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THE NEUROPSYCHOLOGICAL ABILITIES OF YOUNG NORMAL AND RETARDED READERS

by

B. A. Ridgley
B.A., University of Toronto, 1963
M.A., University of Windsor, 1966

A Dissertation
Submitted to the Faculty of Graduate Studies through the
Department of Psychology in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy at the
University of Windsor

Windsor, Ontario, Canada
1970

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Abstract

Reading retardation has been related to many factors, including the following: emotional disturbance, developmental lag, genetic predisposition, disturbance in various sensory functions, cerebral dysfunction, and disturbances in perceptual gestalt. Following the work of Doehring (1968), Knights (1966), Reed (1968), and Reitan (1964) the present investigation employed a neuropsychological test battery and supplementary tests to assess the ability structure of young normal and retarded readers in the age range of seven years, two months to eight years, four months.

Two groups of children, retarded and normal with respect to reading, were selected according to age, the socioeconomic area served by their school, teacher ratings of academic achievement, performance on the reading subtests of the Metropolitan Achievement Test, and FSIQ. Thirty three subjects whose FSIQs fell in the range 90 to 117 were selected for each group. Each subject in the normal reading group was match-paired within 33 days of age with each subject in the retarded reading group. All subjects received an extensive battery of neuropsychological and other tests. In all, 241 measures of performance were obtained for each subject.

The findings of the present study were consistent with those of Doehring (1968) and Reed (1968) who found that retarded reading was associated with a large constellation of verbal and nonverbal

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deficits. The results of the present study indicated that young retarded readers displayed deficits in the following areas: WISC performance, verbal and nonverbal visual-perceptual skills, gross motor and fine psychomotor coordination, and auditory-verbal and language-related abilities. Although no relationship was found between hand preference and reading retardation, retarded readers exhibited marked right-left confusion and disorientation.

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Preface

The present work grew from the author's interest in brain-behavior relationships and the neuropsychological model of human behavior. It is also a response to those many psychologists who, in their studies of human behavior, have forgotten or have failed to realize that the brain is the principal organ of adaptive abilities.

It is impossible to construct a thesis of this nature without acknowledging the influence of those persons who responded to the "idea" with such appropriateness.

The most serious expression of gratitude must be delivered to Dr. B. P. Rourke, who, through his active and objective participation and the commitment of his staff, made actualization of the "idea" possible. In the same token, appreciation is felt for the comments of Dr. G. Carbonin, Dr. R. Daly, and Dr. A. Smith. The assessment of 66 children with a 10-hour neuropsychology battery required the extended commitment of trained technicians who deserve more than mention in this Preface: Marie Durocher, Marilyn Laforet, Margaret Ruston, and Marjorie Zavitz. In addition, Dr. R. M. Reitan's personal contacts with the author and his careful evaluation of the thesis provided a great deal of knowledge and active encouragement towards the completion of the work. Appreciation is also extended to the staff of I.O.D.E. Hospital, Windsor, the staff of the Windsor Separate School Board, and the children themselves.

Peace!

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TABLE OF CONTENTS

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LIST OF TABLES

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Table		Page

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Chapter I

INTRODUCTION

Statement of the Problem

Bond and Tinker (1967) have estimated that somewhere between 5 per cent and 15 per cent of children attending elementary school have a reading deficit which seriously impedes their academic progress. According to Gates (1947), reading retardation accounts for 99 per cent of the children who fail first grade. As well as suffering impeded academic progress, a child who has difficulty reading cannot fully participate in the social, intellectual, and occupational opportunities of our culture.

The high prevelance of reading retardation in populations of school children has stimulated over 20,000 articles and publications on subjects related to the definition of reading retardation, its etiology, and its remediation (Roche, 1968). Generally, there is some concensus regarding the definition of reading. Reading is defined as "an imagining, thinking, and feeling about ideas and thoughts made from past experiences that are suggested by perception of the printed word (Dolch, 1951 in Roche, 1968, p. 133)." However, there is considerably less agreement about the nature and etiology of reading disability. Difficulties in reading have been related to emotional disorders (Rabinovitch, 1959), developmental lags (Critchley, 1964), disturbances in perceptual gestalt (Koppitz, 1964),

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genetic predisposition (Hallgren, 1950), disturbances in various sensory functions (Myklebust, 1962), and cerebral dysfunction (Doehring, 1968).

The present investigation was concerned with the neuropsychological abilities of children with reading retardation. The term "reading retardation" was employed to describe, without theoretical bias, those children who were of normal intelligence but who had fallen behind their age mates in the acquisition of reading skills. Typically, neuropsychological tests are those procedures which are employed for the purpose of assessing abilities which reflect the integrity of the brain.

A great number of studies have attempted to define the ability structure of children with reading retardation. An adequate review of these studies can be found in Bond and Tinker (1967), DeHirsch (1966), and Frostig and Maslow (1968). These studies have attempted to relate reading retardation to deficits in specific abilities such as auditory and visual perception, motor skills, auditory-visual integration, tactile-visual integration, etc.

A number of investigators in this field have approached the problem of delayed reading acquisition with a specific theoretical bias and have restricted the assessment of children's behavior to theory-specific abilities. These studies have usually failed to describe and integrate the broad number of sensory, motor, and perceptual deficits which may be associated in reading retardation. The theoretical viewpoint which was adopted in the present investigation was that reading is a complex skill which is associated with a wide

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number of neuropsychological abilities. In contrast to most previous studies, the present investigation assessed the ability structure of retarded and normal readers with a neuropsychological test battery which tapped a broad spectrum of perceptual, motor, and cognitive skills.

Doehring (1968) and Reed (1968) have employed a comprehensive neuropsychological test battery in their assessment of retarded and nonretarded readers. However, Reed (1968) failed to control for intelligence in his study. Doehring (1968) assessed the neuropsychological abilities of thirty-nine retarded readers who were receiving remedial treatment in a school setting. These children ranged in age from 10 to 15 years. He found that retarded readers in comparison to normal readers suffer from a complex number of deficits in verbal, cognitive, and perceptual-motor skills. He also noted that "the pattern of impairment exhibited by retarded readers could conceivably be associated with inadequate functioning of a circumscribed region in the posterior left cerebral cortex (Doehring, p. 148)." The present study investigated the abilities of children between the ages of seven years, two months and eight years, four months. Whenever possible and profitable a comparison was made between Doehring's (1968) findings with older children and the findings of the present study. It was considered possible that the ability structure of older retarded readers would differ both quantitively and qualitively from that of young retarded readers as a result of maturation and other factors.

Reed (1968) has summarized the issues relevant to the present

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study as follows:

> Reading impairment cannot be understood as an isolated disturbance. Rather this deficit can only be appreciated in relation to a wide range of intellectual, perceptual and motor functions. The problem is considerably more complicated because the inter-relation of these various skills, as well as their relation to reading, may well vary at different chronological ages (p. 44).

Briefly, the present investigation employed a large battery of neuropsychological tests in order to assess the ability structure of retarded and normal readers aged seven to eight years. The general hypotheses under investigation in the present study were that (1) reading retardation in young children is not a specific deficit but occurs in inter-relationship with a large number of intellectual, perceptual, and motor difficulties; (2) children with reading retardation display significantly more neuropsychological deficits than do normal readers; (3) the intellectual, perceptual, and motor deficits of the young retarded reader are consistent with the assumption that retarded readers suffer from left cerebral dysfunction.

Background of Related Research

In 1917, Hinschelwood, a Glasgow ophthalmologist, published a treatise which described a syndrome referred to as "congenital word blindness." Congenital word blindness was used to describe children of apparently normal intelligence who could not read. According to Hinschelwood (1917), the reading deficit was concomitant to a congenital cortical defect in the left cerebral hemisphere.

Cerebral Dominance. Orton (1928) took exception to Hinschelwood's hypothesis that word blindness was consequent to a congenital cortical dysfunction. Orton maintained that the major

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symptom of reading difficulty was the presence of reversals or mirror-image figures in the written work of older children. These reversals were said to arise from a confused directional sense which resulted when a child failed to develop what Orton referred to as a "dominant cerebral hemisphere". According to Orton, the right and left cerebral hemispheres subsume mirror image functions until, with maturation, one hemisphere becomes dominant so as to completely determine speech and language deficits. If dominance does not develop, the hemispheres compete to produce reversals in written work and confused directionality. Orton (1928) maintained that mixed hand, foot, and eye preference reflected a failure in the development of cerebral dominance.

Orton's formulation stimulated a great deal of investigation into the prevelance of mixed hand and foot preference in retarded readers (e.g., Dearborn, 1929; Doehring, 1968). Initial investigators assumed that hand preference was determined by the dominance of the contra-lateral cerebral hemisphere and that this hemisphere subsumed speech and language skills. However, the studies of Penfield and Roberts (1959) indicated that hand preference does not clearly indicate contralateral cerebral dominance for speech and language. Penfield and Roberts (1959) found that, for the most part, the left hemisphere subsumed language skills, regardless of hand preference. Despite these findings, research continued in the absence of a sound theoretical formulation because mixed dominance appeared to be so frequently associated with reading retardation (Critchley, 1964; Harris, 1967). However, recent investigations by Belmont and Birch (1965), Coleman and Deutsch (1964), and Silver

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and Hagin (1960) have indicated that there is no relationship between lateral dominance and reading retardation. In order to test the validity of this assertion, the present investigation assessed the prevelance of left hand preference and left foot preference in a population of children retarded in reading.

Motor Skills and Cerebral Dominance. Orton's theory had a strong influence on the works of Kephart (1960) and Delacato (1963) who placed the concept of cerebral dominance within a general framework of developmental neuropsychology. Delacato (1963) described an orderly sequence of ontogenetic development which precedes and subsumes reading. The initial stages of this developmental sequence are represented by undifferentiated motor movements subsumed by reflex activities of the spinal cord. According to Delacato, the highest level of ontogenetic development is reading, a prerequisite for which is cerebral dominance. Explicit in Delacato's formulation is the assumption that the adequate development of motor and visual-motor skills will lead to cerebral dominance and the development of reading. This assumption is the basis of the "Doman-Delacato Method" which has found extensive acceptance as a training technique for children suffering from reading deficits.

