities?
4. Is there a correspondence between the membership of the subgroups established on the basis of psychological abilities and the membership of those established on the basis of reading subskills?

F. Analysis of Data

Several statistical procedures were used to analyze the data in this investigation. These procedures are listed below:

1. The DERS[1] Principal Components Factoring (Fact20) program was used to analyze test score patterns of reading and psychological variables combined.

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[1]Program developed by the Division of Educational Research Services, Faculty of Education, University of Alberta.

2. To assess the overall predictability of oral reading errors and strategies from psychological abilities, the SPSS[2] Canonical Correlation program was employed.
3. The SPSS Descriptive program provided measures of central tendency (i.e., mean and standard deviation) for reading and psychological measures. In addition, the SPSS Manova program was used to discover if there were any sex differences on both types of measures.
4. Separate factor analyses of the reading and psychological variables were conducted by means of the DERS Fact20 program. The DERS (Fact23) Factor Estimates program provided factor scores for each factor analysis.
5. The CLUSTAN (Wishart, 1978) program was used to classify subjects on the basis of: a) reading factor scores, and b) psychological factor scores.
6. Interpretation of the subgroup characteristics was facilitated by the SPSS program for Oneway Anovas and Scheffes.
7. The predictive relationship between psychological measures and reading patterns was investigated through: a) the SPSS Regression program, using the reading factor scores as criterion variables and the psychological variables as predictors; b) the SPSS program for Oneway Anovas and Scheffes, and the DERS (Mulv16) One-way Multivariate Analysis of Variance and Covariance program; and c) a crosstabulation indicating the members

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[2] Statistical Package for the Social Sciences

shared across reading and psychological subgroups.

G. Limitations of the Study

There were several limitations of the study.

1. The relatively small number of subjects is a limitation of the study because it detracts from the reliability and validity of the clusters.
2. The absence of a control group is another limitation of the study. Difficulties in using a control group included having its members make 6 to 15 percent errors on passages. Because good decoders tend to make very few oral reading errors when reading passages within their range of functioning, it was decided that they should be excluded from the present study.
3. The investigator had intended to sample a roughly equal distribution of children across socioeconomic levels. However, the majority of children meeting the final selection criteria were from lower class backgrounds. The present findings, therefore, remain limited to children from lower socioeconomic backgrounds.
4. Although the investigator obtained a sample of 40 oral reading errors from each subject, only a proportion of those errors were actually used in the data analysis. Researchers (e.g., Leslie, 1980) have shown that patterns of reading errors and strategies change as the level of passage difficulty increases. Therefore, it was necessary to exclude some passages from the analysis in

order to ensure that all errors examined were made on passages of the same difficulty level. However, this restriction limited the reliability of the reading errors made by subjects because fewer errors were examined for each subject. Fortunately, most subjects read more than one passage within the designated passage difficulty range. Averaging these subjects' oral reading performance across passages helped increase the reliability of their performance.

IV. RESULTS AND INTERPRETATION

The results of the present study will be presented in four sections. In the first section, a preliminary analysis of the relationship between psychological and reading variables is presented. In the following two sections, separate discussions of the reading and psychological data are presented. A description of the overall reading and psychological characteristics of the subjects is provided, as well as a discussion of the factors and subgroups based on each type of data. Finally, the relationship between the reading and psychological data is examined.

A. Preliminary Analysis

The first problem addressed in the present study was to determine the overall relationship between the reading and psychological measures which were selected for investigation. Two criteria were used to determine the measures which would be used subsequently to identify subgroups: 1) variables which had little or no discriminatory power between subjects were excluded; 2) reading and psychological variables which were statistically unrelated to each other were excluded. Finally, a canonical correlation (SPSS CANCORR program) was computed to determine whether a significant overall relationship existed between the remaining reading and psychological variables.

1. Variables Excluded Due to Lack of Discriminatory Power

Certain tests failed to discriminate between subjects because performance was almost always at ceiling level. The psychological variables which were excluded because of a lack of discriminatory power were Sound Blending (ITPA) and Ocular Convergence (Purdue). The error type, Letter Orientation Reversals, was excluded from the reading measures for the same reason. In addition, the six subscales of Davids' Hyperkinesis Scale were replaced by the total score on the scale in order to increase variability on this measure.

2. Factor Analysis of Reading and Psychological Variables

The DERS Principal Components Factoring (Fact20) program with varimax rotation was used to provide information about the relationships between the oral reading strategies and psychological abilities measured in the present study. The information obtained from the factor analysis revealed which of the psychological and reading variables were related to each other.

In order to select appropriate factor solutions for each of the factor analyses performed in the present study the following criteria were employed:

1. The number of factors selected was determined by the most meaningful factor solution.
2. A factor loading of .400 or above was considered to be significant.
3. Any variable contributing less than .400 on at least one

factor was considered to lack sufficient defining powers for the factor solution and was excluded from the analysis.

4. Any psychological variable was considered to lack sufficient relationship to the reading variables if it did not load on a factor upon which reading variables also loaded. Reading variables which did not load significantly on a factor upon which psychological variables loaded were excluded for the same reason.

Psychological measures which were excluded were Symbol-Sound and Sound-Symbol Association, Left-Right Discrimination and Word Fluency. Reading variables which did not meet the criteria of acceptability were Consonant and Vowel errors and Grammatical Relationship Patterns. In addition, it was decided that the VADS Total score would be substituted for the VADS subtest scores because the subtests did not add to the interpretability of the factor solution. Finally, the percentages of Omissions and Additions made during reading were combined into a single variable of Omissions-Additions because of their high loadings on the same factor.

The remaining 26 psychological and reading variables were included in the five factor solution which is reported in Table 5. Factor I is a verbal factor with a strong auditory sequential memory component. The tests with the highest loadings were the verbal subtests from the WISC-R, and measures of auditory memory and discrimination. The VADS

Table 5

Factor Analysis of Psychological and Reading Variables

Variables	Factors I	II	III	IV	V
Information	.385	.513	.105	-.051	.321
Similarities	.429	.185	.474	-.191	.010
Arithmetic	.644	.176	-.079	.180	-.059
Vocabulary	.540	.095	.507	-.212	.209
Comprehension	.506	.349	.263	-.047	-.161
Digit Span	.665	.414	-.059	-.056	-.116
Picture Completion	-.117	.125	.808	.032	.099
Picture Arrangement	.037	-.024	.447	-.304	-.323
Block Design	.042	.075	.411	.511	-.031
Object Assembly	-.040	.088	.784	.086	.007
Coding	.168	-.158	.217	-.178	-.555
Beery's VMI Test	.083	.142	.039	.704	-.250
Sentence Repetition	.644	.327	-.173	.314	.134
Visual Tracking	.089	.020	-.264	.715	.102
Wepman	.683	.034	.075	.095	.113
Auditory Closure	.076	.510	.286	-.262	.104
VADS Total	.759	-.097	-.054	-.164	-.266
Davids Total	-.245	.020	.107	-.218	.568
Additions & Omissions	-.115	.827	.071	.110	-.057
Structural Analysis	-.141	-.527	-.272	-.115	-.473
Letter Sequences	.146	-.066	.444	.381	.102
Nonsense Words	-.130	-.180	.098	.668	.165
Scanning	.199	-.080	.134	.038	.783
Visual Similarity	-.052	-.901	.056	.003	-.078
Comprehension Pattern	.465	.642	.035	.031	-.236
Degree of Correction	.503	.110	.421	.032	.058
% of Total Variance	15.156	12.790	11.318	9.203	7.939

Total score contains auditory memory subtests although it also includes subtests of visual input and motor output. Appropriate use of contextual cues and the ability to make self-corrections had moderate loadings on Factor I and reflect verbal conceptualization ability and memory for meaningful material. Comprehension Patterns, which measure use of contextual cues, significantly correlate with the WISC-R Comprehension subtest (r=.558, df=39, $p \leq .01$) and with Sentence Repetition (r=.374, df=39, $p \leq .05$). The WISC-R Comprehension subtest is a measure of verbal (1) conceptualization while Sentence Repetition tests memory for meaningful material. Degree of Correction was significantly related to Similarities (r=.506, df=39, $p \leq .01$), Vocabulary (r=.453, df=39, $p \leq .01$), and Comprehension (r=.422, df=39, $p \leq .01$), all of which measure verbal conceptualization, and to Wepman's Auditory Discrimination Test (r=.445, df=39, $p \leq .01$). It has been suggested that Wepman's Auditory Discrimination Test measures auditory retention as well as discrimination (Blank, 1968). The finding that awareness and use of contextual cues are related to verbal abilities and auditory memory supports the hypothesis of previous researchers that such a relationship exists (e.g., Torgesen, 1978-79; Vernon, 1977).

Factor II showed the incompatibility of a letter-by-letter decoding strategy with adequate understanding of the meaning of a passage. Use of the letter-by-letter decoding strategy, or visual sequential processing strategy, was inferred from a high percentage of letters shared between the reading errors and the text (Visual Similarity). Structural Analysis errors correlated highly with Visual Similarity (r=.637, df=39, $p \leq .01$) and also appeared to reflect a visual sequential processing strategy. Addition and Omission errors did not reflect the use of graphic cues, and loaded in an opposite direction to Visual Similarity and Structural Analysis errors. Auditory Closure also loaded in an opposite direction to Visual Similarity and Structural Analysis errors, suggesting the difficulty of letter-by-letter readers in constructing a whole from an incomplete presentation of its parts. Factor II implies that when the decoding of graphemes commands all the reader's attention the ability to understand the meaning of sentences within a passage (Comprehension Patterns) is limited. The positive loadings of the WISC-R Information and Comprehension subtests and Sentence Repetition reveal the importance of verbal conceptualization and memory for meaningful material in reading strategies which make use of contextual cues. The Information subtest's correlations with Similarities (r=.470, df=39, $p \leq .01$), Vocabulary (r=.395, df=39, $p \leq .01$), Comprehension (r=.366, df=39, $p \leq .05$) and Sentence Repetition (r=.407, df=39, $p \leq .05$) shows the subtest's strong relationship to verbal abilities.

Factor III is primarily a perceptual organization factor, comprising the four WISC-R performance subtests which made up Kaufman's (1975) perceptual organization factor (viz., Picture Completion, Picture Arrangement, Block Design, Object Assembly). Two of the WISC-R subtests (i.e., Similarities, Vocabulary) from Bannatyne's Conceptualization pattern (viz., Similarities, Vocabulary, Comprehension) had moderate loadings on this factor. Mild loadings of two Conceptualization subtests (i.e., Similarities, Comprehension) were also found on Kaufman's (1975) factor. These subtests appear to represent verbal mediation involved in the nonverbal tasks (Sattler, 1974). Reading strategies in Factor III involve a tendency to make letter sequence reversals and to correct reading errors. Letter Sequence errors seem to reflect a strategy in reading which requires a perception of letter groups. Although Degree of Correction correlated with verbal conceptualization subtests, its moderate loading on Factor III suggests that perceptual organization, or the ability to perceive the whole word or group of words, is involved in self-corrections. Because of the numerous WISC-R subtests loading significantly on this factor, a large IQ component entered into the factor as well.

The fourth factor subsumed visual-motor integration skills (measured by the Block Design subtest, Beery's VMI test, Visual Tracking) and nonsense word substitutions in reading. Nonsense Word errors were not related to verbal abilities in the present study, but they were significantly correlated with Beery's VMI Test ($\underline{r}$=.306; $\underline{df}$=39, $\underline{p}\leq.05$) and Visual Tracking ($\underline{r}$=.388; $\underline{df}$=39, $\underline{p}\leq.05$). The findings that

Nonsense Word errors were unrelated to contextual cue use but were related to visual-motor integration suggests that the production of nonsense words reflects visual processing strategies. Letter Sequence errors loaded moderately on this factor, and it has already been noted that Letter Sequence errors appear to be associated with a visual processing strategy which relies on the perception of letter groups rather than letter-by-letter decoding. It seems that Nonsense Word errors are also related to a visual processing strategy which makes use of letter groups or whole words.

Factor V is a visual disorganization factor. Scanning errors had the highest loading on this factor and were a measure of visual disorganization in reading. Structural Analysis errors loaded in an opposite direction to Scanning errors, suggesting that visual sequential processing is the antithesis of visual disorganization. Psychological variables that loaded on this factor included the hyperactivity syndrome (measured by Davids' Total Score) [3] and poor visual sequential memory (measured by Coding). Many researchers (e.g., Croxen & Lytton, 1971) have assumed that difficulties in systematic scanning when reading are associated with difficulty in learning to discriminate between left and right. However, the finding that Scanning errors were related to the hyperactivity syndrome and poor

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[3] The hyperactivity syndrome which is measured by Davids' Total Score is defined by behavioural measures of activity level, attention span, variability, impulsivity, irritability, and explosiveness.

visual sequential memory suggests that erratic scanning during reading is a measure of visual disorganization or inattention rather than an indicator of poor left-right discrimination.

In summary, the five factor solution which comprised 18 psychological variables and eight reading variables indicates that meaningful relationships exist between the two sets of variables. Factor 1 suggests a relationship between verbal abilities and auditory memory on the one hand, and use of contextual cues on the other. Factor II suggests that a visual sequential processing strategy and neglect of contextual cues when reading are associated with poor verbal abilities. The third and fourth factors indicate a relationship between skills in visual organization and the tendency to make letter sequence reversals and nonsense word substitutions. Factor V suggests that there is a relationship between visual disorganization in reading and poor visual sequential memory and the hyperkinesis syndrome.

3. Cannonical Correlation of Reading and Psychological Variables

The SPSS CANCORR *program was used to discover if psychological variables could be significantly predicted from reading measures. The CANCORR program used only those variables which were found to contribute to the interpretability of the relationship between reading and psychological processes. The eighteen psychological

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*Cannonical Correlations

variables and eight reading variables which comprised the five factor solution were therefore used in the analysis. Results indicated that the 18 psychological variables were significantly correlated with the eight reading variables (r=.906, d.f.=144, p=.006). Before further investigation of the relationship between the two sets of variables was undertaken, separate analyses of readi g and psychological measures were conducted.

B. Reading Data

In this section, analysis of the reading data is presented. First, certain general aspects of the reading measures and the reading characteristics of the whole sample are examined. The following topics are discussed: a) inter-rater reliability of the oral reading analysis; b) reliability of the oral reading analysis across passages; c) sex differences in reading performance; d) the reading characteristics of the entire sample; and e) the factors which were based on subjects' reading performance. Second, an analysis of data to determine if there were subgroups of disabled readers based on oral reading strategies is presented.