A number of investigators have been critical of Delacato's position on the grounds that it is unsound theoretically and unsupported by research. Theoretically, the selection of reading or cerebral dominance as the final developmental stage is somewhat arbitrary and hardly represents the ontogenetic end of a maturing central nervous system. Delacato's developmental stages are somewhat simplistic and unidimensional. Additionally, the stages do

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not take into consideration the multidimentional development and integration of sensory, motor, and cognitive abilities.

Current research also fails to confirm Delacato's hypothesis that specialized training at one level of his developmental hierarchy (e.g., visual-motor activities) will instigate the commencement of the next stage (i.e., reading abilities). Robbins (1966) has found no effect on the reading skills of children trained with the Doman-Delacato method. Reed (1968) and Doehring (1968) found no relationships between relatively pure motor abilities and reading skills. In direct contrast to Delacato's theory, Doehring (1968) also found that retarded readers were superior to normal readers in some somesthetic-psychomotor co-ordination activities. However, other investigators (e.g., DeHirsch, 1968; Myklebust & Johnson, 1962), using different assessment procedures, have found motor deficits in children with reading disability. In addition, many clinicians frequently allude to the motor awkwardness which appears to be present in children with reading deficits.

Studies which have investigated motor involvement in reading retardation are somewhat difficult to interpret because each study operationally defines motor and visual activities according to a particular theoretical bias and/or a limited number of motor tests which are not clearly defined. For example, it is somewhat difficult to compare research done with a perceptual-motor task (e.g., the Bender Gestalt Test) with research which has employed pure motor tests such as the rate of finger oscillation. In order to assess fully the possible relationship between motor deficits and reading retardation, the present investigation employed a

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comprehensive battery of tests designed to tap motor speed with the right and left hand and foot, visual-motor co-ordination with the right and left hand, non-visual somesthetic and psychomotor skills with the right and left hand, motor strength with the right and left hand, motor steadiness with the right and left hand, and other complex perceptual-motor abilities.

Perceptual, Motor, and Psychomotor Skills. Motor and visual-motor abilities play an important role in perceptual-motor gestalt theories of reading retardation. These theories consider visual and motor skills to be the respective receptive and expressive components of a mediating cognitive process or gestalt. Proponents of the gestalt tradition maintain that there is a general factor in human abilities which is responsible for the organization and integration of the total sensory and behavioral experience. In reading, the association of meaning with visual stimuli is clearly a gestalt function. In this framework, reading retardation is consequent to one of the many disturbances which can occur in gestalt organization and integration. Doehring (1968) has described some of these disturbances which have direct relevance to reading, as follows: "difficulty in synthesizing visual configurations, difficulties in experiencing spatial and temporal relationships, primitive body image, impairment in figure-background relationships, difficulty in responding to a constellation of stimuli as a whole, difficulty in the orderly recall of sequences, deficiencies of temporal structural localization and difficulty in the patterning of fine motor co-ordination (p. 10)."

The approaches of Bender (1938), Frostig (1965), and Koppitz

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(1964) are weighted heavily in the gestalt tradition. Unlike the theories of Delacato, perceptual-motor or gestalt theories are difficult to operationalize into experimental procedures. Many of these investigators measure gestalt abilities with the Bender Gestalt Test (Bender, 1938) which requires the individual tested to reproduce graphically various printed forms.

The Bender Gestalt Test has been a major research tool used in the assessment of retarded readers. Connor (1967) found some relationships between reading skills and the Bender Gestalt, but there were no significant relationships found between differential reading performance and total measures of gestalt performance. Smith and Keogh (1962) found that differences in reading ability were related to abilities as measured by a group-administered Bender Gestalt Test. Lachman (1960) found visual-motor disturbances on the Bender Gestalt Test not only in poor readers, but also in normal readers with emotional difficulties. Other investigators (e.g., Doehring, 1968; Ferguson, 1967; Santoro, 1968; Trussell, 1967), using other measures of perceptual-motor skills, have found consistent relationships between visual-perceptual abilities and reading retardation. In summary, perceptual-motor abilities do appear to have some relationship to reading retardation.

However, there are a number of neuropsychological and factor-analytic studies which would indicate that the Bender Gestalt Test does not tap general integrating and co-ordinating skills of retarded and normal readers. Factor-analytic studies done by Bean (1968), Cohen (1959), Doehring (1968), and Trussell (1967) have shown that there is a compelling verbal factor present

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in the ability structure of children which is relatively distinct from visual or perceptual-motor factors. Thus, it would seem that perceptual and motor abilities could not account for all of the variance in skills between retarded and normal readers.

The use of the Bender Gestalt Test as an instrument for measuring general gestalt function is also difficult to integrate into what is presently known about brain-behavior relationship. Reitan (1965) has indicated that, in most adults, the posterior regions of the right cerebral hemisphere are responsible for visual spatial organization and that the posterior frontal areas of each hemisphere subsume motor abilities on the contralateral side of the body. Consequently, a test which requires the subject to reproduce graphically various printed geometric figures may not tap general gestalt and integrating ability, per se. For the most part, it may be tapping abilities subsumed by the right parietal and posterior frontal areas of the brain. In conclusion, it is possible that retarded readers who do poorly on the Bender Gestalt Test have specific deficits in visual-motor co-ordination rather than a general deficit in perceptual gestalt. The present investigation employed a large number of visual-motor or perceptual-motor tasks in conjunction with other tests so that the role of perceptual-motor abilities in retarded and normal readers could be assessed more fully.

Birch (1967) has been implicitly critical of the perceptual-motor theories of language development because they are too limited. Birch maintains that the development of reading abilities is dependent upon an orderly maturation and development of skills in

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all sensory modalities. He suggests that perceptual maturation progresses through several stages before adequate reading skills can be acquired. Each one of these stages reflects the dominance of one particular perceptual skill or a combination of skills over the other abilities present in the child. These stages are defined as follows: (1) tactile-kinesthetic sensitivity; (2) visual-auditory sensitivity; (3) the convergence and integration of all sensory inputs in association with particular stimuli; and, (4) sensitization and abstraction of complex sensory stimuli. According to Doehring (1968), if Birch's hypotheses are correct, retarded and normal readers may differ with respect to their dominant sensory and perceptual skill. This hypothesis has found some minor support in the work of Doehring (1968) who found that retarded readers were significantly better than normal readers on a non-visual test of somesthetic skill (Birch's stage one). However, other measures of tactile sensitivity did not confirm this hypothesized difference between retarded and normal readers.

Developmental Dyslexia. In order to describe fully the motor and perceptual-motor theories of retarded reading, this presentation has digressed somewhat from Hinschelwood's original formulation of congenital word blindness. Hinschelwood (1917) maintained that deficits in reading resulted from an underdevelopment of the left angular gyrus in the brain, and that this cortical defect was congenital rather than acquired. This orientation has influenced the works of Benton (1966), Critchley (1964), and Money (1967). These authors have reformulated Hinschelwood's original syndrome and have coined the label "developmental dyslexia" or "specific

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reading disability." Benton (1966), defines developmental dyslexia as:

> A failure to learn to read on the part of a child (usually a boy) who is of adequate intelligence, who is endowed with normal vision and hearing and who has been given satisfactory conventional instruction in reading and who, at least at the beginning of schooling, had normal motivation to learn to read (p. 309).

According to Critchley (1964), developmental dyslexia is probably an hereditary disorder in which the central nervous system fails to develop to that stage at which it can subsume reading skills. Rather than being an acquired deficit which comes as a result of brain trauma, Critchley maintains that it is a developmental lag which affects only reading. Critchley (1964) has been critical of "brain-damage" theories of dyslexia because they conflict with Hallgrin's (1950) finding that specific dyslexia has a genetic component. Critchley also argues that children with dyslexia do not display neurological deficits even after the most searching assessment techniques .

Critchley's assumption that reading retardation can be a specific deficit consequent to a developmental lag which is genetically determined has been questioned implicitly by Doehring (1968). This latter investigator described the neuropsychological abilities of several retarded readers whose fathers had also suffered from reading disability. Their neuropsychological abilities did not differ significantly from a group of children whose retarded reading did not appear genetically determined according to family history. Several findings have cast doubt on Critchley's formulation of reading disability as a specific deficit

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which exists in isolation from other disabilities. Reitan (1960) for example, found that the occurrence of dyslexia in a population of adults with known cerebral lesions was associated with a number of deficits not directly related to reading abilities. Doehring (1968) also found that a large number of non-reading deficits were present in older children who had reading difficulties. These findings suggest that reading disability, rather than being an isolated deficit, is seen in association with a large number of neuropsychological deficits. Doehring also found that children with reading retardation, in comparison to children without reading difficulties, had a disproportionately greater number of positive neurological signs.

Acquired Dyslexia. In contrast to the concept of developmental dyslexia, acquired dyslexia refers to an aphasic deficit which follows known brain injury. The study of aphasia and its related deficits has made a decisive impact on the interpretation of reading retardation. Traditionally, aphasia is a neurological term used to describe an impairment or loss in the understanding and/or production of spoken or written language which is consequent to cerebral injury. Although reading retardation is not a true aphasic deficit in the sense that it does not necessarily involve the loss of a previously acquired ability, difficulties in reading or acquired dyslexia frequently follow cerebral insults which principally involve the posterior portion of the left cerebral hemisphere. The relevance of the concept of aphasia to the study of reading disability is further demonstrated by

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studies which have shown similarities in reading and non-reading neuropsychological disabilities between persons with acquired dyslexia and persons with reading retardation (Doehring, 1968; Reitan, 1964).

A complete review of the literature on aphasia and related disorders is beyond the scope of this presentation. The interested reader is referred to Brain (1961). The following is a brief summary of a number of findings in adult populations with known cerebral damage which have direct relevance to the present study of reading retardation. These findings have proceeded from the investigations of R. Reitan and his colleagues who have employed a neuropsychological test battery similar to the one employed in this study in order to investigate brain-behavior relationships in populations of adults and children with known cerebral damage. These findings are as follows: (1) dysphasic symptoms, when present, provide a valid basis for inferring brain damage (Wheeler & Reitan, 1962); (2) reading impairment (dyslexia) is not characterized as a unique type of behavioral deficiency in its relationship to damage of the left cerebral hemisphere in consideration of its substantial co-relation with other aphasic deficits. However, reading impairment may play something of a central role in the constellation of aphasic symptoms for this reason (Reitan, 1964); (3) the presence of aphasic symptoms provides a valid basis for the inference that the left cerebral hemisphere is damaged (Wheeler & Reitan, 1962).

These findings with adult populations suggested that the

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neuropsychological patterns of young children who are suffering from reading retardation may implicate the posterior region of the left cerebral hemisphere as a location for cerebral dysfunction. Additionally, it was expected that retarded readers would display a large number of aphasoid deficits. It should be noted that the above hypothesis regarding children with relatively immature brains is based on knowledge gained from work with adult populations. It is possible that the profile of abilities displayed by adults with acquired dyslexia consequent to known cerebral dysfunction provides an inappropriate model for the interpretation of the abilities of young children with reading retardation. At any rate, it is clear that the neuropsychological abilities of young retarded readers require further investigation and comparison with adult profiles.

To this point in this presentation an attempt has been made to summarize briefly some of the orientations to reading retardation which are prevelant in the current literature. These orientations fall roughly within the following frames of reference: motor development, perceptual-motor gestalt, perceptual development, developmental dyslexia, acquired dyslexia, and aphasia. A detailed consideration will now be given to some of the studies which have been concerned with the neuropsychological abilities of children with reading retardation.

<u>Wechsler Intelligence Scale for Children</u>. One of the

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most frequently employed clinical and research instruments is the Wechsler Intelligence Scale for Children (WISC) (Wechsler, 1949). In general, it can be said that the WISC is factorally similar to the Wechsler Adult Intelligence Scale (WAIS) (Cohen, 1959), which itself is factorally similar to the Wechsler-Bellevue Scale, Form I (WB-I) (Reed & Fitzhugh, Mimeo; Wechsler, 1944). The WB-I has been a useful indicator of the presence, localization and acuteness of brain injury in adult patients (Reitan, 1955). It has been found that summary measures of the Verbal subtests of the WB-I fall significantly below summary measures of the Performance subtests of the WB-I in patients with lesions of the left hemisphere. A significant converse relationship in the Verbal and Performance subtests of the WB-I exists in patients with lesions of the right cerebral hemisphere. The aforementioned relationships hold regardless of whether the criterion of brain damage has been established by means of known structural damage, EEG lateralization, behavioral losses, homonymous visual field defects, or sensory-perceptual deficits.

Several studies have investigated the relationship of the WISC profile to reading retardation. For the most part, retarded readers do significantly more poorly on the Verbal subtests of the WISC than do readers, and retarded readers do significantly more poorly on the Verbal subtests of the WISC than they do on the Performance subtests. A number of investigators have also employed the ten or eleven subtests of the WISC in an attempt to define a "profile" of WISC scores which will discriminate

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retarded from non-retarded readers. In a review of the literature, Belmont and Birch (1966) are critical of many of these investigations for the following reasons: (1) many of these studies have employed sample sizes which are somewhat small; (2) the age ranges in these samples are large so that the possible changes in reading and non-reading abilities which accompany maturation have not been controlled; (3) many investigations have not controlled for sex, a variable which is known to affect reading (Bentzen, 1963); (4) control samples have not been employed; rather, the performance of retarded and normal readers have been compared to the standardization sample published in the WISC manual; (5) many of these studies have employed populations of children referred to clinics for special investigation. The problem involved in this latter consideration is that the influence of possible emotional and/or behavioral disturbances on WISC performance have not been controlled.

In their own study, Belmont and Birch (1966) administered four reading tests to the total population of children attending school in a medium-sized city. From this original population, they selected 150 children with reading problems who scored below the tenth percentile on three of the four reading tests and fifty normal readers matched for birth year, (Mean C.A., 9.5), sex (male), and school placement. The WISC functioning of the poor readers was compared to that of the normal readers. (It should be noted that the reference populations in this work did not represent children who were clinically defined. They

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were children selected only by tests of reading and not be referral to a reading clinic or social agency. Consequently, the WISC performance of poor readers in this reference population is less likely to be confounded by the effects of emotional variables. This important methodological variation differs from the study of Doehring (1968) which will be discussed later in this presentation.) They found the following: (1) as a whole, poor readers had significantly lower FSIQs; (2) when subjects who had a FSIQ below 90 were eliminated, poor readers functioned better on the Performance subtests of the WISC than they did on the verbal subtests; (3) when poor readers and normal readers were matched for FSIQ, the poor readers were superior to normal readers on the Performance section of the WISC, and (4) the reverse was the case with regards to the verbal section of the WISC. As noted earlier, Reitan (1955) has found similar relationships between populations of adults suffering from left-sided brain damage and a control group. If the neuropsychological profiles of children can be compared with those of adults, the findings of Belmont and Birch (1966) are entirely consistent with the hypothesis that children with reading difficulties suffer from left-sided encephalopathy which impedes their general verbal skills. The present investigation attempted to assess the relationships between verbal and performance abilities as they are measured on the WISC in a much younger sample of retarded and normal readers. An attempt was also made to replicate the selection of reference populations and the procedures for

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controlling variables such as age, sex, class placement, and social and economic status which have been delineated by Belmont and Birch (1966).

Unlike Belmont and Birch (1966), Reed (1967) selected criterion samples, not according to performance on standardized reading tests, but according to VIQ-PIQ differences on the WISC. After subject selection, an assessment was made of reading proficiency in two groups of children aged six and aged ten. He found that children who obtained a lower VIQ in comparison to the PIQ were significantly poorer readers than children who had equal VIQ and PIQ scores or those with higher VIQ than PIQ scores on the WISC. However, Reed found that this relationship between reading achievement and WISC performance was only present in the older age group (CA 10). He also noted that there was no evidence to suggest that VIQ-PIQ differences are a valid predictor of reading success at either age when FSIQ is controlled. In general, it would appear that retarded readers do have VIQ-PIQ discrepancies in favor of the PIQ section. However, the occurrence of a VIQ-PIQ split of this nature does not necessarily imply that a child will have reading difficulties. In a later study, Reed (1968) found that WISC Verbal subtests were significantly lower for poor readers in comparison with normal readers. However, in this study, Reed did not control for FSIQ. One aim of the present investigation was to assess the significance of VIQ-PIQ discrepancies in retarded and normal readers who are in the age range of seven years, two months to eight years, four months.

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Doehring (1968) also found significant differences between populations of retarded readers and normal readers with regard to WISC performance. In conjunction with the WISC, Doehring also administered a large battery of neuropsychological tests which closely approximates the one employed in the present investigation. The following discussion will make frequent mention of Doehring's findings. Hence, it would be appropriate at this time to consider the general design of his study.

Doehring's Study. Doehring (1968) selected a group of male retarded readers from a clinical population of children referred for remedial reading. From this original male population, he selected 39 males according to the following criteria: within the age range of 10 to 14, two years retarded in oral reading on the reading subtest of the Wide Range Achievement Test (WRAT) (Jastak & Jastak, 1946), a WB-I PIQ of 90 or above, no emotional disorders, and normal vision and hearing. This group was compared with 39 boys having normal reading abilities and matched for age, sex, and PIQ. Doehring (1968) controlled for PIQ in order to clarify between-group differences in VIQ which may be related to left cerebral dysfunction.

The results of Doehring's (1968) investigation will follow, but it is appropriate at this point to discuss the relationship of Doehring's procedures to those employed in the present study. Doehring matched retarded and normal readers for PIQ. As noted earlier, Reitan (1965) has reported that, in adult populations, the Performance subtests of the Wechsler intelligence tests are more sensitive to right hemisphere dysfunction than they are to

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left hemisphere dysfunction. If this relationship holds with respect to children, Doehring (1968), by matching subjects for PIQ, may have restricted the possible effects of right-sided encephalopathy on his measurements of the neuropsychological abilities of retarded and normal readers. The present investigation controlled for FSIQ so as to take into consideration the role played by so-called "right-sided" abilities, such as visual-spatial organization, in reading retardation. Doehring (1968) also used a clinical population of retarded readers. Such populations may not represent adequately children who are suffering from reading difficulties exclusive of emotional disturbances. The latter may well affect performance on neuropsychological tests (Knights, 1968). Consequently, their neuropsychological profile may not represent adequately the retarded reader who is falling behind within the school system, but who is not referred for special clinical attention. In the present study subjects were selected from a school population and not from a clinical population of children.

It has been noted that Doehring assessed children ranging in age from 10 to 14 years. He attempted to control for the influence of age on neuropsychological abilities with statistical covariance techniques. This type of statistical control assumes that the variables under investigation vary only in quantity and not in quality. However, it is quite possible that, with maturation between the ages of 10 and 14, neuropsychological abilities may undergo qualitative changes in structure and in their relationship to other abilities. For this reason as well, the ability structure

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of older children cannot necessarily be generalized to younger children. On the other hand, Reed (1968) has maintained that there are close similarities between the patterns of neuropsychological abilities of children C.A.6 and C.A. 10. The present investigation controlled for age differences by match-pairing retarded and normal readers selected from a population of children who were in the age range of seven years, two months to eight years, four months. The ability structures of these children were compared to those of older children as these are reported by Doehring (1968).

In his investigation, Doehring employed the WB-I. The present study employed the WISC, a better standardized test which is more applicable to the assessment of young children. Doehring also employed only one standardized measure of reading ability in his selection of children said to be retarded in reading. He used the reading subtest of the WRAT. This subtest is an oral reading exercise only and does not tap verbal comprehension. Despite its popularity, Hopkins, Dobson, and Oldridge (1962) have stated that practically no validity studies are reported on the WRAT as a predictor of reading retardation. The present study employed a more reliable and standardized reading test, the Metropolitan Achievement Test (MAT) (1959), for the selection of retarded and normal reading groups.

It is appropriate at this point to consider many of Doehring's findings and their relationship to the present study. Doehring's chief testing instrument was the Halstead Battery of neuropsychological tests designed for the assessment of

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children aged nine through fifteen (Reitan, 1965). The present investigation employed a downward extension of this battery (C.A. 5 to 8) together with some other tests which have been found to be significantly related to reading retardation. A complete description of the entire test battery used in the present study can be found in Appendix A.

Peabody Picture Vocabulary Test. Doehring (1968) found significant differences between retarded and normal readers on the Peabody Picture Vocabulary Test (PPVT) (Dunn, 1959). This is a test said to tap naming abilities primarily, and is more closely correlated with the VIQ than with the PIQ of the WISC (Moed, Wright, & James, 1963). The relationship of the WISC subtests and the PPVT was assessed in the present investigation.