1. The Reading Measures and the Reading Characteristics of the Entire Sample

a) Inter-rater reliability of the oral reading analysis

Inter-rater reliability was calculated for the scoring of nine reading errors types (i.e., Additions, Omissions, Letter Order Reversals, Grapheme-Phoneme errors, Repetitions, Nonsense Word Substitutions, Structural Analysis errors, Scanning errors, Words Aided or Mumbled) and three of the qualitative scales (i.e., Visual Similarity, Grammatical Relationship Patterns, Comprehension Patterns). The Experimenter scored all the passages read. Ten subjects were selected randomly so that a second rater could analyze the subjects' oral reading errors. The percent of agreement between the two scorers ranged from 92% to 96% for each subject. An average of 95% agreement between the two raters was found.

b) Reliability of the oral reading analysis across passages

Before reading performance was examined, it was necessary to determine if reading scores could be combined across passages. Because all subjects made errors within the range of 6 to 15 percent on at least one passage, passages on which subjects made 6 to 15 percent errors were initially selected for statistical analysis. However, Leslie (1980) had reported a change in reading strategy as miscues per hundred words (MPHW) increased from 6 to 10 to 11 to 15. Thus, subjects' errors and strategies were compared on passages in which they made 6 to 10 percent errors to passages in which they made 11 to 15 percent errors in order to determine if the errors and strategies differed at the two levels. Although all 41 subjects made errors within the range of 6 to 15 percent on at least one passage, only 29 subjects made 6 to 10 percent errors in one passage and 11 to 15 percent errors in another. Therefore, the analysis which compared errors at the 6 to 10 percent level to errors at the 11 to 15 percent level had to be restricted to 29 subjects.

The DERS (Mulv06) One Sample Hotellings T^2 program was used for the analysis. Results indicated that there was an overall significant difference between the errors and strategies made at both levels of difficulty (F=3.43, df=11,18, $p \leq .01$). A second attempt was made to compare reading errors and strategies on passages with 7 to 10 percent errors and 11 to 14 percent errors. The Hotellings T^2 program indicated that no significant difference in reading errors and strategies existed between these levels of difficulty (F=1.96, df=11,14, p>.05). Reading scores were thus found to be comparable at both levels of difficulty. By combining errors in passages at both levels of difficulty, a larger sample of reading errors was obtained and the reliability of the sample of errors increased. Only those reading performances where all 41 subjects had made 7 to 14 percent errors were used in future analyses.

c) Sex Differences on Reading Measures

The SPSS Multivariate Analysis of Variance (MANOVA) program was used to determine if there were sex differences on the reading measures used in the present study. No statistically significant sex differences were found.

d) Reading Characteristics of All Subjects

Subjects' reading characteristics were interpreted by comparing the frequency of reading error types and by assessing the degree to which the error types reflected the use of graphic and contextual cues. Subjects' performance on reading variables is presented in Table 6.

The most common error type was the misreading of affixes (i.e., Structural Analysis errors). This error type suggests close attention on the reader's part to most of the letters in the text. The error types with the next highest frequencies were whole word additions and omissions. In contrast to Structural Analysis errors, whole word additions and omissions are completely independent of the decoding of graphic information. However, other errors that were noted with moderate frequency (i.e., Nonsense Word Substitutions, and the misreading of consonants and vowels) suggested a reliance on visual cues. The discrepancies in visual cue dependence within the sample may be explained by the existence of distinct subgroups of disabled readers who differ in their dependence on visual cues.

Qualitative analysis of reading error types revealed a moderate use of visual and contextual cues (Table 6). For all subjects there was an average of 55.6 percent of letters shared between their errors and the text. The average scores of 56.4 percent for Comprehension Patterns and 55.0 percent for Grammatical Relationship Patterns also indicated a moderate degree of reliance on contextual cues.

Table 6

Performance on Reading Variables

Reading Variables	Mean	SD	Range
Reading Error Types:			
Structural Analysis Errors	21.8	9.9	6-50
Omissions	9.5	6.4	0-24
Additions	8.1	6.8	0-28
Repetitions	6.3	6.2	0-25
Nonsense Words	6.2	5.2	0-18
Consonant Errors	4.4	3.0	0-15
Vowel Errors	4.3	3.2	0-13
Scanning Errors	1.9	2.4	0-8
Letter Sequence Errors	1.6	2.0	0-8
Words Aided or Mumbled	1.3	2.5	0-10
Letter Orientation Reversals	0.4	1.0	0-4
Qualitative Scales:			
Visual Similarity	55.6	11.3	38-78
Grammatical Relationship Patterns	55.0	13.9	16-81
Comprehension Patterns	56.4	12.4	24-79
Degree of Corrections	21.9	11.4	0-52

However, there may be variations in cue use across subgroups of disabled readers which are not reflected in the mean scores of the entire sample. The wide range of scores in Visual Similarity, Grammatical Relationship Patterns, and Comprehension Patterns suggest that there are, in fact, marked variations in cue use among subjects.

e) Factor Analysis of the Reading Data

The factor analysis of five reading error types (i.e., Structural Analysis errors, Additions & Omissions, Letter Sequence errors, Nonsense Word errors, Scanning errors) and three qualitative scales (i.e., Visual Similarity, Comprehension Patterns, Degree of Corrections) was undertaken in order to identify the reading factors which were determined by the eight variables. Using the principal components analysis with varimax rotation, the four factor solution accounting for 83 percent of the total variance was found to be the most meaningful. The factors are presented in Table 7.

The first factor was characterized by high graphic cue dependence (measured by Visual Similarity and Structural Analysis errors) and low contextual cue use (measured by Comprehension Patterns). The high positive loading of Visual Similarity is contrasted with the high negative loading of Comprehension Patterns, which suggests that a high dependence on graphic cues is related to inattention to contextual cues. The high negative loading of Additions and Omissions indicated that inattention to graphic cues was

Table 7

Factor Analysis of Reading Variables

Reading Variables	Factors I	II	III	IV
Additions & Omissions	-.921	-.094	-.037	.138
Structural Analysis	.494	-.201	-.706	-.057
Letter Sequences	.080	.618	.152	.574
Nonsense Words	.015	-.144	.065	.908
Scanning	.082	.010	.883	.086
Visual Similarity	.916	-.030	-.251	.197
Comprehension Patterns	-.633	.590	-.178	-[illegible]
Degree of Corrections	.009	.891	.112	-.124
% of Total Variance	29.294	19.934	17.670	15.849

associated with whole word additions and omissions. Additions and Omissions correlated negatively with Visual Similarity (r=.76, df=39, $p \leq .01$) and positively with Comprehension Patterns (r=.47, df=39, $p \leq .01$), suggesting that the production of whole word additions and omissions is related to contextual cue dependence.

Factor II reflected appropriate use of contextual cues (measured by Comprehension Patterns) as well as the ability to correct reading errors (measured by Degree of Corrections). Degree of Corrections was significantly related to Comprehension Patterns (r=.45, df=39, $p \leq .01$). Furthermore, there was a high loading of Letter Sequence errors on Factor II, and Letter Sequence errors was related to Degree of Corrections (r=.33, df=39, $p \leq .05$). It is possible that the making of letter sequence reversals is associated with self-corrections because awareness of the linguistic inappropriateness of letter order reversals leads to self-corrections.

The third factor represented visual disorganization, which was indicated by the high positive loading of Scanning errors. Structural Analysis errors had a high negative loading on Factor III and were highly correlated with Visual Similarity (r=.64, df=39, $p \leq .01$). The relationship of Stuctural Analysis errors to Visual Similarity suggests that these errors are associated with an orderly, visual sequential decoding strategy, as opposed to the visual disorganization associated with Scanning errors.

Factor IV consisted of positive loadings on Letter Sequence and Nonsense Word errors. The relationship of these error types to perceptual organization was discussed in reference to the factor solution of reading and psychological variables. The error types which comprise Factor IV suggest a decoding strategy which depends on a global perception of the whole word or groups of words and which therefore involves only a partial use of visual cues. The strategy can be contrasted with a visual sequential decoding strategy because the latter implies a more extensive use of visual cues.

In summary, the four factors which were identified on the basis of the eight reading variables measure:

a. Graphic Cue Dependence
b. Contextual Appropriateness
c. Visual Disorganization
d. Partial Visual Cue Use

2. Cluster Analysis of Subgroups Based on Reading Factors

The factor analysis which was based on the five reading error types and three qualitative scales indicated that the disabled readers in the present study used a variety of reading strategies. The possibility that there were subgroups of disabled readers, differentiated by their reading strategies, was the next issue investigated. The four reading factors were used to distinguish the subgroups because the factors provided a clearer indication of reading strategies than the eight variables. The DERS (Fact23)

Factor Estimates program was employed to obtain factor scores which were derived from subjects' performances on each reading factor. The CLUSTAN (Wishart, 1978) program used the factor scores in order to classify subjects into subgroups according to their reading strategies.

Two methods of clustering were used: Ward's (1963) hierarchical clustering technique and the iterative relocation procedure. The hierarchical clustering technique is designed to classify individuals into clusters or subgroups so as to minimize within-group variation on profiles of test scores and to maximize between-group variation. Ward's method begins by defining each subject as a "group". The groups are then reduced in number by a series of step-decisions. At each step, the decision to combine clusters is based on the minimal increase of within-group variance. Ward's technique provides a measure of within-group variance, which is termed the "Error Sum of Squares" (E.S.S.). Where the E.S.S. shows an increase which is out of proportion to previous increases it is an indication that the combining of the previous two groups created a cluster with extensive variance (Morris, Blashfield, & Satz, 1981). The number of groups prior to a substantial increase in the E.S.S. is the one usually selected for interpretation (Veldman, 1967). Ward's method cannot reassign an individual to later forming clusters once he or she is placed in a cluster, even if his/her similarity to another group is greater. The iterative relocation procedure differs from Ward's technique in that it is able to check clusters and relocate any subject who is not in a cluster of minimum variance. The iterative relocation procedure allows the investigator to determine the number of relocated subjects and provides a check on the stability of the cluster solution (Morris et al., 1981).

When applied to the four reading factors, Ward's hierarchical clustering procedure showed its first substantial increase in the E.S.S. from five clusters (E=4.304) to four (E=7.433). Thus, the five cluster solution was selected. The iterative relocation procedure was applied to Ward's solution and seven subjects were relocated to clusters of minimum variance. The findings that only 17 percent of the subjects were relocated and that very little change occurred in the subgroups' profiles supported the stability of the clusters.

Validation of cluster solutions is of critical importance because most methods will find solutions even in random data (Satz & Morris, 1981). Three procedures were used to achieve internal validation. The procedures showed that the subgroups did in fact differ significantly on the factors and variables upon which the subgroups were based. First, visual inspection of the five subgroups' profile shapes and elevations provided information about the distinctive patterns of each subgroup. In Figure 1, mean

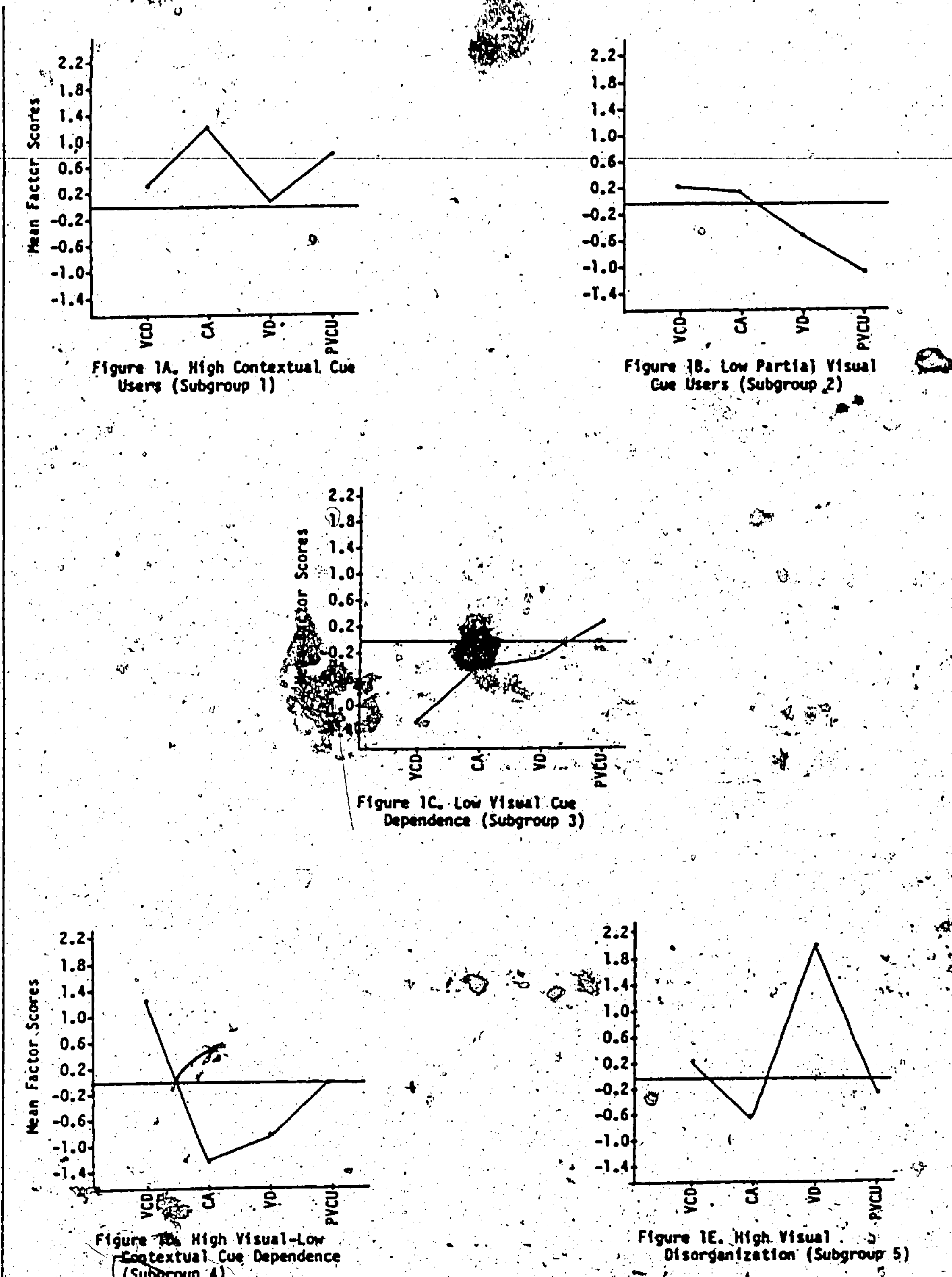

Figure 1A. High Contextual Cue Users (Subgroup 1)

Figure 1B. Low Partial Visual Cue Users (Subgroup 2)

Figure 1C. Low Visual Cue Dependence (Subgroup 3)

Figure 1D. High Visual-Low Contextual Cue Dependence (Subgroup 4)

Figure 1E. High Visual Disorganization (Subgroup 5)

Figure 1. Mean Factor Scores of Subgroups Based on Reading Factors

Key

VCD - Visual Cue Dependence

CA - Contextual Appropriateness

VD - Visual Disorganization

PVCU - Partial Visual Cue Use

factor scores[5] were plotted, allowing for the comparison of each subgroup's performance against the total sample mean of zero and standard deviation of one (Wishart, 1978). Second, one way analyses of variance (ANOVAs) were computed to provide a statistical measure of the differences between subgroups on the four reading factors. A Scheffe multiple comparison of means was also performed in order to ascertain which pairs of subgroups were significantly different on each of the reading factors. The .10 level of significance was used for Scheffe's test because of the conservative nature of the test (Winer, 1962). Subgroup means, standard deviations, F-ratios, and the results of the Scheffe multiple comparison of means are presented in Table 8. Finally, comparison of the subgroups on the eight variables used to determine the four reading factors provided further internal validation of the subgroups. ANOVAs and Scheffes were used to compare the subgroups on the eight reading variables. Results are presented in Table 9.

Subgroup 1 was composed of seven boys and two girls. Figure 1A indicates that Subgroup 1 differed significantly from the sample mean on appropriate use of contextual cues. Performance on the Contextual Appropriateness factor was significantly higher than all other subgroups (Table 8), and hence Subgroup 1 was designated "High Contextual Cue Users". An examination of the reading variables which made up the

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[5]Mean factor scores of each cluster on each reading factor was provided by the CLUSTAN program.

Table 8

Subgroups Based on Reading Factors:
Comparison of Subgroups on Reading Factors

Reading Factors		1	2	3	4	5	F Value[1]	Scheffe Multiple Comparisons[2]
V.C.D.	Mean	0.3	0.3	-1.2	1.3	0.3	16.5***	All other subgroups > Subgroup 3
	S.D.	0.7	0.7	0.5	0.3	0.8		
C.A.	Mean	1.2	0.2	-0.3	-1.2	-0.6	14.0***	Subgroup 1 > All other subgroups
	S.D.	0.8	0.7	0.5	0.6	0.7		Subgroup 2 > Subgroup 4
V.D.	Mean	0.1	-0.5	-0.2	-0.7	2.0	15.7***	Subgroup 5 > All other subgroups
	S.D.	0.7	0.7	0.7	0.5	0.6		
P.V.C.U.	Mean	0.8	-1.0	0.4	0.0	-0.2	6.8***	Subgroups 1, 3 > Subgroup 2
	S.D.	1.1	0.5	0.6	0.9	0.9		

1 *** $p < .001$

2 Significant at 0.10 level

Key

V.C.D. - Visual Cue Dependence
C.A. - Contextual Appropriateness
V.D. - Visual Disorganization
P.V.C.U. - Partial Visual Cue Use

Table 9

Subgroups Based on Reading Factors: Comparison of Subgroups on Reading Variables Used in the Factors

Reading Variables		Subgroups[1] 1	2	3	4	5	F Value[2]	Scheffe Multiple Comparisons[3]
Error Types:								
Additions & Omissions	Mean	14.0	11.8	30.6	7.2	14.6	[illegible].5***	S[illegible]oup 3 > All other subgroups
	S.D.	6.7	8.3	5.3	4.7	8.7		
Structural Analysis	Mean	19.3	25.7	19.1	35.4	11.4	7.4***	Subgroup 4 > Subgroups 1, 3, 5 Subgroup 2 > Subgroup 5
	S.D.	8.0	8.7	6.7	10.0	4.2		
Letter Sequences	Mean	4.6	0.4	1.2	0.0	1.0	18.9***	Subgroup 1 > All other subgroups
	S.D.	1.7	0.8	1.1	0.0	1.4		
Nonsense Words	Mean	8.0	1.4	8.3	7.0	6.8	3.7*	Subgroups 1, 3 > Subgroup 2
	S.D.	6.1	1.6	4.0	7.2	4.3		
Scanning	Mean	2.1	0.5	1.5	0.6	6.2	10.8***	Subgroup 5 > All other groups
	S.D.	2.4	1.1	1.7	1.3	1.5		
Qualitative Scales:								
Visual Similarity	Mean	59.4	58.2	45.8	70.0	52.8	8.3***	Subgroups 1, 2, 4 > Subgroup 3 Subgroup 4 > Subgroup 5
	S.D.	10.2	10.5	6.1	5.6	8.4		
Comprehension Patterns	Mean	60.8	59.1	63.5	37.2	45.[illegible]	10.5***	Subgroups 1, 2, 3 > Subgroup 4 Subgroups 1, 3 > Subgroup 5
	S.D.	10.5	5.6	6.7	8.0	15.2		
Degree of Corrections	Mean	31.1	24.4	18.5	10.2	20.2	4.2**	Subgroup 1 > Subgroup 4
	S.D.	10.8	11.9	8.1	9.1	8.5		

[1] df = 4,36

[2]
* p < .05
** p < .01
*** p < .001

[3] Significant at 0.10 level

factors showed the distinctive character of Subgroup 1 (Table 9). The subgroup scored significantly higher than two others on Comprehension Patterns and had a significantly higher Degree of Corrections score than one other subgroup. Furthermore, Subgroup 1's scores on Letter Sequence errors were significantly higher than all other subgroups, confirming the relationship between Letter Sequence errors and the contextual appropriateness of errors which was reported earlier in the discussion of the Contextual Appropriateness factor.

Subgroup 2 was made up of four boys and six girls. Figure 1B shows that Subgroup 2 produced very few errors reflecting partial use of visual cues (i.e., Letter Sequence errors and Nonsense Word errors). Table 8 indicates that this subgroup performed significantly lower than two others on the factor measuring partial visual cue use. Subgroup 2 was therefore entitled "Low Partial Visual Cue Users". The distinctive character of subgroup 2 was also supported by the comparison of the subgroups on the variables which made up the reading factors (Table 9). Subgroup 2 made significantly fewer Nonsense Word errors than two other subgroups, and also made few Letter Sequence errors. In contrast to the low frequency of these two error types, production of Structural Analysis errors was significantly higher than one other subgroup, suggesting that children in Subgroup 2 paid close attention to the sequence of letters within a word.

Subgroup 3 consisted of five boys and seven girls. The subgroup differed from the sample mean on the factor measuring visual cue dependence (Figure 1C). Subgroup 3 demonstrated significantly less visual cue dependence than all other subgroups (Table 8) and was therefore designated "Low Visual Cue Dependence". The low visual cue dependence which distinguished Subgroup 3 was evident in their performance on the variables which made up the reading factors (Table 9). The subgroups scored significantly higher than all other subgroups on Additions and Omissions and significantly lower on Visual Similarity than three other subgroups. Subgroup 3 also scored significantly higher than two other subgroups on Comprehension Patterns, suggesting that the subgroup relied more on contextual than graphic cues.

Two boys and three girls comprised Subgroup 4. This subgroup performed higher than the total sample mean on Visual Cue Dependence and lower than the sample mean on Contextual Appropriateness (Figure 1D). Table 8 shows that Subgroup 4 was significantly lower than two other subgroups on the Contextual Appropriateness factor. The subgroup was given the title "High Visual-Low Contextual Cue Dependence". The high visual cue dependence of Subgroup 4 was evident in their pattern of performance on the variables upon which the reading factors were based (Table 9). High scores on Visual Similarity and Structural Analysis errors suggested a high degree of visual cue dependence. In contrast, Subgroup 4's lack of dependence on contextual cues was indicated by their low scores on Comprehension Patterns and Degree of Corrections.

The four boys and one girl of Subgroup 5 differed from the sample mean on the Visual Disorganization factor (Figure 1E). Subgroup 5's performance on this factor was significantly higher than all other subgroups (Table 8). Thus, Subgroup 5 was characterized by "High Visual Disorganization". In the comparison of the subgroups on the variables underlying the reading factors, Subgroup 5's high visual disorganization emerged clearly (Table 9). The subgroup scored significantly higher than all other groups on Scanning errors, and their low scores on Structural Analysis errors and Visual Similarity suggest that letter-by-letter decoding is not compatible with the visual disorganization represented by Scanning errors. Subgroup 5 performed significantly worse than two other subgroups on Comprehension Patterns, indicating that the subgroup made relatively poor use of contextual cues.

External validation of the subgroups is obtained by discovering significant differences between the subgroups on relevant variables not used in the actual clustering procedure (Morris et al., 1981). To provide external validation for the subgroups in the present study, two sources of data were used: a) reading variables which were not included in the computation of the reading factors, and b) descriptive variables.

The reading variables which were not employed to determine the reading factors (i.e., Additions, Omissions, Consonant errors, Vowel errors, Repetitions, Words Aided or Mumbled, Grammatical Relationship Patterns, Reading Rate at Grade Placement, Reading Rate at Instructional Level) were included in univariate analyses of variance. Results of the analyses which showed significant between group differences on four variables are presented in Table 10. Subgroup means on reading variables which did not significantly distinguish between subgroups are reported in Appendix D.

Subgroup 3 (Low Visual Cue Dependence) made significantly more whole word additions than all other subgroups and significantly more whole word omissions than Subgroups 2 (Low Partial Visual Cue Users) and 4 (High Visual-Low Contextual Cue Dependence). It was reported earlier that Subgroup 3 scored higher on the Additions and Omissions variable than all other subgroups, and the finding that separate variables measuring whole word additions and omissions also distinguished Subgroup 3 from other subgroups provided support for the subgroup's distinctive characteristics. The fact that Subgroups 2 and 4 made relatively few omissions confirmed their tendency to pay close attention to graphic cues. Subgroup 4 (High Visual-Low Contextual Cue Dependence) made significantly more consonant errors than two other subgroups. This finding suggested that the subgroup's letter-by-letter decoding strategy was associated with the misreading of single consonants or

Table 10

Subgroups Based on Reading Factors:
Comparison of Subgroups on Reading Variables External to the Factors

Reading Variables		Subgroups[1] 1	2	3	4	5	F Value[2]	Scheffe Multiple Comparisons[3]
Error Types:								
Additions	Mean	5.6	5.1	16.3	3.6	3.6	22.1***	Subgroup 3 > All other subgroups
	S.D.	3.0	3.5	3.8	5.4	1.8		
Omissions	Mean	8.3	6.7	14.3	4.2	11.0	3.6*	Subgroup 3 > Subgroups 2, 4
	S.D.	7.1	5.4	5.7	4.1	7.4		
Consonants	Mean	4.6	3.6	4.2	8.2	2.4	3.5*	Subgroup 4 > Subgroups 2, 5
	S.D.	2.1	2.5	1.9	4.3	3.6		
Vowels	Mean	6.1	3.9	2.3	4.6	6.4	2.9*	No significance between subgroup differences
	S.D.	4.0	2.9	1.9	3.2	2.7		

1 df = 4,36

2 * p < .05
** p < .01
*** p < .001

3 Significant at 0.10 level

consonant blends.

Comparison of the five subgroups' performance on the descriptive variables of age, grade placement, and instructional reading level is presented in Table 11. Subgroup 3's (Low Visual Cue Dependence) subjects were the oldest, and had the highest grade placements and oral instructional level of all the subgroups. Subgroup 3's low visual cue dependence and greater reliance on contextual cues may be related to the fact that they were older and more experienced readers. Many researchers (e.g., Burke, 1976; Goodman, 1965) maintain that greater proficiency in reading leads to less and less reliance on graphic cues. However, the large number of reading errors made by Subgroup 3 suggest that their reading strategy, although similar to the strategy which more able readers appear to use, was not used efficiently.

In short, external validation for three of the subgroups was achieved through analyses of reading and descriptive data which were not used in the determination of the subgroups. The distinctiveness of Subgroups 2, 3 and 4 was confirmed by significant differences in their scores on reading and descriptive variables.

C. Psychological Data

Analysis of the psychological data is presented in this section. First, general characteristics of the entire sample are examined. The specific topics discussed are: a) sex

Table 11

Subgroups Based on Reading Factors:
Comparison of Subgroups on Descriptive Variables

Descriptive Variables		Subgroups[1] 1	2	3	4	5	F Value[2]	Scheffe Multiple Comparisons[3]
Chronological Age[4]	Mean	126.4	117.7	136.8	122.0	122.8	3.4*	Subgroup 3 > Subgroup 2
	S.D.	13.4	12.2	15.1	9.0	8.2		
Actual Grade Placement	Mean	5.2	4.8	6.1	4.8	4.4	6.5***	Subgroup 3 > Subgroups 2, 4, 5
	S.D.	0.9	0.8	0.8	0.7	0.5		
Expected Grade Placement	Mean	5.4	5.0	6.5	5.2	5.2	3.9**	Subgroup 3 > Subgroup 2
	S.D.	1.0	1.1	1.1	0.5	0.9		
Oral Instructional Reading Level	Mean	3.8	3.2	4.4	3.3	3.3	4.8**	Subgroup 3 > Subgroup 2
	S.D.	0.7	0.7	0.8	0.9	0.4		

[1] df = 4,36

[2] * $p < .05$
** $p < .01$
*** $p < .001$

[3] Significant at 0.10 level

[4] Reported in months

differences in psychological performance; b) the psychological characteristics of the entire sample; and c) the factors which were based on the sample's performance on psychological variables. Second, an analysis of data to determine if there were subgroups of disabled readers based on their performance on psychological tests is presented.

1. The Characteristics of the Entire Sample

a) Sex Differences in Psychological Test Performance

The SPSS MANOVA program was computed to determine if there were significant sex differences on any psychological variables used in the present study. Multivariate tests showed that there was an overall significant difference between the 22 males and 19 females in the present study only on the WISC-R subtests (F=2.46, df=11,29, $p \leq .05$). The WISC-R subtests which were found to have sex differences were Information (F=7.15, df=1,39, $p \leq .01$) and Coding (F=7.83, df=1,39, $p \leq .01$). Males obtained higher scaled scores on the Information subtest, while females were superior on Coding.

b) Psychological Characteristics of the Entire Sample

<u>WISC-R.</u> The results of the WISC-R subtests are presented in Table 12. Subjects' average performances were within the average range on all WISC-R subtests, although the means ranged from 8.2 (low average) to 11.7 (high average). Examination of the number of subjects performing below average (i.e., scaled scores ≤7) on WISC-R subtests indicated that almost half of the subjects performed poorly

Table 12

Performance on WISC-R Subtests

WISC-R Subtests[1]	Mean[2]	S.D.	Range	Percent of Ss scoring ≤ 7 on each subtest
Verbal				
Information	9.2	2.2	4-14	22
Similarities	10.2	2.5	4-17	10
Arithmetic	10.3	2.6	5-16	12
Vocabulary	9.9	2.4	3-14	10
Comprehension	10.9	2.4	6-15	10
Digit Span	8.2	2.4	4-15	44
Nonverbal				
Picture Completion	11.2	2.9	6-18	12
Picture Arrangement	11.7	2.2	8-17	0
Block Design	10.5	2.7	3-14	10
Object Assembly	11.2	2.9	7-18	10
Coding	10.2	2.6	7-16	15

[1] Reported as scaled scores
[2] Based on 41 subjects

on the Digit Span subtest. Scores on the Information subtest were low for almost a quarter of the subjects. Although subjects' average performance on nonverbal WISC-R subtests, was not notably different from their average performance on verbal subtests, 18 subjects (44%) had a Verbal IQ which was 10 or more points lower than their Performance IQ. In contrast, only five subjects (12%) had a Performance IQ which was 10 or more points lower than their Verbal IQ.