Wide Range Achievement Test. All subjects in the present study received the WRAT, 1965 edition (Jastak & Jastak, 1965). The WRAT consists of three subtests: Reading, Spelling, and Arithmetic. Jastak and Jastak (1965) report split-half reliabilities for the subtests at the seven-year-old level which range from .962 to .993. The inclusion of the WRAT in this battery yielded some information on its concurrent validity and its possible usefulness as a test which is sensitive to early reading retardation.

Several investigators (e.g., Myklebust & Johnson, 1962) maintain that difficulties in arithmetic or dyscalculia are an integral part of dyslexia or reading retardation. Doehring (1968) demonstrated that the Arithmetic subtest of the WISC significantly differentiated normal and poor readers. However,

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Doehring did not employ the arithmetic subtest of the WRAT and its inclusion in the present study helped clarify the possible relationship between arithmetic disability and reading disability.

Halstead-Wepman Aphasia Screening Test. Included in the Indiana-Reitan Battery (C.A. 5 to 8) is a modification of the Halstead-Wepman Aphasia Screening Test (HWAT) (Reitan, 1965). This test is used extensively at the Neuropsychology Laboratory at Indianapolis and it has been shown to be useful in detecting the presence and location of cerebral dysfunction (Reitan, 1965). A full description of the HWAT can be found in Appendix A. Primarily, it is composed of twenty-two items which tap the intactness of the following abilities: naming, spelling, writing, enunciation, reading, arithmetic, and the comprehension of verbal instructions. It was hypothesized that retarded readers would display significantly more aphasic errors than would normal readers on the HWAT. If such were the case, this would lend further support to the hypothesis that children who are retarded in reading suffer from left-sided cerebral dysfunction.

Visual-Motor Tests. Included in the HWAT is a three-item test which requires the subject to reproduct graphically various geometric forms. The role of visual-motor abilities in reading retardation has been discussed above. In adult patients, some difficulties with this type of task are frequently indicative of right cerebral dysfunction (Reitan, 1965). Doehring (1968) found that two out of three of these items failed to differentiate retarded and normal reading groups. However, Doehring also

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employed a large number of perceptual motor tasks which did differentiate the two groups. The present study also employed a number of visual-motor and perceptual tasks which have been developed for children aged five to eight. These tests are fully described in Appendix A under the following headings: Progressive Figures, Matching Pictures, Individual Performance Test, Target Test, Color Form Test, Underlining Tests, and Thurstone Reversals Test. As noted above, Doehring found a significant perceptual and motor component in the defective abilities of older retarded readers. Reed (1968) and Birch (1967) have suggested that visual-motor and visual-spatial abilities correlate more highly with tests of reading at earlier age levels than at later age levels. If this be the case, the perceptual-motor factor which may be present in the ability structure of children aged C.A.7 may have a higher correlation with reading skills than was evident in older children C.A. 10 to 15 (Doehring, 1968).

Tests of Sensory and Perceptual Disturbances, Tactile Discrimination. In adult populations, Reitan (1965) has found that sensory-perceptual disturbances on the right side of the body are more closely correlated with aphasic symptoms than are sensory-perceptual disturbances on the left-side of the body. Included in the Indiana-Reitan battery (C.A.5 to 8) were tests of gross tactile perception and suppression, finger agnosia, finger-tip symbol writing recognition and astereognosis.

The measurement of gross tactile sensitivity and suppression

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is an established neurological technique employed in the diagnosis of cerebral dysfunction (Brain, 1962). The procedure used in this study involved the assessment of tactile perception under conditions of unilateral stimulation of both hands, double simultaneous stimulation of the right and left hands, and double simultaneous stimulation of the hand and face (Appendix A). Typically, tactile imperception in one hand is said to be indicative of cerebral dysfunction in the contralateral hemisphere. Doehring (1968) found no significant differences in measures of double simultaneous tactile perception with the hand and face between groups of older retarded and normal readers. However, as noted earlier, it is possible that Doehring found no significant differences between older groups of children because initial deficits in tactile sensitivity clear with maturation. Studies of adult populations with known acquired dyslexia suggested that young retarded readers as compared to normal readers would display significantly more deficits associated with gross tactile imperception and suppression with the right hand than with the left hand.

Tests of finger agnosia are also a frequently used neurological technique. One such test requires a blindfolded subject to identify that finger on his right or left hand which has just been touched lightly by an examiner (Appendix A). Benton (1959) has maintained that dyslexia exists in close association with directional confusion as it is measured by tests of finger localization. Reed (1967) found that, at the chronological age

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of ten, children with a predominance of right-handed errors on this task read significantly less well than did a group of children with predominantly left-sided errors. This finding supports the contention that poor readers at this age level suffer from dysfunction within the left cerebral hemisphere. However, Reed also found that this relationship between reading skills and finger agnosia was not present at a younger age level (C.A. 6).

There are a number of aspects of the design of Reed's (1967) study which may have resulted in his failure to demonstrate between-group differences in finger agnosia at the chronological age of six years. Reed selected only two groups of subjects. One group made more errors in finger localization with the right hand; the second group made more errors with the left hand. In effect, Reed (1967) did not include a normal control group and it is possible that both groups in his study contained children with cerebral dysfunction. Reed also employed only one subtest in setting his criterion for reading skills, the Comprehension section of the Gates Diagnostic Survey Test. The present investigation employed a control group and made a more adequate assessment of reading ability.

Doehring (1968) found no significant differences between a group of retarded readers and a control group of normal readers with regard to right-sided finger agnosia. However, Doehring found that retarded readers had significantly more left-sided errors in finger agnosia than did non-retarded readers. This finding is somewhat contradictory to Reed's (1967) results and

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would suggest that older retarded readers are more likely to have left-sided finger agnosia than right-sided agnosia. These findings also fail to support an exclusively left cerebral dysfunction theory of reading retardation. It is clear that the relationship of finger agnosia to reading retardation requires further investigation in populations of young children.

The Indiana-Reitan battery (C.A. 5 to 8) also includes a neurological technique which requires the subject to identify stimuli delivered to the finger-tips of the right and left hand. Doehring (1968) found that older retarded and normal readers did not differ with regard to finger-tip sensitivity. However, there was a tendency for retarded readers to have more difficulty in perceiving stimuli with the finger-tips of the right than with the left hand. It was expected that the present study would demonstrate that retarded readers would have significantly more errors in finger-tip sensitivity with their right hand than did normal readers, and that retarded readers, in comparison with normal readers, would have significantly more difficulty in discriminating tactile stimuli with the finger-tips of the right hand than they would have in discriminating tactile stimuli with the finger-tips of the left hand.

Doehring (1968) also reports the somewhat surprising finding that retarded readers performed significantly better than did normal readers on tasks requiring the tactile discrimination and naming of familiar forms with the right and left hand. This finding is contrary to what one would expect if children who are retarded in reading have only left-sided cerebral

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dysfunction. The present study investigated further the relationship between reading abilities and tactile-form discrimination.

It is appropriate at this point to summarize the hypotheses which were concerned with tactile perception with the right and left hand. The previous discussion has attempted to present the findings of past studies with regard to gross tactile sensitivity and suppression, finger agnosia, fine finger-tip discrimination, and tactile form recognition in the right and left hand. The findings of the present study had direct relevance to developmental and cerebral dysfunction theories of reading retardation. As noted earlier, Birch (1967) has suggested that reading retardation is a developmental lag in perception characterized by dominance of tactile-kinesthetic sensitivity in the child's sensory system. If this be the case, retarded readers in the present study should have shown superiority over normal readers in the aforementioned sensory-tactile tasks. However, if reading retardation is associated with left-sided cerebral dysfunction, as it is in adults, the following hypotheses were forthcoming: (1) retarded readers as compared to normal readers will have significantly more errors in tactile perception with the right hand than with the left hand; (2) retarded readers will have significantly more tactile perception errors with the right hand than will normal readers.

<u>Tests of Sensory and Perceptual Disturbances, Right-Left Awareness</u>. Another symptom which has been observed in children with reading disability is right-left confusion (Benton, 1959). According to Benton, right-left confusion may account for letter

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reversals in writing and inadequate visual direction in reading. Belmont and Birch (1965) found that a group of retarded readers and non-retarded readers selected by means of achievement tests differed with respect to right-left confusion related to body position. These investigators assessed children within the age range of 9 years, 4 months to 10 years, 4 months. The present study included an assessment of this ability in younger children.

Tests of Sensory and Perceptual Disturbances, Auditory Discrimination. The role of poor auditory perception and auditory discrimination skills in reading retardation is well documented in the literature (e.g., Hanesian, 1967; Myklebust & Johnson, 1962). For the most part, these studies have shown that reading disability is strongly associated with difficulties in auditory discrimination. However, Reynolds (1964) is critical of many of these studies for not controlling variables such as intelligence and sex, and for not employing normal control groups. Reynolds found no relationship between many auditory skills and reading in a large population of children attending the fourth grade. Knights (1966) and Reitan (1965) have employed a number of non-verbal and verbal tests which require auditory perception in their assessment of children with suspected brain damage. A complete description of the tasks of this nature which were included in the present study can be found in Appendix A. It was expected that normal readers, in comparison to retarded readers, would do significantly better on tasks requiring the auditory discrimination of verbal material. The rationale for this prediction was based upon the assumption

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that reading retardation is symptomatic of a constellation of verbal and language deficits which, in turn, would seem to be radically dependent upon this type of ability.

Tests of Sensory and Perceptual Disturbances, Visual Perception. Every thorough neurological examination includes a test for visual field defects under conditions of unilateral and bilateral presentation. Doehring (1968) found no differences between groups of older retarded and normal readers with this measure. However, it is possible that such visual deficits remit with maturation, and for this reason the present study employed assessment procedures for visual field defects. If children who have reading difficulties are suffering from left cerebral dysfunction, it was thought that they might display significantly more visual defects within the right field of vision than will normal readers.