Verbal Abilities. Means, standard deviations, and the percentage of subjects having difficulty on verbal tests are presented in Table 13. Twenty-two percent of all subjects performed one or more standard deviations below the age norms on the Word Fluency test (Spreen & Benton, 1969). Performance on the Auditory Discrimination Test (Wepman, 1975) was below the eight-year-old norms for 27% of the subjects. Deficiencies on the ITPA subtests were also found. Seven percent (3/41) of the subjects did not reach ceiling level on the Sound Blending subtest. Although the norms on Sound Blending only extend as far as eight years, seven months, the three subjects who failed to reach ceiling level were between nine years, five months and nine years, 11 months. Therefore, these three subjects were identified as having difficulty on Sound Blending. The majority of subjects (80%) performed poorly on Auditory Closure. Norms on this test extend only as far as ten years, zero months. Twenty-two percent of the eight- and nine-year-olds scored one or more years below their expected psycholinguistic age

Table 13

Performance on Verbal Tests

Verbal Tests	N	Mean	S.D.	Test Norms: Mean	Test Norms: S.D.	% of Ss having difficulty
a) Word Fluency[1]						
8-yr-olds	2	33.0	8.0	22.8	6.8	0
9-yr-olds	12	23.0	9.4	24.0	6.9	10
10-yr-olds	13	24.7	6.4	25.6	7.8	5
11-yr-olds	9	25.4	5.9	29.7	7.6	5
12-yr-olds	3	29.7	8.9	30.7	7.4	0
13-yr-olds	2	20.5	15.0	32.3	8.4	2
b) ITPA subtests:						
Sound Blending[2]	41	102.2	3.2	-	-	7
Auditory Closure[2]						
8-yr-olds	2	89.0	24.0	-	-	2
9-yr-olds	12	87.2	19.5	-	-	20
10-yr-olds	13	88.0	15.4	-	-	29
11-yr-olds	9	89.0	22.5	-	-	17
12-yr-olds	3	88.3	14.8	-	-	7
13-yr-olds	2	94.5	35.0	-	-	5
c) Auditory Discrimination[3]	41	2.8	1.1	-	-	27

[1] Raw scores are reported. Subjects with difficulty scored more than one S.D. below the test means. Norms for Word Fluency test (Spreen & Benton, 1969) are from Gaddes & Crockett, 1975.

[2] Psycholinguistic age scores are reported in months. Subjects with difficulty did not reach ceiling level even though their chronological age exceeded test norms.

[3] Scores are reported in ratings from 1 to 5. Ratings are based on 8-yr-old norms provided by Wepman (1975). Subjects with severe difficulty scored below the average rating of 3.

scores. Another 58% of the ten- to twelve-year-olds did not reach ceiling level, indicating that they had difficulty on this task. The relatively small number of subjects who performed poorly on the WISC-R's verbal conceptualization subtests (Table 12) suggests that the subjects' verbal difficulties lay primarily in automatic verbal processing.

Integration. Tests measuring intersensory integration included the VADS Test (Koppitz, 1977), Sound-Symbol Association and Symbol-Sound Association (Spache, 1972), and the Developmental Test of Visual-Motor Integration (Beery & Buktenica, 1967). Means, standard deviations, and the percentage of subjects who had difficulty on the integration tests are reported in Table 14. Although the overall performance of the subjects on the VADS Test was in the low average to average range, approximately half of the subjects had serious difficulty on subtests with an auditory input (i.e., Auditory-Oral and Auditory-Written subtests). Seventeen percent of the subjects had serious difficulty on subtests requiring visual input (i.e., Visual-Oral and Visual-Written subtests). Sound-Symbol and Symbol-Sound Association involve the integration of graphemes and phonemes. Subjects had greater difficulty matching phonemes to graphemes than matching the reverse. Forty-three percent of the subjects performed at least two and-a-half years below their expected chronological age level on the VMI Test. An additional 22% had more moderate difficulties on the test, performing one to two and-a-half years below their

Table 14

Performance on Measures of Integration

Integration Tests	N	Mean	S.D.	% of Ss having difficulty
a) VADS Subtests[1]:				
Auditory-Oral	41	28.3	26.8	56
Visual-Oral	41	47.1	28.5	17
Auditory-Written	41	34.9	28.1	41
Visual-Written	41	39.6	24.3	17
Total Score	41	33.7	27.5	29
b) Sound-Symbol Association[2]	41	23.1	2.1	22
c) Symbol-Sound Association[3]	41	19.1	1.6	12
d) VMI Test[4]				
8-yr-olds	2	88.5	29.0	2
9-yr-olds	12	99.7	25.5	7
10-yr-olds	13	99.5	25.0	15
11-yr-olds	9	105.6	31.4	12
12-yr-olds	3	127.0	24.6	5
13-yr-olds	2	116.3	8.0	2

[1] Reported in percentile socres appropriate for age level. Subjects having serious difficulty were estimated to be those with a percentile score ≤ 10.

[2] Reported in raw scores. Range of possible scores was 0-26. Since norms were not provided by Spache (1972), scores more than 1 S.D. below the sample mean were estimated to be indicators of those with the most serious difficulty.

[3] Reported in raw scores. Range of possible scores was 0-21. Since norms were not provided by Spache (1972), scores more than 1 S.D. below the sample mean were estimated to be indicators of those with the most serious difficulty.

[4] Reported in VMI age equivalent scores according to months. Subjects having serious difficulty were estimated to be those scoring 2½ years below their expected chronological age level.

expected chronological age level.

Memory. Measures of auditory sequential memory for nonmeaningful material included the WISC-R Digit Span subtest and the VADS Auditory-Oral and Auditory-Written subtests (Tables 12 and 14). As previously noted, approximately half of the subjects had difficulty on these tests. The Sentence Repetition test (Table 15) measured auditory sequential memory for meaningful material. Forty percent of the subjects had difficulty on this test. Tests of visual sequential memory included the WISC-R Coding subtest and the VADS Visual-Oral and Visual-Written subtests. Between 15 and 17% of the subjects performed poorly on each of these subtests. The results suggest that subjects had more difficulty on tasks measuring auditory rather than visual memory.

Visual Abilities. Subjects' performance on tests measuring ocular pursuits (Purdue) and the ability to make left-right discriminations (Laurendeau & Pinard, 1970) is presented in Table 16. When compared to the sample mean, 15% of the disabled readers had difficulty in visual tracking, while only 7% had problems with ocular convergence. A total of 21% of the subjects had not developed the understanding of left-right discrimination that was expected by their age level.

c) Factor Analysis of Psychological Variables

The 18 psychological variables which had been selected for further investigation (i.e., Information, Similarities,

Table 15

Performance on a Memory Test

Memory Test	N	Mean	S.D.	Test Norms: Mean	S.D.	% of all Ss having difficulty
Sentence Repetition[1]						
8-yr-olds	2	11.0	0	11.5	1.3	0
9-yr-olds	12	11.6	1.6	11.7	2.0	2
10-yr-olds	13	11.2	1.5	12.5	1.5	22
11-yr-olds	9	11.1	1.5	13.2	1.7	12
12-yr-olds	3	11.7	1.9	13.6	1.9	2
13-yr-olds	2	12.5	1.0	13.8	1.4	2

[1] Raw scores are reported. Subjects with difficulty scored more than one S.D. below the test means. Norms for the Sentence Repetition test (Spreen & Benton, 1969) are provided by Gaddes & Crockett, 1975.

Table 16

Performance on Visual Tests

Visual Tests	N	Mean	S.D.	% of Ss having difficulty
a) Ocular Pursuits (Purdue):				
Visual Tracking[1]	41	10.5	2.4	15
Convergence[2]	41	3.7	0.8	7
b) Left-Right Discrimination[3]				
8-yr-olds	2	2.0	0.0	0
9-yr-olds	12	2.6	1.1	5
10-yr-olds	13	3.3	0.8	7
11-yr-olds	9	3.1	1.0	7
12-yr-olds	3	2.7	0.7	2
13-yr-olds	2	4.0	0.0	0

[1] Scores were the total ratings derived from three subtests, each with a scale ranging from 1 to 4. Because norms were not available, Ss having difficulty scored more than 1 S.D. below the sample mean

[2] Scores were the ratings derived from one subtest which ranged from 1 to 4. Ss having difficulty scored more than 1 S.D. below the sample mean.

[3] Scores representing stage of development are given according to the following criteria: 1 = knows left-right on own body but has not reached mastery level;
2 = Stage I: masters knowledge of left-right on own body (by age 8);
3 = Stage II: masters knowledge of left-right on own body and on person's body opposite to child (by age 10); and
4 = Stage III: masters Stages I and II and masters knowledge of spatial relations among objects (by age 12 or 13).

Arithmetic, Vocabulary, Comprehension, Digit Span, Picture Completion, Picture Arrangement, Block Design, Object Assembly, Coding, Beery's VMI Test, Sentence Repetition, Visual Tracking, Wepman, Auditory Closure, VADS Total Score, Davids' Total Score) were included in a factor analysis. Using the principal components analysis with varimax rotation, the four factor solution which acounted for 56 percent of the total variance was found to be the most meaningful. The four factors are presented in Table 17.

The first factor was characterized by high loadings on verbal abilities. Tests loading significantly on this factor included the WISC-R verbal subtests which made up Kaufman's (1975) Verbal Comprehension factor (i.e., Information, Similarities, Arithmetic, Vocabulary, Comprehension). Other verbal tests which had high loadings on Factor I were measures of auditory discrimination (Wepman) and memory for meaningful material (Sentence Repetition). Auditory Closure had a moderate loading on this factor.

Factor II is a Perceptual Organization factor. The same WISC-R subtests which comprised Kaufman's (1975) Perceptual Organization factor (i.e., Picture Completion, Picture Arrangement, Block Design, Object Assembly) had moderate to high loadings on Factor II. The moderate loadings of Similarities and Vocabulary on Factor II were also found on Kaufman's (1975) Perceptual Organization factor.

The third factor is a Sequential Memory and Attention factor. Sequential memory tests that had high loadings on

Table 17

Factor Analysis of Psychological Variables

Psychological Variables	Factors I	II	III	IV
Information	.731	.103	-.278	-.023
Similarities	.497	.392	.221	-.165
Arithmetic	.625	-.122	.280	.176
Vocabulary	.593	.468	.141	-.123
Comprehension	.582	.258	.148	.012
Digit Span	.213	-.122	.777	.077
Picture Completion	.045	.874	-.135	.050
Picture Arrangement	-.035	.412	.374	-.382
Block Design	.086	.482	-.047	.582
Object Assembly	.038	.772	.034	-.013
Coding	-.037	.211	.596	-.143
Beery's VMI Test	.046	.096	.018	.750
Sentence Repetition	.724	-.233	.065	.317
Visual Tracking	.080	-.229	-.092	.707
Wepman	.683	-.049	.178	.068
Auditory Closure	.440	.310	-.228	-.295
VADS Total	.399	-.116	.795	-.045
Davids Total	.060	.032	-.461	-.445
% of Total Variance	18.197	13.970	12.831	11.338

this factor included the WISC-R Digit Span and Coding subtests and the VADS Total score. Picture Arrangement had a moderate loading on Factor III, and together with the Digit Span and Coding subtests made up Bannatyne's Sequential pattern (Bannatyne, 1971). The Davids' Total score loaded negatively on Factor III, giving weight to the factor's attentional component.

Factor IV is best defined by the VMI Test, Visual Tracking, and the WISC-R Block Design subtest. All three tests measure the ability to implement a motor plan. Support for the relationship between visual scanning ability and the ability to copy designs was found by Locher and Worms (1977). The negative loading of Davids' Total score on Factor IV suggests that an attentional component is involved in visual-motor coordination. A number of researchers have found reading disabled children's poor scanning ability to be related to poor attention (e.g., Lefton, Lahey, & Stagg, 1978; Pavlidis, 1979).

In summary, the four psychological factors were found to measure:

a. Verbal Abilities
b. Perceptual Organization
c. Sequential Memory and Attention
d. Visual-Motor Integration

2. Cluster Analysis of Subgroups Based on Psychological Factors

The factor analysis which included 18 psychological variables indicated that the tests were assessing four areas of psychological abilities (i.e., verbal abilities, perceptual organization, sequential memory and attention, visual-motor integration). The possibility that there were subgroups of disabled readers which could be differentiated on the basis of performance in the four areas was the next issue addressed. The four factors were substituted for the 18 variables because the factors provided a clearer basis for comparing subgroups.

The clusters based on psychological data were determined according to the same procedure as that employed in distinguishing the reading clusters. Thus, factor scores derived from subjects' performances on each psychological factor were used in the CLUSTAN program. Ward's hierarchical clustering technique and the iterative relocation procedure were used to classify subjects into subgroups. Ward's technique showed its first substantial increase in the E.S.S. from five clusters (E=5.050) to four (E=8.067). Thus, the five cluster solution was selected. When the iterative relocation procedure was applied to Ward's solution, nine subjects (22%) were relocated to clusters of minimum variance. Although almost a quarter of the sample were relocated, little change occurred in the shape and elevation of the subgroups' profiles. The lack of any substantial change in shape and elevation supported the stability of the clusters.

Internal validation of the five subgroups distinguished by the relocation procedure was accomplished in three ways. First, visual inspection of the five subgroups' profile shapes and elevations revealed the distinctiveness of each subgroup. In Figure 2, mean factor scores of each subgroup on each of the four psychological factors were plotted. Subgroup profiles were compared to the total sample mean of zero and standard deviation of one. Second, one way analyses of variance (ANOVAs) were computed to provide a statistical measure of the differences between subgroups on the four psychological factors. A Scheffe multiple comparison of means was also computed to ascertain which pairs of subgroups were significantly different on each factor. Results are presented in Table 18 and indicate significant between group differences on each factor. Finally, comparison of the subgroups on the 18 variables used to determine the four psychological factors provided further internal validation of the subgroups. Results of the ANOVAs and Scheffe multiple comparisons of means computed to compare the subgroups on the 18 psychological variables are presented in Table 19. Table 19 indicates that 15 of the 18 variables showed significant between group differences. A description of each of the subgroups will now be presented.