Halstead's Category Test and the Cognitive-Perceptual Task. Reitan (1955b) has found that the Halstead Category Test (Adult Form) significantly differentiates brain-damaged adult populations from non-brain-damaged adult populations. This differentiation appears to exist regardless of the location of the brain damage. The Category Test is primarily a test of complex concept formation. It requires the individual to pose hypotheses regarding the relationship between stimulus figures and to test these hypotheses with responses. These hypotheses can be tested by a constant monitoring of the positive or negative reinforcement which follows each response. Two downward extensions of this test have been developed for the assessment of young children

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(C.A. 5 to 8) and older children (C.A. 9 to 15). Knights and Tymchuk (1968) have found that the Category Test (C.A. 9 to 15) successfully differentiates normal populations of children from epileptic, emotionally disturbed, retarded, and brain damaged populations. However, according to Knights and Tymchuk (1968), this test does not discriminate between emotionally disturbed and brain-damaged children. Additionally, Reed (1968) found that the Category Test did not differentiate good and poor readers at either the chronological age of six or ten. Doehring (1968), who assessed older children, found significant differences between retarded and normal readers with this measure. It would appear that further investigation into the discriminative power of the Indiana-Reitan Category Test (C.A. 5 to 8) is required. It should also be noted that the Category Test is said to be an excellent overall indicator of general cerebral integrity. In the present study, it was hypothesized that normal readers would do significantly better on the Category Test than would retarded readers.

Also included in the test battery employed in the present study was a Cognitive-Perceptual Task (CPT) (Rourke, 1966), which requires the child to discriminate similarities and differences in stimuli which are very similar to those used in the Category Test. However, the CPT is not a learning test in the sense that it does not utilize negative or positive reinforcement. The CPT has not been employed in the assessment of normal and retarded readers, although its similarity to the Category Test suggested that it would differentiate retarded from normal

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readers.

Psychomotor, Kinesthetic, and Related Tests. The possible relationship of motor abilities to reading retardation has been discussed above. Despite the frequency with which authors (e.g., Delacato, 1963; Myklebust & Johnson, 1962) refer to the presence of poor motor skills in retarded readers, very few extensive and well controlled studies have been reported on this topic. Cohn (1961) studied normal and retarded readers aged seven to ten and found that a large number of retarded readers suffered from poor motor co-ordination. However, Cohn (1961) did not describe what measures were taken of motor co-ordination, nor did he control for age, sex, and socioeconomic status. In a correlational study with first and second grade students, Trussell (1967) found that reading achievement as measured by the Metropolitan Achievement Test was significantly related to measures of chronological age, perceptual-motor and motor skills. However, the motor skills assessed in this study were limited to the Frostig (1964) tests, pursuit rotor tasks, and a scale of neurological development. What follows is a description of the motor, psychomotor, and kinesthetic tasks employed in the present investigation.

(1) Motor Speed. In adult populations, Reitan (1965) has demonstrated the sensitivity of tests of motor speed with the right and left hand to the presence of cerebral dysfunction within the frontal lobes. Reed (1968) found that motor speed with the right and left hands did not differ significantly in older and younger groups of good and poor readers. Doehring

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(1968) also found no motor speed differences between older retarded and normal readers. The present study assessed motor speed with the right and left hand and foot in young children. If there were significant differences in motor speed between retarded and normal readers, it was expected that retarded readers would be significantly slower than normal readers on measures of motor speed with the right hand and right foot.

(2) Tactual Performance Test. The Indiana-Reitan Battery (C.A. 5 to 8) also utilizes a modification of the Seguin-Goddard Formboard in order to tap non-visual psychomotor and somesthetic skills with the right and left hands. Additionally, it involves a test of the ability to remember and properly locate forms learned through the tactile mode. Reitan (1958) has found that a comparison of the mean differences between performance with the right and left hands in adult subjects with lateralized brain lesions indicates that patients with left cerebral lesions perform significantly more poorly with their right hand than with their left hand; the opposite state of affairs obtains in the case of patients with right cerebral lesions. Reitan has also demonstrated that the subject's ability to remember the shapes and locations of the test objects is a sensitive indicator of brain damage, regardless of its locus. Reitan (1965) has described two modifications of this test, the Tactual Performance Test (TPT), for use with children aged five to eight and nine to fifteen.

In his study, Reed (1968) found that performance on the

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TPT significantly differentiated between good and poor readers. However, the obtained differences were not in line with expectation. Reed (1968) reported that, although poor readers did not perform as well as did good readers when required to use two hands simultaneously on this task, they did not differ with regard to their performance with the preferred hand (usually the right). Also, good readers performed significantly better than did poor readers with the non-preferred hand (usually the left). Doehring (1968) found that male retarded readers were superior to normal readers when required to use the preferred hand and two hands simultaneously on the TPT. There were no performance differences between groups when the non-preferred hand was employed or with regard to the localization and memory components of this test. Using the results of studies with adults as a model, these findings do not support a left cerebral dysfunction theory of reading retardation. Rather, they support Doehring's (1968) interpretation of Birch's theory, viz., that reading retardation is consequent to a developmental lag in visual-auditory skills with consequent dominance of tactile-kinesthetic abilities.

(3) Motor Steadiness Battery. Kløve (1963) has described a battery of motor tests which are presently employed in the assessment of children and adults with suspected brain damage. The present investigation employed a modification of this test battery and included three tests of motor co-ordination and/or motor steadiness. These assessment procedures are fully described in Appendix A of this presentation under the following headings:

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Maze Test, Graduated Holes Test, and the Purdue Pegboard Test. Kløve (1963) reports that these tests of motor co-ordination and steadiness discriminate adequately between normal and brain-damaged populations of children. Costa, Vaughn, Levita and Farber (1963), and Fernald, Fernald and Rines (1966) have reported studies which indicate that the Purdue Pegboard Test is useful in discriminating both the presence and location of brain damage in children. However, despite their usefulness, these assessment procedures have not been employed in previous studies of reading retardation.

Factorial Studies. The review of the literature to this point has dealt with the performance of retarded and normal readers on a number of specific tests. A few studies have employed statistical techniques such as factor analysis to define more specifically the ability structure of normal and retarded readers. For example, Bean (1968) matched 25 retarded readers from grades 7, 8 and 9 for age and intelligence with an equal number of average readers. These subjects received a battery of tests designed to measure intelligence, reading ability, and perceptual and motor skills. On the basis of his factor analysis of these test results, Bean concluded that: (1) children retarded in reading exhibit a generalized verbal deficit which was shown on all tests with a verbal component; (2) visual-motor co-ordination, as such, does not appear to be an important element in this age group; and, (3) the deficit critical in reading retardation relates to sequential memory. However, Trussell (1967), in his work with younger children (Grades 1 and 2), reported the

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presence of a large visual-motor and motor factor in relationship to reading retardation. Santoro's (1968) work suggests that deficits in visual-motor and perceptual-motor skills are more prevelant in the young retarded reader than in the older retarded reader.

Doehring (1968) found that a definite reading factor emerged as the strongest factor in retarded reading and normal reading groups and that, unlike Santoro's (1968) finding, a visual-perceptual factor related to speed was associated with reading and spelling retardation in older retarded readers. Doehring (1968) also confirmed Bean's (1968) finding that sequential memory was an important factor in the retarded reading group. Doehring employed a number of other statistical techniques such as multiple discriminant analysis. The present investigation employed those test items which Doehring found to be highly discriminative of older (C.A. 10 to 15) retarded and normal readers. These items are fully described in Appendix A.

The Metropolitan Achievement Test. As a measure of reading achievement, the present investigation employed three subtests of the Metropolitan Achievement Test, Primary - II (MAT) (1959). It was designed for the assessment of children in Grade II. The MAT was standardized on an original sample of 11,407 children located in school systems of municipalities ranging in population from roughly 2,500 to 100,000. The MAT is composed of a number of subtests. The title of these tests and their median split-half reliabilities are reported in the manual as

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follows: Word Knowledge, .93; Word Discrimination, .88; Reading, .94; Spelling, .93. It should be noted that the MAT is an achievement test and no inferences were made from subject performance other than the general reading ability of each child.

Summary

This presentation has been critical of some previous investigations which have dealt with the ability structure of retarded readers because these studies were characterized by one or all of the following limitations: the tapping of only a restricted number of abilities, a failure to employ control groups, a failure to define exactly the criterion used for the selection of retarded readers. Many of these studies have not controlled for age, sex, socioeconomic status and level of intelligence. In the present investigation, 33 male retarded and 33 male normal readers in Grade II were selected from a metropolitan school system according to teacher ratings and a standardized test of reading ability, the MAT. The subjects were matched for age, socioeconomic status, and range of FSIQ. The present investigation employed the Indiana-Reitan Battery (C.A. 5 to 8) of neuropsychological tests in conjunction with the WISC and several other procedures reported by Doehring (1968) which have been shown to be sensitive to reading retardation. The Indiana-Reitan battery was selected because it taps a large number of abilities and it is useful in making inferences about the adaptive abilities of subjects with suspected cerebral dysfunction.

Briefly, the more general expectations posed for the

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present study were as follows: (1) reading retardation is a complex phenomenon related to a large number of motor, perceptual, language, and cognitive abilities and not a specific deficit; (2) children with reading retardation display significantly more neuropsychological deficits than do normal readers; and, (3) the deficit profile of retarded readers is similar to the profile of adults with known left cerebral encephalopathy. In addition to these generaly hypotheses, the present work also investigated the relationship of WISC performance, sensory and motor skills, handedness, perceptual speed, and right-left awareness to reading retardation.

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Chapter II

METHODOLOGY AND PROCEDURE

Subjects

Subjects consisted of 33 Normal Readers (NR) and 33 Retarded Readers (RR) (N = 66) drawn from an initial population of Grade 1 and Grade 2 male students who were attending one of seven schools in the Separate School System of Windsor, Ontario, Canada. These seven schools were selected because they had geographical proximity and served lower middle to upper middle income families.

Selection

Initial selection was done by school principals and teachers who were asked to choose children between the ages of 7 years and 8 years, 4 months who were of two types: (1) those having the most difficulty with academic subjects; and (2) those children rated as average with respect to school performance. These children received a group administration of the Word Knowledge, Word Discrimination, and Reading subtests of the MAT (see Appendix A). In four schools, all children between the ages of 7 and 8 were given these subtests of the MAT in order to assess the distribution of MAT scores for this age range. Approximately 240 children received this assessment procedure.

The Reading subtest of the MAT in conjunction with the

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principal's or teacher's rating of the child were the main criteria employed for the selection of retarded and normal readers. The items of the Reading subtest closely fit the definition of reading outlined in the literature. Subjects were included in the RR group if they: (1) were rated by principals and teachers as poor students; (2) obtained a percentile score of 20 or less on the Reading subtest of the MAT; and (3) obtained a percentile score of 35 or less on one of the other two subtests of the MAT. This additional requirement was employed in order to guarantee that no subject would be included in the RR group because of a spuriously low performance on only one of the subtests of the MAT.

The criteria for inclusion in the NR group required that each subject: (1) be rated as at least an average student; (2) obtain a percentile score of 50 or more on the Reading subtest of the MAT; and (3), obtain a percentile score of 50 or more on one of the other two subtests of the MAT. Similarly, this additional requirement guaranteed that no subject would be placed in the NR group because he obtained a spuriously high score on the Reading subtest of the MAT. In order that the population of NRs did not represent a population of very good rather than average readers, children scoring closest to the 50th centile were selected whenever possible.

All children who fulfilled the initial criteria for inclusion in the NR and RR groups were given the WISC. Initially, the criterion set for admission into either group was a FSIQ between 90 and 115. However, a shortage of subjects necessitated including two NRs and one RR with IQs of 117. Fifteen children

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were excluded because they obtained a FSIQ above or below this range.

All children with a medical history of known neurological impairment, serious limb injury, psychiatric illness, or marked visual or auditory defects were excluded from the study.

Tests and Procedures

After initial screening, an attempt was made to match-pair children in the NR and RR groups within one month of age. This procedure was fairly successful. These children received the complete battery of neuropsychological tests and the supplementary tests. For the most part, the tests were administered in the school setting. All tests were administered by technicians trained in the administration of the Indiana-Reitan battery and the other tests employed. A complete description of the tests employed can be found in Appendix A. A more detailed and extensive manual for the administration of the Indiana-Reitan battery is published by Dr. R. Reitan, Indianapolis Medical Centre, Indianapolis, Indiana, U.S.A.

Unfortunately, the shortage of time made it necessary for the principal investigator to administer some of the battery. However, only the simplest and most objective subtests were given by the principal investigator, and all scoring was conducted by the technicians. The order in which the subtests were administered was essentially random and determined by such variables as recesses, number of technicians available, testing accommodations, absenteeism, gymnasium classes, etc. The total amount of assessment time per subject amounted to approximately 10 hours. The complete assessment program took approximately 6 weeks to complete.

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As noted earlier, all tests were scored by technicians who also made ratings of the childrens' behaviour during testing. One child selected for the NR group was not included in the sample because his test behaviour was described as severely disturbed. All scoring which required the subjective evaluation of a response was conducted by two technicians and, when unanimity was not reached, two other technicians were consulted and the principle of "majority rules" was adopted.

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Chapter III

PRESENTATION AND ANALYSIS OF RESULTS

Results of Selection Procedures

Exactly 33 subjects fulfilled the selection procedure for the NR and RR groups (N=66). Included in Table 1 are the mean percentile scores and standard deviations for the Word Knowledge (WK), Word Discrimination (WD), and Reading (R) subtests of the MAT for the NR and RR groups. Also included in Table 1 are the *t* ratios for the comparisons in performance of the NR and RR groups on the subtests of the MAT.

Table 2 contains the mean age in days as of June 1, 1969, standard deviations, and *t* ratios for the NR and RR groups. All subjects in the NR and RR groups were match-paired within 33 days of age and the range of age differences between individual subjects in the NR and RR groups fell between 1 day and 33 days. Table 2 indicates that the mean age difference between the NR and RR groups was not significant.

Results of Assessment Procedures

Table 3 includes the mean VIQ, PIQ, FSIQ, and standard deviations, and *t* ratios for the NR and RR groups. In addition, Table 3 contains the mean scaled scores, standard deviations, and *t* ratios of the various subtests of the WISC for the NR and RR groups. It should be noted that the procedure employed for calculating the *t* statistic for between-group differences on the WISC was the *t* procedure for a

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Table 1

MEAN PERCENTILE SCORES AND STANDARD DEVIATIONS FOR THE WORD KNOWLEDGE (WK), WORD DISCRIMINATION (WD), AND READING SUBTESTS (R), OF THE METROPOLITAN ACHIEVEMENT TEST, AND *t* RATIOS FOR THE NR AND RR GROUPS

Test	Mean		S.D.		
	NR	RR	NR	RR	*t* Ratio
WK	68.69	19.93	19.89	13.94	10.28 ***
WD	86.51	35.78	13.55	20.47	10.72 ***
R[1]	67.96	10.06	11.05	6.85	22.09 ***

1 Main Selection Criterion

*** $P < .001$

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Table 2

COMPARISON OF MEAN AGE (IN DAYS) FOR THE NR AND RR GROUPS (N = 66)

Measure	NR Group	RR Group	*t* Ratio
Mean Age	2,792.55	2,792.58	0.00

matched-pairs design. This procedure was also employed to calculate the *t* ratios for all performance measures reported in this section. Significant differences were obtained for the FSIQ, VIQ and PIQ sections of the WISC and the Information, Arithmetic, Digit Span, Object Assembly, and Coding subtests. In each case, the NR group performed significantly better than did the RR group.

Further WISC results related to the VIQ-PIQ split are contained in Table 4. This Table includes the standard deviations and the mean differences for the VIQ minus the PIQ, the mean absolute difference between the VIQ and the PIQ, and appropriate *t* ratios for the NR and RR groups. This calculation of the absolute difference between VIQ and PIQ (VIQ minus PIQ, absolute difference) yields a measure of VIQ-PIQ discrepancies independent of direction. Neither measure of the VIQ-PIQ split on the WISC between NR and RR groups described significant differences. Also noted in Table 4 is a measure of individual WISC subtest scatter between NR and RR populations indicated by the mean standard deviation of the WISC subtests for the NR and RR groups and the standard deviation of the standard deviation for the two groups. The resulting *t* ratio

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Table 3

MEANS, STANDARD DEVIATIONS AND t RATIOS OF WISC VIQ, PIQ, FSIQ AND SUBTEST SCORES FOR THE NR AND RR GROUPS

Test	Mean NR	Mean RR	S.D. NR	S.D. RR	t Ratio
FSIQ	107.78	101.33	6.71	7.31	3.77****
VIQ	103.18	97.90	9.23	9.51	2.29**
PIQ	111.48	104.78	8.60	9.69	3.58****
Information (Scaled scores)	10.30	8.27	2.39	2.57	3.69****
Comprehension	10.06	10.78	2.73	2.87	1.10
Arithmetic	11.63	10.09	2.48	2.54	2.44**
Similarities	11.12	10.03	2.93	3.05	1.41
Vocabulary	9.81	9.36	2.37	2.21	0.80
Digit Span	10.30	9.00	2.01	2.26	2.54***
Picture Completion	12.42	12.21	2.54	2.53	0.46
Picture Arrangement	11.21	10.75	2.54	2.37	0.85
Block Design	11.66	10.78	2.76	2.76	1.31
Object Assembly	11.66	10.48	2.15	2.64	1.76*
Coding	10.93	9.18	2.01	2.64	2.50***

* $P < .05$
** $P < .025$
*** $P < .01$
**** $P < .001$

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Table 4

MEANS, STANDARD DEVIATIONS, AND t RATIOS
FOR VIQ-PIQ DIFFERENCES AND MEAN STANDARD DEVIATIONS,
STANDARD DEVIATIONS OF THE STANDARD
DEVIATIONS AND t RATIOS FOR THE WISC
SUBTESTS FOR THE NR AND RR GROUPS

Measure	Mean		S.D.		t Ratio
	NR	RR	NR	RR	
VIQ minus PIQ	-8.72	-7.54	12.83	13.79	0.43
VIQ minus PIQ, Absolute Diff.	5.36	7.06	12.91	10.35	0.60
S.D. WISC Subtests	2.36	2.62	0.55	0.44	2.39**

** P .025

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Table 5

MEANS, STANDARD DEVIATIONS, AND
t RATIOS FOR THE NR AND RR GROUPS ON
THE PPVT AND WRAT

Measure	Mean NR	Mean RR	S.D. NR	S.D. RR	*t* Ratio
PPVT - MA	8.74	8.07	1.22	1.31	2.57***
PPVT - IQ	109.75	103.33	10.67	12.46	2.43**
WRAT - Read (S.S.)	118.50	92.15	14.08	7.41	8.96 ****
WRAT - Spell (S.S.)	112.33	92.75	12.85	7.62	6.75 ****
WRAT - Arith (S.S.)	99.81	95.15	4.41	5.66	3.69****

**** $P < .001$
*** $P < .01$
** $P < .025$

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is significant which indicates that the RR populations displayed significantly more WISC subtest scatter than did the NR population.

Consideration will now be given to those items which make up the main content of the Indiana-Reitan battery of Neuropsychological Tests of children C.A. 5-8. Table 5 presents the means, standard deviations and t ratios for the Peabody Picture Vocabulary Test (PPVT) and the mean standard scores, standard deviations, and the t ratios for the various subtests of the Wide Range Achievement Test (WRAT). The results indicated that the NR group performed significantly better than did RR group on the two measures of performance on the PPVT and on the Reading, Spelling, and Arithmetic subtests of the WRAT.

Table 6 reports the results on the first section of the Halstead-Wepman Aphasia Screening Test (HWAT) which is described in Appendix A. Very few errors were noted in the Dysnomia, Dysgraphia, Dyscalculia, Body Orientation, and Right-Left Discrimination sections of the screening test for subjects in both the NR and RR groups. In this respect, the significant differences indicated for the Dyslexia and the Constructional Dyspraxia items should be interpreted with caution. It should be noted that the NR group performed significantly better than the RR group on the Dyslexia items of the HWAT but that the reverse was true with regard to the Constructional Dyspraxia items, in which case the RR group made fewer errors than did the NR group. These results deal directly with reading and visual-spatial skills relevant to some of the hypotheses under investigation.
A summary measure is reported which indicates significant differences

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Table 6

MEANS, STANDARD DEVIATIONS, AND *t* RATIOS FOR THE NR AND RR GROUPS ON THE MODIFIED HALSTEAD-WEPMAN APHASIA SCREENING TEST

Measure	Mean NR	Mean RR	S.D. NR	S.D. RR	*t* Ratio
Dysnomia (Errors)	.09	.00	.29	.00	--
Dysgraphia	.09	.16	.29	.36	.81
Dyslexia	.18	.73	.57	.86	3.13***
Dyscalculia	.06	.12	.22	.31	.00
Body Orient.	.50	.56	.55	.55	.42
R-L Discrimin.	.20	.48	.60	.85	1.40
Const. Dyspraxia	.51	.30	.60	.57	2.10**
Aphasia Total	1.66	2.27	1.24	1.60	1.79*

*** $P < .01$
** $P < .025$
* $P < .05$

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between the NR and RR groups in favour of the NR group when all items of the Aphasia screening test are totalled (Aphasia Total).