Subgroup 1 was composed of four boys and two girls. Figure 2A indicates that Subgroup 1 was significantly below

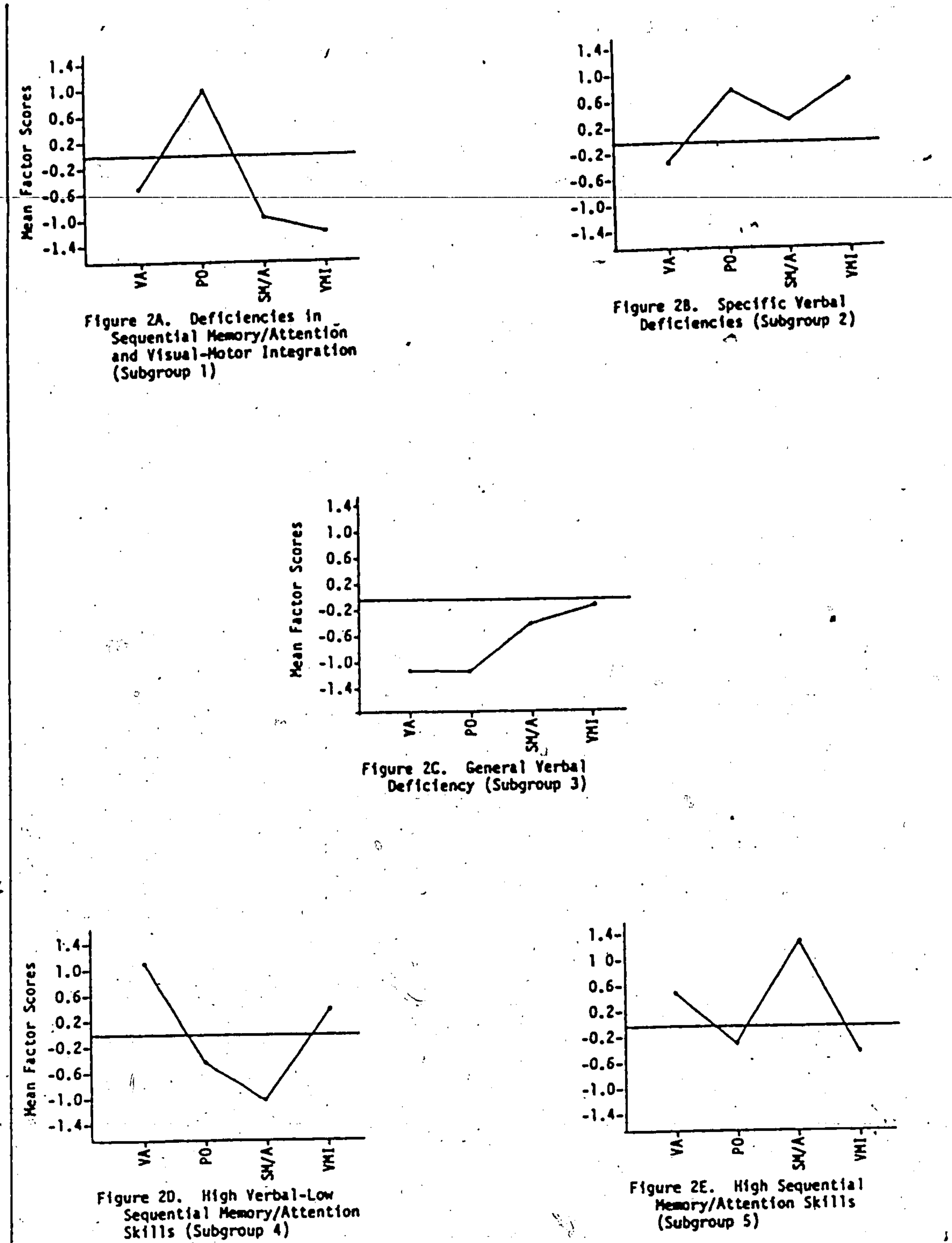

Figure 2. Mean Factor Scores of Subgroups Based on Psychological Factors

Key

VA - Verbal Ability

PO - Perceptual Organization

SM/A - Sequential Memory/Attention

VMI - Visual-Motor Integration

Table 18

Subgroups Based on Psychological Factors:
Comparison of Subgroups on Psychological Factors

Psychological Factors		Subgroups[1] 1	2	3	4	5	F Value[2]	Scheffe Multiple Comparison[3]
V.A.	Mean	-0.5	-0.3	-1.1	1.1	0.5	12.1***	Subgroup 4 > Subgroups 1,2,3
	S.D.	0.5	0.5	0.9	0.8	0.7		Subgroup 5 > Subgroup 3
P.O.	Mean	0.9	0.8	-1.1	-0.4	-0.3	9.2***	Subgroups 1,2 > Subgroups 3,4,5
	S.D.	0.8	0.8	0.6	0.9	0.7		
S.M./A.	Mean	-0.9	0.3	-0.4	-1.0	1.3	24.0***	Subgroup 5 > All other subgroups
	S.D.	0.7	0.8	0.3	0.2	0.5		Subgroup 2 > Subgroups 1,4
V.M.I.	Mean	-1.2	0.9	-0.1	0.4	-0.4	8.1***	Subgroup 2 > Subgroups 1,5
	S.D.	0.6	0.4	1.0	0.6	1.1		Subgroup 4 > Subgroup 1

[1] df = 4,36

[2] *** $p < .001$

[3] Significant at 0.10 level

Key

V.A. - Verbal Abilities
P.O. - Perceptual Organization
S.M./A. - Sequential Memory/Attention
V.M.I. - Visual-Motor Integration

Table 19

Subgroups Based on Psychological Factors: Comparison of Subgroups on Psychological Variables Used in the Factors

Psychological Variables		Subgroups[1] 1	2	3	4	5	F Value[2]	Scheffe Multiple Comparison[3]
Verbal Abilities Factor:								
Information	Mean	9.7	8.4	7.4	11.5	9.0	5.0**	Subgroup 4 > Subgroups 2,3
	S.D.	1.9	1.4	2.4	1.6	2.2		
Similarities	Mean	11.3	10.0	7.3	10.8	11.4	4.5**	Subgroups 1,4,5 > Subgroup 3
	S.D.	3.8	1.7	1.8	2.1	1.5		
Arithmetic	Mean	7.0	10.8	9.0	11.9	11.4	6.7***	Subgroups 2,4,5 > Subgroup 1
	S.D.	1.5	2.7	2.2	1.8	1.4		
Vocabulary	Mean	10.0	10.3	6.7	10.8	11.1	6.1***	All other subgroups > Subgroup 3
	S.D.	0.9	1.8	2.1	1.6	2.6		
Comprehension	Mean	9.5	11.3	9.0	12.3	11.5	2.9*	No significant between subgroup differences
	S.D.	3.0	2.7	1.4	2.1	1.6		
Sentence Repetition	Mean	10.0	11.1	10.9	12.5	12.0	5.3**	Subgroups 4,5 > Subgroup 1
	S.D.	0.6	1.0	1.7	1.1	1.2		
Wepman	Mean	2.3	2.8	1.6	3.3	3.4	4.7**	Subgroups 4,5 > Subgroup 3
	S.D.	1.0	0.8	1.0	1.4	0.5		
Auditory Closure	Mean	97.0	84.7	76.1	96.8	88.7	2.1	No significant between subgroup differences
	S.D.	19.9	16.8	10.1	16.2	15.8		
Perceptual Organization Factor:								
Vocabulary	Mean	10.0	10.3	6.7	10.8	11.1	6.1***	All other subgroups > Subgroup 3
	S.D.	0.9	1.8	2.1	1.6	2.6		
Picture Completion	Mean	13.3	12.8	8.9	11.0	10.3	4.0**	Subgroups 1,2 > Subgroup 3
	S.D.	1.5	2.5	3.0	2.7	2.4		
Picture Arrangement	Mean	12.7	12.6	10.9	10.3	12.0	2.1	No significant between subgroup differences
	S.D.	2.9	1.6	2.0	1.9	2.3		
Block Design	Mean	10.7	12.3	9.0	10.4	9.6	2.2	No significant between subgroup differences
	S.D.	2.5	1.3	3.4	1.8	3.3		
Object Assembly	Mean	12.8	13.3	9.0	10.0	10.8	4.0**	Subgroup 2 > Subgroup 3
	S.D.	3.2	3.3	2.1	2.3	1.8		
Sequential Memory/Attention Factor:								
Digit Span	Mean	5.8	8.4	7.1	7.3	11.1	12.7***	Subgroup 2 > Subgroup 1 Subgroup 5 > All other subgroups
	S.D.	1.0	1.9	1.5	1.4	1.9		
Coding	Mean	10.2	10.2	9.0	8.4	12.4	4.0**	Subgroup 5 > Subgroups 3,4
	S.D.	1.8	2.9	2.2	1.3	2.6		
VADS Total	Mean	13.3	29.5	15.0	22.8	72.0	19.8***	Subgroup 5 > All other subgroups
	S.D.	9.3	19.2	9.6	5.3	23.4		
Davids' Total	Mean	24.5	18.8	20.1	21.8	20.1	4.0**	Subgroup 1 > Subgroup 2
	S.D.	5.2	1.0	3.2	3.0	2.2		
Visual-Motor Integration Factor:								
Block Design	Mean	10.7	12.3	9.0	10.4	9.6	2.2	No significant between subgroup differences
	S.D.	2.5	1.3	3.4	1.8	3.3		
Beery's VMI Test	Mean	86.7	123.1	84.1	112.9	97.7	5.6**	Subgroup 2 > Subgroups 1,3
	S.D.	15.0	13.4	21.6	20.3	26.6		
Visual Tracking	Mean	7.5	11.7	10.9	12.0	9.8	6.1***	Subgroups 2,3,4 > Subgroup 1
	S.D.	2.8	0.7	1.2	0.0	3.0		
Davids' Total	Mean	24.5	18.8	20.1	21.8	20.1	4.0**	Subgroup 1 > Subgroup 2
	S.D.	5.2	1.0	3.2	3.0	2.2		

[1] df = 4.36

[2] * $p < .05$
** $p < .01$
*** $p < .001$

[3] Significant at 0.10 level

the sample mean on the VMI factor. Although not significantly different from the sample mean on other factors, the subgroup demonstrated poor sequential memory and attention skills and well-developed skills in perceptual organization. Table 18 indicates Subgroup 1's significantly poorer performance on the Visual-Motor Integration and Sequential Memory/Attention factors relative to other subgroups, and its higher performance on the Perceptual Organization factor. The subgroup's performance on variables that loaded significantly on the four factors is presented in Table 19. Poor visual-motor integration skills were measured by the subgroup's inferior visual tracking skills and their poor performance on Beery's VMI Test. Poor attention skills were revealed by a discrepantly low score on the Distractibility Index (i.e., Arithmetic and Digit Span) and a high rating on Davids' scale for hyperactivity. Difficulties in sequential memory were confirmed by the subgroup's poor performance on Sentence Repetition, the VADS Total Score, and the Digit Span subtest. Subgroup 1's strength in perceptual organization was substantiated by the average to superior performance on the subtests measuring this skill (i.e., Picture Completion, Picture Arrangement, Block Design, and Object Assembly). Subgroup 1 was designated "Deficiencies in Sequential Memory/Attention and Visual-Motor Integration" because of its main areas of weakness.

Subgroup 2 was made up of five boys and five girls. As Figure 2B indicates, the subgroup was not significantly different from the total sample mean on any of the four psychological factors. Nonetheless, Table 18 shows that Subgroup 2 had a significantly lower mean factor score on the Verbal Abilites factor than one other subgroup. In addition, performance on the three other factors was significantly higher than most other subgroups. An examination of the psychological variables that loaded significantly on the Verbal Abilities factor (Table 19) revealed that the subgroup's average performance on the WISC-R Information subtest was in the low average range (mean=8.4), and was significantly lower than one other subgroup. In addition, all but one subgroup member performed poorly on the Auditory Closure subtest, and four of the ten subgroup members had difficulty on the Sentence Repetition subtest. Because the verbal deficits which characterized Subgroup 2 did not amount to a general verbal deficiency the subgroup was designated "Specific Verbal Deficiencies".

Subgroup 3 included three boys and four girls. As Figure 2C shows, the subgroup performed significantly below the sample mean on the Verbal Abilites and Perceptual Organization factors. Table 18 indicates that Subgroup 3 had the lowest mean factor scores on these two factors, and performed significantly lower on the factors than two other subgroups. An examination of the variables which loaded significantly on the Verbal Abilities factor (Table 19) revealed that Subgroup 3 performed below average on the WISC-R Information, Similarites, and Vocabulary subtests. Performance on Vocabulary was significantly lower than all other subgroups, while performance on Similarities was significantly worse than three other subgroups. Five of the seven subgroup members had serious difficulty on Wepman's Auditory Discrimination Test and on the Sentence Repetition test. All subjects in Subgroup 3 had difficulty on the Auditory Closure subtest. Table 19 presents Subgroup 3's performance on the nonverbal WISC-R variables which loaded significantly on the Perceptual Organization factor. Although performance on these WISC-R variables tended to be worse than other subgroups, Subgroup 3 performed within the average range on these subtests. Subgroup 3 was entitled "General Verbal Deficiency" because it exhibited a pervasive deficit in verbal areas.

Subgroup 4 comprised seven boys and one girl. Figure 2D indicates that the subgroup's mean factor score on the Verbal Abilities factor was significantly higher than the sample mean, while performance on the Sequential Memory/Attention factor was significantly below the sample mean. Table 18 indicates that Subgroup 4 performed significantly better than three other subgroups on the Verbal Abilities factor, and significantly worse than two other subgroups on the Sequential Memory/Attention factor. Subgroup 4's high verbal abilities were displayed in their consistently high average scores on the WISC-R verbal subtests and in their relatively good performance on Sentence Repetition and the Wepman (Table 19). Evidence of Subgroup 4's poor skills in sequential memory and attention was found in the subgroup's poor performance on the WISC-R Digit Span subtest (mean=7.3). Performance on the Coding subtest was the poorest of all subgroups (mean=8.4), although only significantly poorer than one other subgroup. In addition, the subgroup's performance on the VADS Total score (mean=22.8) was below average. Two of the subgroup's members had a high rating of 26 on the Davids' Total score, which is a measure of the hyperactivity syndrome. The subgroup was designated "High Verbal-Low Sequential Memory/Attention Skills" because of its most salient characteristics.

The fifth subgroup consisted of three boys and seven girls. Figure 2E shows that the subgroup was significantly higher than the sample mean on the Sequential Memory/Attention factor. Subgroup 5 was significantly higher than all other subgroups on the Sequential Memory/Attention factor and had poor visual skills (measured by the Perceptual Organization and Visual-Motor Integration factors) compared to the subgroup's other skills (Table 18). Subgroup 5's distinctive strength in sequential memory and attention skills was confirmed by its performance on the psychological variables which made up the factors (Table 19). For example, Subgroup 5 was the only subgroup whose mean performance on the VADS Total score and Digit Span subtests were in the high average range. The subgroup's mean scores on the two measures was significantly higher than all other subgroups. Performance on the WISC-R Coding subtest was also in the high average range and significantly better than two other subgroups. Subgroup 5's skills in perceptual organization were within the average range of performance (Table 19), suggesting that the mean factor score of -.30 on the Perceptual Organization factor was not indicative of a deficiency in this area. Performance on tests of visual-motor integration was not significantly poorer than other subgroups, although four children did have serious difficulty on Beery's VMI Test and two had great difficulty in Visual Tracking and on the Block Design test. Furthermore, like all other subgroups, Subgroup 5 performed poorly on Auditory Closure. Thus, Subgroup 5 had some areas of psychological deficiency, although none were distinctive of the subgroup. Therefore, the subgroup was designated "High Sequential Memory/Attention", according to its area of strength.