In each table of results reporting measures of right and left limb function there are also included measures reporting differential right versus left limb function under the heading "Right-Left" or "Right minus Left." This measure follows the clinical practice of comparing the relative performance of one side of the body with performance on the contralateral side so that inferences can be made regarding the differential integrity of the right and left cerebral hemispheres. The mean Right-Left measure for the population of NR and RR groups is determined by first calculating the difference between right and left hand function for each individual subject. This measure will be referred to as the Right-Left measure or the measure of differential right versus left performance. The measure, as it applies to between-group comparisons, addresses itself mainly to the question of whether subjects in one group displayed significantly more lateralized deficits on a task than did subjects in the other group. To some degree, the results may be confounded by differences in hand preference between subjects in the two groups. However, inspection of Table 16 indicates that the NR group had only one less subject with left hand preference than did the RR group. It should also be noted that, in the selection of the subjects, it was possible to match-pair two left-handed subjects in the NR group with two left-handed subjects in the RR group.

It will be recalled that measures were taken of tactile perception with the right and left hand under conditions of unilateral

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Table 7

MEAN NUMBER OF ERRORS, STANDARD DEVIATIONS, AND *t* RATIOS FOR NR AND RR GROUPS ON MEASURES OF TACTILE SENSITIVITY WITH THE RIGHT AND LEFT HANDS IN CONDITIONS OF UNILATERAL STIMULATION (TAC-UNIL) AND BILATERAL STIMULATION (TAC-BIL)

Measure	Mean NR	Mean RR	S.D. NR	S.D. RR	*t* Ratio
Tac-Unil Right	.03	.03			
Tac-Unil Left	.00	.12			
Tac-Unil R-L	-18	.12			
Tac-Unil Total	.03	.16			
Tac-Bil Right	0.75	0.90	1.25	1.13	0.53
Tac-Bil Left	0.66	0.48	1.19	0.95	0.64
Tac-Bil R-L	0.09	0.21	1.50	0.80	0.38
Tac-Bil Total	1.42	1.39	1.93	1.87	0.06
Tac Total	1.51	1.69	1.93	1.94	0.34

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and bilateral simultaneous stimulation delivered to the hands and face. Measures of the number of errors in the unilateral mode are useful in the interpretation of individual profiles. However, there were so few errors in both the NR and RR groups that the results are not amenable to a statistical approach. Nevertheless, some of these results are entered in Table 7. The measures of tactile sensitivity under conditions of bilateral simultaneous stimulation are also reported in Table 7. With respect to the investigation of possible differential sensitivity between the right and left hands, Table 7 contains this difference under the headings TAC R-L (the number of errors with the right hand minus the number of errors with the left hand). In addition Table 7 also includes measures of the total number of errors under unilateral and bilateral conditions and a measure of the total number of errors under both of these conditions. None of these measures yielded significant differences between the NR and RR groups.

Further measures related to tactile sensitivity with the fingers of the right and left hands (Finger Agnosia, Finger Tip Writing, Tactile Form Recognition) are reported in Table 8 in the same format as was employed in Table 7. Significant differences between groups in favour of the NR group are indicated on tasks of Finger Agnosia with the left hand and the total number of errors. A comparison of right hand versus left hand performance on tests of Finger Agnosia and Finger Tip Writing indicated that the RR group, compared to the NR group, had more difficulty in making discriminations with their left hand as compared to their right hand.

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Table 8

MEAN NUMBER OF ERRORS, STANDARD DEVIATIONS, AND t RATIOS FOR THE NR AND RR GROUPS FOR THE RIGHT AND LEFT HANDS ON TESTS OF FINGER AGNOSIA (FAg.), FINGER TIP WRITING (FTWR), AND TACTILE FORM RECOGNITION (TACF)

Measure	Mean		S.D.		t Ratio
	NR	RR	NR	RR	
FAg. Right	1.57	1.96	1.66	1.78	1.05
FAg. Left	1.48	2.84	1.68	2.29	2.61***
FAg. R-L	0.08	-0.85	1.97	2.17	1.66
FAg. Total	3.06	4.81	2.69	3.48	2.46***
FTWR Right	1.93	1.72	1.30	1.45	0.70
FTWR Left	2.06	2.24	1.61	2.00	0.47
FTWR R-L	0.12	-0.57	1.62	1.87	1.60
FTWR Total	3.84	3.93	2.54	2.98	0.13
TACF Right	0.12	0.15	0.31	0.42	0.33
TACF Left	0.12	0.06	0.40	0.22	0.81
TACF R-L	0.00	0.06	0.25	0.38	1.00
TACF Total	0.34	0.31	0.75	0.64	0.17

*** $P < .01$

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Table 9

MEANS, STANDARD DEVIATIONS, AND t RATIOS
FOR THE NR AND RR GROUPS ON
TESTS INVOLVING VISUAL PERCEPTION

Measure	Mean		S.D.		
	NR	RR	NR	RR	t Ratio
Visual Total (Errors)	.036	0.60	0.53	0.83	1.20
Prog. Fig. (Time)	62.00	78.03	32.98	44.46	1.48
Prog. Fig. (Errors)	0.51	0.81	0.85	1.08	1.25
Mat. Fig. (Time)	31.84	30.93	12.43	9.97	0.30
Mat. Fig. (Errors)	0.00	0.00	0.00	0.00	0.00
Mat. V's (Time)	44.84	40.24	17.11	15.08	1.16
Mat. V's (Errors)	1.24	1.72	1.45	1.56	1.45
Star (Time)	19.96	17.00	12.55	9.92	1.07
Star (Errors)	0.24	0.40	0.70	1.29	0.53
Squares (Time)	30.21	26.81	20.99	8.79	0.77
Squares (Errors)	2.72	3.68	2.38	2.64	1.23
Mat. Pic. (Correct)	17.24	16.12	1.43	2.43	2.73***
Target (Correct)	14.25	12.66	3.51	2.69	2.20**
Reversals (Errors)	33.78	31.12	3.94	5.57	2.29**
Colour Fm. (Time)	25.39	33.60	10.17	16.87	2.38**
Colour Fm. (Errors)	0.36	0.66	0.84	0.90	1.50

*** $P < .01$
** $P < .025$

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The measure was not quite statistically significant at the .05 level of confidence. Tests of Finger Tip Writing and Tactile Form Recognition did not yield significant differences between the RR and NR groups.

Included in the battery were tasks heavily dependent on skills related to visual perception. Table 9 includes a summary measure of assessment procedures for visual field defects. Only a few subjects in the total population exhibited difficulties in this area. Only the summary measures are reported. Results on the Progressive Figures Test (Prog. Fig.), Matching Pictures Test (Mat. Pic.), Matching Figures Test (Mat. Fig.), Matching V's (Mat. V's), Concentric Squares (Squares), Star Drawing (Star), Color Form Test (Col. Fm.), and Target Test (Target) are also reported in Table 9. Significant differences are indicated for the Matching Pictures Test, the Colour Form Test, and the Target Test. In addition, Table 9 includes results on the Reversals Test reported by Doehring (1968) which significantly differentiated the NR and RR groups. In each case the performance of the NR group was superior to that of the RR group.

Performance measures for the NR and RR groups on the subtests of the Category Test and the Cognitive Perceptual Task are presented in Table 10. These tests which are presumed to tap abstract thinking skills did not describe significant differences between the NR and RR groups.

A number of tests involving auditory perception were administered as part of the test battery employed in this study.

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Table 10

MEANS, STANDARD DEVIATIONS AND *t* RATIOS FOR THE NR AND RR GROUPS ON THE CATEGORY TEST (CAT) AND THE COGNITIVE PERCEPTUAL TASK (CPT)

Test	Mean		S.D.		*t* Ratio
	NR	RR	NR	RR	
CAT-1 (Errors)	0.24	0.12	2.49	1.63	1.25
CAT-2	2.90	3.39	2.24	1.98	1.02
CAT-3	3.30	3.51	2.10	2.20	0.40
CAT-4	6.15	6.54	5.47	6.28	0.25
CAT-5	1.27	1.48	1.10	1.37	0.70
CAT-Total	14.06	15.21	8.48	9.07	0.51
CPT-1 (Correct)	6.48	6.33	1.70	1.38	0.35
CPT-2	6.45	5.81	1.61	1.72	1.42
CPT-3	5.30	5.00	1.40	1.57	0.96
CPT-4	3.39	3.33	1.59	1.60	0.15
CPT-5	2.51	2.30	1.70	1.40	0.52
CPT-Total	24.09	22.78	5.32	5.92	0.86

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Table 11

MEANS, STANDARD DEVIATIONS, AND t RATIOS FOR THE NR AND RR GROUPS ON TESTS INVOLVING AUDITORY PERCEPTION

Measure	Mean NR	Mean RR	S.D. NR	S.D. RR	t Ratio
Auditory Tot. (Errors)	0.30	0.60	1.08	0.33	1.20
Speech. Perc. (Correct)	22.57	16.75	3.45	6.25	4.65****
Aud. Closure (Correct)	13.51	9.66	3.48	4.03	3.70****
Sent. Memory (Correct)	12.48	10.54	2.61	2.01	3.18***
Verbal Fluency (Correct)	6.80	4.37	2.49	2.31	4.05****
Rhymes (Correct)	16.12	13.21	3.73	5.15	2.77***

**** $p < .001$
*** $p < .01$

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The results of these measures for NR and RR groups can be found in Table 11. A measure of auditory perception (Auditory Tot.) reflects the total number of errors for the NR and RR group under conditions of unilateral and bilateral simultaneous stimulation delivered to the right and left ears. Total measures of right ear function and left ear function are not presented in Table 11 because of the very low number of errors displayed by the subjects in both the NR and RR groups. The total measure, as is noted in Table 11, did not significantly differentiate the NR and RR groups. However, more complex tests of Speech Perception (Speech Perc.), Auditory Closure (Aud. Closure), and Sentence Memory (Sent. Memory) did significantly differentiate the NR and RR groups. In each instance, the NR group performed significantly better than did the RR group.