Psychological variables which were not included in the computation of the psychological factors were used to obtain external validation for the subgroups. These psychological variables were included in univariate analyses of variance (ANOVAs). Those variables which demonstrated significant differences between subgroups are presented in Table 20. Those which did not demonstrate significant differences between subgroups are presented in Appendix E.

Table 20

Subgroups Based on Psychological Factors:
Significant Subgroup Differences on Psychological Variables External to the Factors

Psychological Variables		Subgroups[1] 1	2	3	4	5	F Value[2]	Scheffe Multiple Comparisons[3]
WISC-R IQ:								
Verbal IQ	Mean	95.6	100.9	86.7	108.4	105.2	9.8***	Subgroups 2,4,5 > Subgroup 3
	S.D.	8.5	5.5	7.9	7.1	8.2		Subgroup 4 > Subgroup 1
Performance IQ	Mean	113.5	115.4	94.9	101.1	106.7	6.6***	Subgroups 1,2 > Subgroup 3
	S.D.	11.3	10.6	7.0	8.9	7.9		Subgroup 2 > Subgroup 4
VADS Subtests:								
Auditory-Oral	Mean	7.5	22.5	11.4	20.0	65.0	17.3***	Subgroup 5 > All other subgroups
	S.D.	2.7	16.0	6.3	18.5	23.2		
Auditory-Written	Mean	15.8	35.0	19.3	34.4	57.5	3.6*	Subgroup 5 > Subgroups 1,3
	S.D.	16.9	23.2	15.7	28.7	31.6		
Visual-Written	Mean	27.5	37.2	35.0	31.3	59.0	2.7*	No significant between
	S.D.	24.8	26.2	19.4	11.6	25.3		subgroup differences
Davids' Scale:								
Variability	Mean	4.3	3.1	3.3	3.5	3.4	2.8*	Subgroup 1 > Subgroup 2
	S.D.	1.2	0.3	0.8	0.8	0.7		

[1] df = 4,36

[2] * p < .05
** p < .01
*** p < .001

[3] Significant at 0.10 level

External validation of Subgroup 1's (Deficiencies in Sequential Memory/Attention and Visual-Motor Integration) deficiency in sequential memory and attention skills was provided by the subgroup's poor performance on the VADS Auditory-Oral and Auditory-Written subtests and by their high rating on Davids' Variability subtest. The latter subtest measures one component of the hyperactivity syndrome. The finding that Subgroup 2 (Specific Verbal Deficiencies) had a significantly higher Performance IQ (mean=115.4) than Verbal IQ (mean=100.9) is further evidence of the subgroup's weakness in verbal areas. Subgroup 3's general verbal deficiency was demonstrated by their significantly lower Verbal IQ (mean=86.7) relative to three other subgroups. In addition, the previously reported finding that Subgroup 3's perceptual organization skills were average but poorer than other subgroups was supported by the subgroup's Performance IQ (mean=94.9), which was in the average range but significantly lower than two other subgroups. Subgroup 4's characteristic of high verbal abilities was supported by their significantly higher Verbal IQ relative to two other subgroups (Table 20). Evidence of Subgroup 4's poor sequential memory/attention skills was also found in its below average performance on the VADS Auditory-Oral subtest. Subgroup 5's distinctive characteristic of high sequential memory/attention was clearly supported by the subgroup's average performance on the VADS subtests (Table 20) and by their significantly superior mean score on the VADS Auditory-Oral subtest relative to all other subgroups. In summary, variables external to the classification procedure supported the descriptions of the subgroups and provided evidence of their external validity.

Comparison of the subgroups on descriptive measures indicated that Subgroup 3 (General Verbal Deficiency) was the oldest subgroup and had the highest degree of reading retardation (Table 21). Subgroup 3 had the largest discrepancy between actual and expected grade placement compared to the other subgroups based on psychological factors. In fact, six of Subgroup 3's seven members repeated at least one grade. The finding that the subgroup's average Verbal and Performance IQs were lower than other subgroups (Table 20) helps explain the high degree of reading retardation and the large number of children who repeated grades within Subgroup 3.

D. The Relationship Between the Psychological and the Reading Data

Two main aspects of the relationship of the psychological data to the reading data are examined in this section. Earlier in the present chapter, a significant canonical correlation was reported between the 18 psychological variables and the eight reading variables. Three major steps were now taken to determine what specific relationships existed between the psychological variables or

Table 21

Subgroups Based on Psychological Factors:
Comparison of Subgroups on Descriptive Measures

Descriptive Measures		Subgroups[1] 1	2	3	4	5	F Value[2]	Scheffe Multiple Comparisons[3]
Chronological Age	Mean	122.0	127.2	135.7	132.6	116.6	2.9*	Subgroup 3 > Subgroup 5
	S.D.	14.2	12.9	12.2	15.1	11.2		
Actual Grade Placement	Mean	4.6	5.6	5.2	5.6	4.9	1.8	N/A
	S.D.	1.2	0.8	0.8	0.9	1.0		
Expected Grade Placement	Mean	5.1	5.7	6.2	6.0	5.0	2.0	N/A
	S.D.	1.4	1.0	0.8	1.2	1.0		
Years of Reading Retardation	Mean	1.7	1.7	2.7	1.9	1.5	3.0*	Subgroup 3 > Subgroup 5
	S.D.	0.9	0.6	0.4	0.7	0.9		

1 df = 4,36
2 * $p < .05$
3 Significant at 0.10 level

profiles and reading patterns: a) a stepwise regression program was employed in order to ascertain what psychological variables could be identified as significant predictors of the reading factors; b) the relationship between psychological measures and the reading strategies used by subgroups of disabled readers based on the four reading factors was investigated through the use of univariate and multiple analyses of variance (ANOVAs and MANOVAs); and c) the relationship between the psychological profiles of subgroups of disabled readers based on the four psychological factors and performance on reading variables was explored through the use of ANOVAs. The second main topic addressed is the question of whether membership in the subgroups based on reading factors can be predicted from membership in the subgroups based on psychological factors.

1. The Relationship Between Psychological Variables and Reading Strategies

a) Stepwise Regression Analysis

The SPSS Stepwise Regression program used the correlation matrix between the psychological variables and reading factor scores and entered into the regression the predictor variable (i.e., a psychological variable) most highly correlated with the criterion (i.e., a reading factor score). The stepwise regression determined in successive stages which variables best predicted the factor scores. The DERS (Fact23) Factor Estimates program was used to obtain factor scores for the eight reading variables used in the factor analysis. Table 22 presents the stepwise regression analysis. No correlations are given a negative value in the SPSS Stepwise Regression program so the investigator must infer the existence of any negative predictive relationships on the basis of other information.

The results indicated that the WISC-R Information subtest was the only significant predictor of Factor I (Visual Cue Dependence). The subtest accounted for only 13% of the variance of Factor I. In a previous section, Table 5 presented Information as loading in an opposite direction to Visual Similarity, suggesting that the predictive relationship between knowledge of general information and reliance on graphic cues is negative.

Significant predictors of Factor II (Contextual Appropriateness) included the WISC-R Similarities subtest on its own, and the WISC-R Similarities and Comprehension subtests in combination. Together these subtests accounted for 36 percent of the variance of Factor II, and illustrate the relationship between verbal conceptualization abilities and the ability to use contextual cues appropriately when reading.

Factor III (Visual Disorganization) had two significant predictors -- Vocabulary alone, and Vocabulary and Coding together. Both predictors accounted for 22 percent of Factor III's variance. It is difficult to explain the relationship between Vocabulary and the Visual Disorganization factor. However, a negative relationship between Coding and Visual

Table 22

Stepwise Regression Analysis of Psychological Variables and Reading Factors

Reading Factors	Psychological Variable(s)	df	Multiple Correlation	F Value[1]	Percent Variance
V.C.D.	Information	1,39	.37	6.01*	13.47
C.A.	Similarities	1,39	.48	11.90**	23.43
	Similarities & Comprehension	2,38	.60	10.54***	35.64
V.D.	Vocabulary	1,39	.34	5.12*	11.63
	Vocabulary & Coding	2,38	.47	5.48**	22.37
P.V.C.U.	Tracking	1,39	.37	6.09*	13.54

1
* $p < .05$
** $p < .01$
*** $p < .001$

Key

V.C.D. - Visual Cue Dependence
C.A. - Contextual Appropriateness
V.D. - Visual Disorganization
P.V.C.U. - Partial Visual Cue Use

Disorganization was observed in Table 5 and suggests an association between poor visual sequential memory and visual disorganization or inattention in reading.

The fourth reading factor (Partial Visual Cue Use) was predicted by Visual Tracking ability, which accounted for 14 percent of the factor's variance. The predictive relationship between Visual Tracking ability and Partial Visual Cue Use suggests that good ocular control is related to the decoding of letter groups or whole words.

b) Psychological Abilities Associated with Subgroups of Disabled Readers Based on Reading Factors

The relationship between psychological abilities and the reading strategies of the subgroups based on reading factors was examined through the use of ANOVAs and MANOVAs. The results of the ANOVAs demonstrated significant subgroup differences on only two psychological variables, Sentence Repetition ($\underline{F}=2.8$, $\underline{df}=4,36$, $\underline{p}\leq.05$) and the Davids' Explosiveness subtest ($\underline{F}=3.1$, $\underline{df}=4,36$, $\underline{p}\leq.05$). While the Scheffe procedure revealed that no pairs of groups differed on Sentence Repetition at the 0.10 level of significance, four out of Subgroup 4's five members (High Visual-Low Contextual Cue Dependence) had difficulty on this task.[‘]

‘Scores on several of the psychological tests were dependent on age norms (i.e., Beery's VMI Test, Sentence Repetition, Word Fluency, Left-Right Discrimination, Auditory Closure). An examination of each subject's scores within each subgroup revealed that no subgroup displayed a distinctively high or low performance on any of these variables, with the exception of Subgroup 4's (High Visual-Low Contextual Cue Dependence) poor performance on the Sentence Repetition test.

Subgroup 5 (High Visual Disorganization) had a significantly higher rating on the Davids' Explosiveness scale than Subgroups 2 (Low Partial Visual Cue Use) and 3 (Low Visual Cue Dependence). The finding that Subgroup 5 had a higher rating on one of Davids' subtests provided further external validation for the subgroup's characteristics of visual disorganization and/or inattention.

The possibility that subgroups based on reading factors might be differentiated by groups of psychological variables measuring one type of ability (e.g., variables measuring verbal ability) was explored through the use of MANOVAs. Four MANOVAs were computed that were based on variables which loaded significantly on each of the four psychological factors. The SPSS MANOVA program showed that the group of variables selected from Factor III (Sequential Memory/Attention) demonstrated significant differences between the subgroups based on reading factors ($F=1.7$, $df=20,107.1$, $p \leq .05$). The DERS (Mulv16) Multivariate and Covariate Analysis program was then used to discover which pairs of subgroups contrasted significantly on the group of sequential memory and attention variables. An examination of subgroup means within each set allowed inferences to be made about which subgroup in a pair had the better performance (Table 22). Psychological patterns based on the Verbal Abilities factor ($F=1.0$, $df=36,106.7$, $p>.05$), the Perceptual Organization factor ($F=1.2$, $df=28,109.6$, $p>.05$) and the Visual-Motor Integration factor ($F=1.5$, $df=20,107.1$, $p>.05$).

did not show significant differences between subgroups. It is possible that significant differences did not emerge because of the small sizes of the subgroups. Therefore, nonsignificant trends in the subgroups' verbal and visual skills were also examined (Table 23).

Table 23 reveals that Subgroup 5's (High Visual Disorganization) sequential memory and attention skills were significantly worse than all other subgroups. It is likely that Subgroup 5's poor performance on the WISC-R Coding subtest and their tendency towards hyperactivity (as measured by Davids' Total score) contributed to their visual disorganization in reading.

Although the MANOVA which was based on visual-motor integration skills did not demonstrate significant differences between subgroups, the finding that Subgroup 2 had a lower, though not a significantly lower, mean Visual Tracking score than other subgroups (Table 23) suggested that Subgroup 2's weak ocular motor control could be responsible for the low frequency of reading errors which indicated partial visual cue use (i.e., Nonsense Word and Letter Sequence errors).

A relationship between verbal competence and contextual cue use was also evident. For example, Subgroup 4 (High Visual-Low Contextual Cue Dependence) had low average verbal abilities and made poor use of contextual cues when reading. In contrast, Subgroups 1, 2 and 3 (High Contextual Cue Users; Low Partial Visual Cue Users; Low Visual Cue

Table 23

Subgroups Based on Reading Factors:
Comparison of Subgroups on Psychological Measures

		Subgroups[1]					F Value[2]
		1	2	3	4	5	
Verbal Abilities:							
Information	Mean	9.9	8.0	9.9	8.8	9.0	1.3
	S.D.	3.0	1.5	1.2	1.8	3.6	
Similarities	Mean	11.7	10.5	10.0	9.0	8.8	1.6
	S.D.	2.1	3.4	1.3	2.0	3.3	
Arithmetic	Mean	11.4	9.7	11.0	9.0	9.0	1.5
	S.D.	2.4	3.1	2.1	2.2	2.5	
Vocabulary	Mean	10.3	10.4	9.7	8.4	10.4	0.7
	S.D.	2.9	2.1	1.4	4.3	1.9	
Comprehension	Mean	11.8	10.7	11.6	9.6	9.2	1.6
	S.D.	2.4	1.9	2.6	1.9	2.6	
Sentence Repetition	Mean	11.8	10.8	12.2	10.4	11.0	2.8*
	S.D.	1.1	1.3	1.3	1.1	1.6	
Wepman	Mean	3.3	2.7	2.8	2.2	2.4	1.1
	S.D.	0.9	1.3	1.1	1.1	1.3	
Auditory Closure	Mean	92.0	87.4	91.7	83.2	81.0	0.6
	S.D.	13.6	16.8	15.9	20.8	23.2	
Perceptual Organization:							
Vocabulary	Mean	10.3	10.4	9.7	8.4	10.4	0.7
	S.D.	2.9	2.1	1.4	4.3	1.9	
Picture Completion	Mean	12.0	9.9	11.9	10.4	11.8	1.0
	S.D.	2.9	3.0	3.3	1.7	1.5	
Picture Arrangement	Mean	11.9	12.8	12.1	10.0	10.0	2.6
	S.D.	2.6	2.0	2.1	1.0	1.6	
Block Design	Mean	12.0	9.2	11.0	8.8	10.6	2.1
	S.D.	1.4	3.3	3.0	0.8	1.9	
Object Assembly	Mean	12.8	9.9	11.8	9.4	11.8	1.9
	S.D.	3.1	1.4	4.0	1.5	1.6	
Sequential Memory/Attention:							
Digit Span	Mean	7.9	8.9	7.9	8.2	8.4	0.3
	S.D.	2.1	3.2	2.1	2.7	1.8	
Coding	Mean	11.0	10.3	9.8	12.0	7.6	2.3
	S.D.	2.5	2.0	2.7	3.4	0.9	
VADS Total	Mean	33.9	40.0	38.9	23.0	19.0	0.8
	S.D.	25.1	30.6	32.5	17.5	19.2	
Davids' Total	Mean	20.6	20.0	20.7	19.6	24.0	1.5
	S.D.	2.7	3.2	2.6	2.3	6.0	
Visual-Motor Integration:							
Block Design	Mean	12.0	9.2	11.0	8.8	10.6	2.1
	S.D.	1.4	3.3	3.0	0.8	1.9	
Beery's VMI Test	Mean	102.0	97.5	111.1	97.8	100.4	0.5
	S.D.	27.1	25.6	24.1	23.6	24.3	
Visual Tracking	Mean	11.1	8.9	11.2	11.4	10.4	1.8
	S.D.	1.7	3.3	1.7	1.3	2.5	
Davids' Total	Mean	20.6	20.0	20.7	19.6	24.0	1.5
	S.D.	2.7	3.2	2.6	2.3	6.0	
WISC-R IQ:							
Verbal IQ	Mean	106.0	98.9	102.3	93.6	95.0	1.9
	S.D.	12.4	6.7	5.7	13.5	12.5	
Performance IQ	Mean	113.2	102.6	108.8	100.2	104.8	1.7
	S.D.	11.7	10.9	13.1	10.2	3.6	

[1] df = 4,36

[2] * $p < .05$

Dependence) had average to high average verbal abilities (Table 23) and had significantly higher scores than Subgroup 4 on Comprehension Patterns (Table 9). Because subgroups did not differ significantly on the Information subtest it was not possible to confirm whether poor performance on the WISC-R Information subtest was associated with a high visual cue dependence, as predicted by the stepwise regression analysis. The one subgroup which was characterized by high visual cue dependence (i.e., High Visual-Low Contextual Cue Dependence) had a mean score on Information in the average range (mean=8.8, SD=1.8). The subgroup's performance on other verbal abilities ranged from below average to low average, suggesting that weak verbal skills might be a better predictor of high visual-low contextual cue dependence than the Information subtest alone.

c) Reading Variables Associated with Subgroups of Disabled Readers Based on Psychological Factors

The relationship between reading variables and the psychological profiles of the subgroups based on psychological factors was examined through the use of ANOVAs. Only one reading variable, Omissions, demonstrated significant between group differences (Table 24). Nonsignificant trends in the reading strategies associated with psychological profiles were also considered because the small number of subjects in each subgroup reduced the probability of variables discriminating significantly between subgroups.

Table 24

Subgroups Based on Psychological Factors:
Comparison of Subgroups on Reading Variables

Reading Variables		Subgroups[1] 1	2	3	4	5	F Value[2]
Error Types:							
Additions & Omissions	Mean	23.7	19.0	11.1	21.4	13.9	1.8
	S.D.	6.7	11.0	6.7	8.6	14.4	
Additions	Mean	8.5	9.3	6.1	8.4	7.9	0.2
	S.D.	4.3	6.0	5.6	6.8	8.6	
Omissions	Mean	15.3	9.6	4.0	12.9	7.1	4.0**
	S.D.	3.4	5.5	3.6	6.4	8.0	
Structural Analysis	Mean	17.3	20.7	29.0	16.4	24.9	2.4
	S.D.	7.8	7.7	13.6	7.3	9.2	
Letter Sequences	Mean	1.6	2.5	0.9	1.8	0.9	1.1
	S.D.	2.4	2.5	1.6	1.8	1.5	
Nonsense Words	Mean	4.2	8.3	6.4	7.0	4.6	0.9
	S.D.	3.7	3.9	7.7	4.3	5.8	
Scanning	Mean	2.3	1.9	1.1	2.3	1.7	0.3
	S.D.	3.7	2.4	2.0	2.3	2.1	
Repetitions	Mean	7.0	4.2	3.0	9.3	7.8	1.5
	S.D.	6.8	4.5	4.0	5.9	8.0	
Consonant Errors	Mean	3.5	4.7	5.7	3.8	4.2	0.6
	S.D.	3.3	2.5	4.3	1.9	3.1	
Vowel Errors	Mean	5.7	3.6	5.1	3.1	4.6	0.8
	S.D.	5.0	2.4	3.7	2.5	3.0	
Words Aided or Mumbled	Mean	1.2	1.7	0.4	0.6	2.0	0.6
	S.D.	1.8	2.8	1.1	1.2	3.8	
Qualitative Scales:							
Visual Similarity	Mean	52.2	55.8	62.1	48.5	58.6	1.8
	S.D.	4.8	10.1	10.7	9.5	14.4	
Grammatical Relationships	Mean	48.7	55.2	50.3	61.8	56.4	1.2
	S.D.	16.6	8.3	10.2	9.5	17.7	
Comprehension Patterns	Mean	50.7	58.9	48.3	63.9	57.0	2.1
	S.D.	13.3	8.2	13.4	10.0	13.9	
Degree of Correction	Mean	22.0	23.1	11.0	26.5	24.6	2.4
	S.D.	10.3	8.5	8.6	14.2	11.1	

[1] df = 4,36

[2] ** p < .01

Subgroup 1 > Subgroup 3 at 0.10 level of significance

As Table 24 indicates, Subgroup 1 (Deficiencies in Sequential Memory/Attention and Visual-Motor Integration) made significantly more whole word omissions than Subgroup 3 (General Verbal Deficiency). Subgroup 4's (High Verbal-Low Sequential Memory/Attention) tendency to make omissions was almost as pronounced as Subgroup 1's. The previously reported finding that Additions and Omissions loaded highly on the same factor as Comprehension Patterns (Table 7) suggested that addition and omission errors are associated with the appropriate use of contextual cues when reading. Furthermore, a positive relationship between verbal abilities and contextual cue use was indicated by the stepwise regression analysis (Table 22) as well as by the previously reported correlation between Comprehension Patterns and the WISC-R Comprehension subtest. Subgroup 4's relatively high tendency to make omissions seemed to be related to their high verbal abilities, while Subgroup 3's low tendency to make omissions seemed related to their verbal deficiency. However, Subgroup 1's high production of omission errors could not be as readily explained because their verbal abilities were only average.

A relationship between verbal abilities and the use of contextual cues was found in a number of subgroups based on psychological factors. For example, Subgroups 4 and 5's well-developed verbal abilities were related to their relatively good use of contextual cues (measured by Grammatical Relationships and Comprehension Patterns).

Conversely, Subgroup 3's poor verbal abilities were associated with poor use of contextual cues (Table 24).

Partial support for the relationship between poor performance on the Information subtest and high visual cue dependence was found in Subgroup 3 (General Verbal Deficiency). Subgroup 3's performance on the Information subtest was below average (mean=7.4), and their reading strategy involved a greater reliance on graphic than contextual cues (Table 24). However, Subgroup 3's performance on other verbal tests aside from Information was also below average, suggesting that a general verbal deficiency rather than poor performance on the Information subtest per se may be the best predictor of high graphic cue dependence.

Relationships between other psychological abilities and reading strategies that were expected to emerge on the basis of the stepwise regression analysis were not supported by the subgroups. For example, Subgroup 1's (Deficiencies in Sequential Memory/Attention and Visual-Motor Integration) poor visual tracking skills were not related to a notably low percentage of Letter Sequence and Nonsense Word errors. Moreover, higher frequencies of these error types were not related to the well-developed visual tracking skills of Subgroups 2 (Specific Verbal Deficiencies) and 4 (High Verbal-Low Sequential Memory/Attention). The relationship between poor scores on the WISC-R Coding subtest and visually disorganized decoding strategies could not be confirmed because subgroups did not score below average on Coding.

2. The Prediction of Membership in Subgroups Based on Reading Factors from Membership in Subgroups Based on Psychological Factors

The last issue to be addressed in the present study pertains to whether subgroups of reading disabled children based on reading factors can be predicted from subgroups based on psychological factors. A crosstabulation between reading and psychological subgroup members revealed little correspondence between the two sets of subgoups (Table 25). It is possible that the small number of subjects used in this study prevents the discovery of any substantial correspondence that might exist between these groups.

Table 25

Number of Subjects Shared in Subgroups Based on Reading and Psychological Factors

Subgroups Based on Reading Factors	Subgroups Based on Psychological Factors				
	1	2	3	4	5
1	1	3	1	3	1
2	2	2	2	0	4
3	1	4	1	3	3
4	0	0	2	1	2
5	2	1	1	1	0

V. Summary and Conclusions

The present study was designed to investigate questions regarding: a) the heterogeneity of reading disabled children's reading strategies; b) the heterogeneity of reading disabled children's psychological profiles; and c) the relationship between reading strategies and psychological profiles. Forty-one children with specific reading disabilities were selected for the study. A reading test and a series of psychological tests were administered individually to each child.

The results of the data analysis indicated that disabled readers could be divided into subgroups on the basis of their reading characteristics. Subgroups of disabled readers could also be differentiated according to their psychological attributes. A limited predictive relationship between subtypes of reading skills and subtypes of psychological skills emerged. The findings of the present study will now be discussed in relation to each of the questions posed for investigation.

Question 1. Can subgroups of disabled readers be determined on the basis of a statistical analysis of reading strategies? If so, what are the distinguishing features of these subgroups?

The results of the cluster analysis indicated that reading disabled children could be classified into subgroups according to their reading strategies. The patterns of reading skills which distinguished the subgroups were based on their performance on four reading factors (i.e., Visual Cue Dependence, Contextual Appropriateness, Visual Disorganization, Partial Visual Cue Use). The use of four factors to distinguish the subgroups rather than the eight reading variables which made up the factors facilitated comparison of the subgroups' reading patterns. Five subgroups were found, each with distinguishing characteristics. Subgroups were described by the following characteristics: High Contextual Cue Users, Low Partial Visual Cue Users, Low Visual Cue Dependence, High Visual-Low Contextual Cue Dependence, and High Visual Disorganization. The finding of statistically significant differences between subgroups' mean factor scores on each of the four reading factors provided support for the internal validity of each subgroup. Comparison of the subgroups on the eight variables used to determine the four reading factors also provided internal validation of the subgroups. Descriptive measures and those reading variables which were not used in the factors upon which the subgroups were based provided further evidence for the subgroups' distinctiveness.

The classification of reading disabled children according to reading patterns may help to explain some of the inconsistencies within the reading literature on how the inefficient reader uses graphic and contextual cues. One view among researchers has been that poor or disabled readers rely more on graphic properties and pay little attention to contextual cues (e.g., Goodman & Burke, 1973;

Leslie, 1980) while other investigators have claimed just the opposite (e.g., Schvaneveldt et al., 1977; West & Stanovich, 1978). In the present study, both points of view were upheld when the subgroups of readers were differentiated. Subgroup 3 (Low Visual Cue Dependence) relied more on contextual than graphic cues, while Subgroup 4 (High Visual-Low Contextual Cue Dependence) relied more on graphic than contextual cues.

For two of the subgroups the distinctive characteristic of their reading performance was found in the type of visual processing strategy they used rather than in their degree of reliance on visual or contextual cues. Subgroup 5 (High Visual Disorganization) seemed to use graphic more than contextual cues, but their visual processing strategy was characterized by disorganization. Poor visual scanning of the text has frequently been reported as a characteristic of disabled readers (e.g., Benton, 1975). Two other subgroups used graphic and contextual cues to a similar degree, but their visual processing strategies differed. Although Subgroup 1 was designated High Contextual Cue Users, some of the subgroup's reading errors (i.e., Letter Sequence and Nonsense Word errors) reflected a reliance on visual processing of letter groups or whole words. Subgroup 2's (Low Partial Visual Cue Use) errors suggested equal use of both graphic and contextual cues, but their errors generally indicated a letter-by-letter processing strategy.

Question 2. Can subgroups of disabled readers be determined on the basis of a statistical analysis of psychological characteristics? If so, what are the distinguishing features of these subgroups?

The results of the cluster analysis indicated that reading disabled children could be classified into subgroups on the basis of their performance on the four psychological factors (i.e., Verbal Abilities, Perceptual Organization, Sequential Memory/Attention, Visual-Motor Integration). Five subgroups emerged. Three of the subgroups were distinguished on the basis of deficiencies in one area (i.e., Specific Verbal Deficits, General Verbal Deficiency, Low Sequential Memory/Attention). Another subgroup had two areas of deficiency (i.e., Deficiencies in Sequential Memory/Attention and Visual-Motor Integration). The fifth subgroup was distinguished by its strength in sequential memory and attention, although the subgroup had deficits in verbal and nonverbal areas which were common to all other subgroups. Statistically significant differences between subgroups' mean factor scores on each of the four reading factors provided support for the internal validity of each subgroup. Comparison of the subgroups on the 18 variables used to compute the four psychological factors revealed that significant differences between subgroups existed for 15 of the 18 variables and provided further internal validation for the subgroups. Psychological variables which were not included in the computation of the factors provided external validation of the subgroups.

One of the subgroups which had deficiencies in only one general area was Subgroup 2, which was characterized by verbal deficits. The subgroup's deficits included general knowledge (measured by the WISC-R Information subtest) and auditory closure ability (measured by the ITPA). Forty percent of the subgroup's members also had difficulty in auditory memory for meaningful material (measured by the Sentence Repetition Test). To the writer's knowledge, subgroups defined solely by deficits in these verbal areas have not been identified in previous studies, although Mattis et al.'s (1975) Language Disorder syndrome was defined by subjects' anomia, measured by the Naming Test, and poor performance on any one of three other verbal tests (i.e., Token Test, Sentence Repetition, Speech-Sound Discrimination). Furthermore, Subgroup 2's significantly lower Verbal IQ than Performance IQ has been found in other subgroups with language disorder syndromes (e.g., Petrauskas & Rourke, 1979; Mattis et al., 1975).

Subgroup 3's general language deficiency resembled the global language impairment syndrome found by other researchers (e.g., Fisk & Rourke, 1979; Lyon & Watson, 1981; Petrauskas & Rourke, 1979; Satz & Morris, 1980). The better visual-spatial than verbal abilities which were found in Subgroup 3 were also characteristic of language impairment subgroups identified by other researchers (e.g., Fisk & Rourke, 1979; Petrauskas & Rourke, 1979). However, Subgroup 3's Verbal IQ was not significantly lower than its

Performance IQ. The lack of a significant Verbal IQ-Performance IQ discrepancy may be attributed to the generally low IQ of Subgroup 3. Thus, the subgroup appeared to resemble a borderline slow learner group rather than a group of learning disabled children with a specific verbal deficit.

Subgroup 4 was distinguished by well-developed verbal abilities, deficient sequential memory for nonmeaningful material, and poor attention skills. The subgroup performed in the low average range on the Coding subtest and was particularly weak on sequential memory tasks involving digits. In contrast, performance on the task requiring the repetition of sentences was average to high average. Several researchers isolated subgroups which performed poorly on both Digit Span and Sentence Memory tasks and were described as having sequencing/linguistic deficiencies (i.e., Lyon & Watson, 1981; Mattis, 1978; Petrauskas & Rourke, 1979). Subgroup 4 differed from these subgroups in that their verbal abilities and memory for meaningful material were well-developed while visual and auditory memory for nonmeaningful material was weak.

Subgroup 5 was characterized by well-developed skills in sequential memory and attention. The psychological deficits of the subgroup could not be interpreted as a distinctive pattern of weaknesses since its deficits were common to other subgroups. Ninety percent of the subjects in Subgroup 5 had difficulty in auditory closure, and 40% had serious difficulty on one or more measures of visual-motor integration. Subgroups with visual-motor impairment have been reported by several researchers (e.g., Lyon & Watson, 1981; Mattis et al., 1975; Mattis, 1978; Satz & Morris, 1980). Difficulties in auditory closure were also found across subgroups in previous studies (e.g., Fisk & Rourke, 1979; Petrauskas & Rourke, 1979).

Subgroup 1 had mixed deficiencies in visual-motor integration and in sequential memory and attention skills. Tendencies toward distractibility and hyperactivity were characteristic of the subgroup. As noted in the preceding paragraph, subgroups of disabled readers characterized by visual-motor impairment have been reported in previous studies. In addition, Vance, Wallbrown, and Blaha (1978) identified a subgroup of reading disabled children characterized by distractibility.

In short, it is clear that no one psychological deficit or pattern of deficits can be taken as characteristic of all disabled readers. The inconclusiveness of much previous research concerning the psychological correlates of reading disability may be largely due to the failure to recognize that disabled readers are heterogeneous with respect to their psychological profiles.

Question 3. Can reading strategies be predicted from psychological abilities?

The relationship between oral reading strategies and the psychological abilities of the subjects was first investigated through a factor analysis of reading and psychological variables and later through a stepwise regression analysis. Results indicated that well-developed verbal ability and auditory memory were positively related to appropriate use of contextual cues and to the ability to make self-corrections. The finding that awareness and use of contextual cues is related to verbal competence supports the hypothesis of previous researchers that such a relationship exists (e.g., Vernon, 1977; Vogel, 1975). The importance of good memory skills for retaining the meaning of a sentence or a story has also been noted by investigators (Torgesen, 1978-79; Vernon, 1977). The relationship between verbal competence, memory for meaningful material, and contextual cue use was supported in the subgroups. Those subgroups with mild to moderate verbal deficiencies and with difficulty on the Sentence Repetition test (i.e., High Visual-Low Contextual Cue Dependence; General Verbal Deficiencies) tended to make poor use of contextual cues. In contrast, subgroups with well-developed verbal abilities and memory for meaningful material (i.e., High Contextual Cue Users; Low Partial Cue Users; Low Visual Cue Dependence; High Verbal-Low Sequential Memory/Attention; High Sequential Memory/Attention) tended to use contextual cues appropriately. Moreover, one subgroup had average verbal skills and poor memory for sentences and digits (Mixed Deficiencies in Sequential Memory/Attention and Visual-Motor Integration) and made poor use of contextual cues.

Poor left-to-right scanning of the text has often been attributed to difficulty in making left-right discriminations (e.g., Croxen & Lytton, 1971). However, the results of the present study suggested that poor visual sequential memory and attention skills are related to inefficient scanning of the text. Support for the relationship between visual sequential memory and scanning was provided by the High Visual Disorganization subgroup. The subgroup had significantly worse sequential memory and attention skills than the four other subgroups to which it was compared.

Visual skills such as perceptual organization and visual-motor integration were found to be related to letter sequence reversals and nonsense word substitutions. The relationship suggested that the two error catgories reflected a type of visual processing strategy during decoding. Specifically, the processing strategy seemed to involve a global perception of letter groups or words, and contrasted with the letter-by-letter processing strategy which was reflected in high Visual Similarity and Structural Analysis errors. Vernon (1977) suggested that memory for word structures, rather than perception, may be related to difficulties in the use of letter groups or whole words for decoding. However, the results of the present study suggested that there may be some relationship between perceptual abilities and errors involving the decoding of letter groups or whole words. The relationship between perceptual abilities and the decoding of letter groups or words received some support in the subgroups. Subgroups with poorly developed skills in perceptual organization and visual-motor integration (i.e, Low Partial Visual Cue Users; Deficiencies in Sequential Memory/Attention and Visual-Motor Integration) made relatively few letter sequence reversals and nonsense word substitutions compared to most other subgroups. However, Low Partial Visual Cue Users were the only subgroup that made significantly fewer nonsense word substitutions than two other subgroups. Subgroups with well-developed visual skills (i.e., High Contextual Cue Users; Specific Verbal Deficiencies) were not distinguished by a high frequency of letter sequence reversals and nonsense word substitutions. Thus, only limited support for the relationship between visual skills and a decoding strategy involving partial visual cue use was found.

The patterns of graphic cue-contextual cue dependence were also examined in relation to visual and verbal skills. One subgroup with better verbal than visual abilities relied more on contextual cues (i.e., High Verbal-Low Sequential Memory/Attention) while another subgroup with better visual than verbal skills (i.e., General Verbal Deficiency) relied more on graphic cues. However, subgroups based on reading factors which did not have clear discrepancies in their visual and verbal skills also relied more on one type of cue than another (i.e., Low Visual Cue Dependence; High Visual-Low Contextual Cue Dependence).

Thus, it seems that only a limited predictive relationship is found between psychological abilities and oral reading strategies. The failure to find a strong predictive relationship may be due to the effects of variables other than psychological strengths and weaknesses on children's reading strategies, such as the type of reading instruction to which the learner is exposed. For example, children who are taught according to the whole word approach may adopt a decoding strategy which focuses on letter groups and whole words. Conversely, those who are taught according to the phonics approach may use a letter-by-letter decoding strategy.

Question 4. Is there a correspondence between the membership of the subgroups established on the basis of psychological abilities and the membership of those established on the basis of reading subskills?

In the present study, there was little correspondence between the two sets of subgroups. The low correspondence meant that one could not predict a child's reading pattern on the basis of his psychological profile. It is possible that the small number of subjects used in the study prevented the discovery of any substantial correspondence that might exist between the two sets of subgroups.

Recommendations

1. Further studies concerning the reading strategies of disabled readers must attempt to identify subgroups of

disabled readers according to their different reading strategies.

2. Future research on reading strategies should examine the types of visual processing strategies used as well as the degree of dependence on contextual and graphic cues. Some subgroups' primary reading characteristics would have been overlooked if subjects' oral reading had been examined simply in terms of cue dependence.
3. In order to understand the psychological correlates of reading disability, it is necessary to identify subgroups of disabled readers according to their different psychological profiles.
4. Further research is needed to determine the predictive relationship between psychological profiles and oral reading strategies. If the predictability between the two is as limited as the present study suggests then conjectures about a child's reading strategy made on the basis of his or her psychological profile must be highly tentative. In order to understand the child's reading strategy and his or her reading-related psychological strengths and weaknesses it appears necessary to conduct both a reading and a psychological assessment.
5. Studies using a sample at least three times larger than that examined in the present study are needed to identify subgroups of disabled readers and to determine the relationship between membership of groups based on reading data and membership based on psychological data.

The small number of subjects investigated in the present study limits the generalization of the findings beyond the confines of the sample.

6. Future research concerning the reading strategies and psychological profiles of disabled readers should employ a control group of normal readers to permit comparison of the disabled to the normal reader.

7. Subjects with more severe reading disabilities should be employed in future studies. It is possible that the relationship between psychological profiles and oral reading strategies is stronger among severely disabled readers than among the mildly to moderately disabled readers examined in the present study.

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Appendix A

Error Categories defined by Spache (1972, p. 16):

1. Omissions - any word, word part, or group of words omitted.
2. Additions - any word or word part added.
3. Substitutions or Mispronunciations - Count a substituted word or a group of substituted words as one error. Do not correct the student or tell him any words, unless he shows that he is becoming upset. Then tell him the word and count it as an error. Do not count repeated errors of mispronunciation of the same name; e.g., Spotty. Count such errors once only.
4. Repetitions - Count repetitions only when two or more words are repeated. Underline the repeated words with an arrow. If the child repeats a group of words several times, indicate each repetition by an arrow under the words. Count each arrow as an error.
5. Reversals - Show reversals of words or word parts by curved lines.
6. Words Aided - Wait about five seconds for the child to try, then tell him the word. Cross out the aided word.

Do not count regional or dialectal mispronunciations as errors.

Hesitations are not counted as errors. Self-corrections, those instances in which a child fumbles over a word and finally says it correctly, are not counted as errors. Do not score more than one error for each mistake. E.g., if a student has fumbled with a word several times, and you tell him the word to relieve his anxiety, he may then repeat the word or an entire phrase before continuing to read. Score only as a single mispronunciation, ignoring the repetition. If he repeats a whole phrase after having worked out one word in it, credit him for the for the word but score the repetition.

Appendix B

Summary of Oral Reading Error Analysis

1. Quantitative Scales

a) Additions

b) Omissions

c) Structural Analysis errors

d) Grapheme-Phoneme errors

e) Letter Orientation Reversals

f) Letter Sequence errors

g) Scanning errors

h) Repetitions

i) Words Aided or Mumbled

j) Nonsense Words

Score = Frequency Count of Category x 100/Total Number of errors.

2. Qualitative Scales

(Excludes analysis of error categories #6, 7, 8)

a) Visual Similarity

0 = No letters shared

1 = 1-25% letters shared

2 = 26-50% letters shared

3 = 51-75% letters shared

4 = 76-100% letters shared

b) Grammatical Relationship Patterns

0 = Weakness

1 = Partial Strength

2 = Strength

c) Comprehension Patterns

0 = Loss of Comprehension

1 = Partial Loss

2 = No Loss

d) Degree of Correction

0 = No attempt

1 = Unsuccessful attempt, or correct form abandoned

2 = Error corrected

Score = Sum of Scale Score x 100/Maximum Score

(Maximum score = Highest score in scale x Total number of errors in scale).

APPENDIX C

ERROR ANALYSIS WORKSHEET

NAME: ______________________________

GRADE: ________________

			Quantitative Scales:										Qualitative Scales:											
																		Grammatical Relationships				Comprehension Patterns		
PASSAGE	TEXT	ERROR	Add.	Om.	Struc. Anal.	Gr.-Ph.	Lett. Or.	Lett. Seq.	Scan.	Rep.	Wds. Aid.	Nons. Wds.	Vis. Sim.	Deg. Corr.	Gram. Acc.	Sem. Acc.	Mean Ch.	S.	P.S.	W.	O.C.	N.L.	P.L.	L.

Key:

Add. = Additions
Om. = Omissions
Struc. Anal. = Structural Analysis errors
Gr.-Ph. = Grapheme-Phoneme errors
Lett. Or. = Letter Orientation Reversals
Lett. Seq. = Letter Sequence errors
Scan. = Scanning errors

Rep. = Repetitions
Wds. Aid. = Words Aided or Mumbled
Nons. Wds. = Nonsense Words
Vis. Sim. = Visual Similarity
Deg. Corr. = Degree of Corrections
Gram. Acc. = Grammatical Acceptability
Sem. Acc. = Semantic Acceptability

Mean. Ch. = Meaning Change
S. = Strength
P.S. = Partial Strength
W. = Weakness
O.C. = Overcorrection
N.L. = No Loss
P.L. = Partial Loss
L. = Loss

Appendix D

Subgroups Based on Reading Factors: Nonsignificant Subgroup Differences on Reading Variables External to the Factors

Reading Variables		Subgroups 1	2	3	4	5	F Value
Error Types:							
Repetitions	Mean	7.3	6.6	7.2	5.2	2.6	0.6
	Standard Deviation	6.9	5.6	7.1	6.8	3.3	
Words Aided or Mumbled	Mean	1.0	1.9	0.4	1.6	2.2	0.7
	Standard Deviation	1.6	3.5	1.0	3.6	3.2	
Qualitative Scales:							
Grammatical Relationships	Mean	59.0	56.4	58.9	45.8	44.6	2.1
	Standard Deviation	10.6	13.0	9.0	16.8	16.6	
Achievement Levels:							
Reading Rate at Grade Placement	Mean	78.6	73.0	90.6	72.4	69.2	1.5
	Standard Deviation	19.2	26.1	15.6	25.1	20.6	
Reading Rate at Instructional Level	Mean	99.7	91.4	108.6	93.8	78.8	1.9
	Standard Deviation	16.6	29.5	18.5	24.5	20.7	
Comprehension at Grade Placement	Mean	79.3	70.1	75.9	71.4	77.8	0.4
	Standard Deviation	20.5	12.1	21.3	23.5	16.1	
Comprehension at Instructional Level	Mean	80.3	84.3	88.8	87.4	89.4	0.9
	Standard Deviation	11.4	13.2	11.1	8.9	11.9	
Years of Reading Retardation	Mean	1.6	1.8	2.2	1.8	1.8	0.6
	Standard Deviation	0.9	0.9	0.8	0.7	0.7	

Appendix E

Subgroups Based on Psychological Factors: Nonsignificant Subgroup Differences on Psychological Variables External to the Factors

Psychological Variable		Subgroups 1	2	3	4	5	F Value
VADS Subtest:							
Visual-Oral	Mean	28.3	49.5	40.7	42.5	64.0	1.8
	S.D.	18.1	29.0	21.9	33.6	28.1	
Spache Subtests:							
Sound-Symbol Association	Mean	23.2	22.7	22.0	24.0	23.4	1.0
	S.D.	1.5	1.8	3.5	1.9	1.6	
Symbol-Sound Association	Mean	20.0	18.8	18.7	19.1	19.2	0.7
	S.D.	1.1	2.0	1.0	1.9	1.5	
Word Fluency	Mean	27.5	22.8	21.7	23.0	29.3	1.9
	S.D.	5.8	5.0	7.5	8.3	7.7	
Ocular Convergence	Mean	3.0	4.0	3.7	3.6	4.0	2.0
	S.D.	1.5	0.0	0.5	1.1	0.0	
Left-Right Discrimination	Mean	2.8	3.0	3.0	2.9	2.8	0.1
	S.D.	1.0	1.1	0.8	1.0	0.9	
Davids' Subtests:							
Hyperactivity	Mean	3.7	3.0	3.1	3.5	3.3	1.6
	S.D.	1.0	0.0	0.4	[illegible].5	0.7	
Attention Span	Mean	4.8	3.6	3.7	3.8	3.5	2.3
	S.D.	1.2	1.1	1.0	0.7	0.7	
Impulsiveness	Mean	4.0	3.0	3.3	3.8	3.4	2.2
	S.D.	1.3	0.0	0.8	0.9	0.5	
Irritability	Mean	3.8	3.1	3.4	3.9	[illegible].3	1.4
	S.D.	1.0	0.3	1.1	1.0	[illegible].7	
Explosiveness	Mean	3.8	3.0	3.3	3.4	3.2	1.4
	S.D.	1.2	0.0	0.8	0.7	0.6	