Also included in Table 11 are measures of general language fluency (Verbal Fluency, Rhymes) described in Appendix A which also yielded significant results in favour of the NR group.

A number of hypotheses are related to the possible differences in non-visual somesthetic skills between subjects in the NR and RR groups. Measures of this skill, as tapped by the Tactual Performance Test (TPT), are noted in Table 12. This table presents measures of performance for the right hand (TPT Right), the left hand (TPT Left), and both hands simultaneously (TPT Both). Also reported in Table 12 are measures of right hand versus left hand performance (TPT Right minus Left), summary measures of right and left hand performance (TPT Total), and measures of performance on the Memory (TPT Mem) and Location (TPT Loc) sections

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Table 12

MEANS, STANDARD DEVIATIONS, AND t RATIOS
FOR THE NR AND RR GROUPS ON THE
TACTUAL PERFORMANCE TEST

Measure	Mean		S.D.		t Ratio
	NR	RR	NR	RR	
TPT Right (Time)	6.74	6.79	3.03	3.95	0.06
TPT Left (Time)	4.09	4.70	2.16	3.07	1.01
TPT Both (Time)	2.04	2.97	1.08	2.11	2.21**
TPT R minus L	2.63	2.16	3.02	4.03	0.79
TPT Total (Time)	12.91	14.39	5.01	7.48	0.92
TPT Pref. (Time)	6.82	7.25	3.03	3.83	0.51
TPT NPref. (Time)	4.01	4.26	2.04	2.84	0.43
TPT P-NP (Time)	2.79	3.03	2.88	3.39	0.38
TPT Mem. (Correct)	4.33	3.72	1.29	1.15	1.96*
TPT Loc. (Correct)	2,96	2.51	1.64	1.37	1.21

** $P < .025$
* $P < .05$

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of the TPT. For subjects in both the NR and RR groups, the preferred hand is not necessarily the right hand. For this reason, Table 12 also includes an adjustment of the above measures in consideration of hand preference (TPT Pref.). This format will be followed for the remaining tests which assess right or left limb function.

An inspection of Table 12 indicates that the NR and RR groups did not differ significantly on TPT measures of right hand and left hand performance, and that the adjustment for hand preference did not alter this state of affairs. There is some evidence that the RR group performed somewhat better than did the RR group when required to employ their right hand or their left hand, but the results were not statistically significant. However, the NR group performed significantly better than did the RR group when required to employ both hands simultaneously on the TPT. The NR group performed significantly better than did the RR group on the Memory section of the TPT, but not on the Location section.

The assessment procedures employed in the present study included an extensive assessment of motor skills. Some of the motor tasks originated directly from the Indiana-Reitan Battery, and others originated from the Motor Steadiness Battery described by Kløve (1963). The combined battery is described in Appendix A. The battery includes tests of relatively pure motor skills and tests of relatively complex motor abilities related to tactile-motor and visual-motor skills. The results of these assessment procedures for both NR and RR groups are noted in Tables 13 and 14. Following the format of previous Tables, results are presented for the

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Table 13

MEANS, STANDARD DEVIATIONS, AND $\underline{t}$ RATIOS FOR THE NR AND RR GROUPS ON TESTS OF RELATIVELY PURE MOTOR SKILLS

Measure	Mean NR	Mean RR	S.D. NR	S.D. RR	$\underline{t}$ Ratio
DYN PREF. (Kilgms.)	12.47	12.45	2.64	2.00	0.03
DYN N. PREF.	11.92	11.68	2.22	2.11	0.48
DYN P-NP	0.67	0.65	1.27	1.23	0.06
DYN Total	24.40	24.16	4.72	4.02	0.24
DYN RIGHT	12.58	12.38	2.64	2.19	0.37
DYN LEFT	11.83	11.75	2.20	2.02	0.17
DYN R - L	0.79	0.71	1.24	1.30	0.21
NAME PREF. (Time)	20.92	18.66	7.96	6.52	1.13
NAME N. PREF.	38.42	33.60	11.27	14.22	1.36
NAME P-NP	-16.86	-13.87	10.21	11.81	1.02
NAME Total	59.34	52.10	16.90	20.45	1.41
NAME RIGHT	22.16	21.00	7.89	12.20	0.39
NAME LEFT	37.15	31.51	13.02	13.23	1.73*
NAME R - L	-14.31	-10.34	13.54	14.73	1.20
TAP PREF. (Number)	29.92	28.70	4.62	5.66	0.96
TAP N. PREF.	28.44	26.15	3.30	5.09	2.08**
TAP P-NP	1.49	2.52	3.60	3.19	1.18
TAP Total	58.63	54.81	6.75	10.28	1.80*
TAP RIGHT HAND (No.)	29.94	28.08	4.67	5.96	1.45
TAP LEFT HAND	28.04	26.17	3.58	4.87	1.85*
TAP R - L	1.91	1.81	3.40	3.64	0.12
TAP PREF. (Number)	25.19	24.90	5.13	4.86	0.26
TAP N. PREF.	24.15	23.10	4.15	4.04	0.89
TAP P-NP	1.05	1.29	3.02	4.02	0.32
TAP Total	49.34	47.90	8.90	8.05	0.66
TAP RIGHT FOOT (No.)	25.73	24.67	5.00	4.71	0.92
TAP LEFT FOOT	23.62	23.16	4.11	4.11	0.39
TAP R - L	3.09	1.21	5.57	4.13	1.43

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Table 13 Continued

Measure	Mean NR	Mean RR	S.D. NR	S.D. RR	t Ratio
HOL PREF. (Time)	2.43	2.49	1.64	0.12	
HOL N. PREF.	4.56	4.55	3.02	4.70	0.01
HOL P-NP	-2.16	-1.99	2.87	2.76	0.24
HOL Total	6.99	7.02	3.92	6.85	0.02
HOL RIGHT (Time)	2.40	2.78	1.56	2.76	0.76
HOL LEFT	4.59	4.27	3.05	4.61	0.33
HOL R - L	-2.22	-1.39	2.83	3.11	1.18
HOL PREF. (Count)	18.81	19.51	10.25	13.04	0.27
HOL N. PREF.	29.48	27.15	15.65	17.51	0.68
HOL P-NP	-9.51	-7.45	13.79	9.97	0.69
HOL Total	48.21	46.48	23.14	29.27	0.32
HOL RIGHT (Count)	18.30	21.33	9.69	14.99	1.11
HOL LEFT	30.00	25.15	15.63	16.54	1.50
HOL R - L	-11.69	-3.81	12.00	11.85	3.04***

*** $P < .01$
** $P < .025$
* $P < .05$

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right and left limbs as well as for the preferred (PREF.) and nonpreferred (NPREF.) limbs. In addition, summary measures (Total) are presented for both the right and left limbs as well as for measures of the difference between right and left limb function (R-L).

The Dynamometer (DYN) results contained in Table 13 indicated that there were no significant differences in motor strength with the right and left hands between the NR and RR groups. Similarly, no significant differences were found with the preferred and nonpreferred hand on a task of writing speed (NAME) measured as the time in seconds taken by NR and RR subjects to write their name. When these measures are regrouped to consider writing speed for both the right and the left hands the results indicate that NR subjects took significantly longer than did RR subjects to write their names with their left hand. Measures of the differential proficiency of motor strength and motor writing speed with the right versus the left hand (DYN R-L, NAME R-L) failed to yield significant differences.

The results of tests for motor speed (TAP) with the right and left hand and right and left foot are also contained in Table 13. Significant differences between NR and RR groups are indicated on summary measures of preferred plus nonpreferred hand performance (TAP Total) and measures of nonpreferred (TAP N.PREF.) and left hand (TAP Left HAND) performance. In each instance the NR group performed significantly better than did the RR group. No significant differences were found between NR and RR groups on measures of motor speed with the right and left foot.

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The Holes Test (Appendix A) incorporates two measures of fine motor steadiness with the right and left hands. The only significant difference found on The Holes Test was on the Counter measure for right versus left hand performance (HOL R-L Count.). The difference between right and left handed performance was much more marked for the NR group.

The Maze Test of visual-motor coordination and steadiness, Appendix A, includes three measures of performance with the right and left hands; the time in seconds to complete the task (MZE Speed), the number of times the subject's stylus touches the side of the maze (MZE Count), and the length of time which the stylus remains on the side of the maze (MZE Time). The results reported in Table 14 indicate that, on Maze Time and Counter measures of preferred and nonpreferred hand function, NR subjects performed significantly better than did RR subjects. In addition, the totalled score for the Time and Counter measures (MZE Total) indicates that the NR group performed significantly better than did the RR group. When Time and Counter measures are considered for the right and left hands irrespective of preference, significant differences are indicated for Counter measures for left and right hand performance and Time measures for the right hand. The difference between NR and RR groups on Maze Time measures for the left hand was not statistically significant. In each of these right and left hand performance measures, the NR subjects performed significantly better than did the RR subjects.

With respect to Maze Speed measures, no significant differences between the NR and RR groups are noted for the preferred,

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Table 14

MEANS, STANDARD DEVIATIONS, AND t RATIOS
FOR THE NR AND RR GROUPS ON TESTS
OF VISUAL-MOTOR AND TACTILE-MOTOR SKILLS

Measure	Mean		S.D.		t Ratio
	NR	RR	NR	RR	
MZE PREF. (Time)	3.84	5.38	1.92	4.04	2.08**
MZE N.PREF.	8.20	10.37	3.94	5.69	1.92*
MZE P-NP	-4.36	-5.04	3.10	3.48	0.83
MZE Total	12.38	16.07	5.47	9.32	2.01*
MZE RIGHT (Time)	4.21	6.13	2.81	5.27	2.28**
MZE LEFT	7.83	9.64	3.77	5.26	1.67
MZE R - L	-3.61	-3.31	3.95	5.15	0.32
MZE PREF. (Count)	30.33	37.09	16.39	20.03	1.76*
MZE N. PREF.	54.21	68.18	21.27	31.99	2.44**
MZE P-NP	-24.03	-32.03	17.96	23.46	1.73*
MZE Total	83.90	104.33	32.44	47.88	2.35**
MZE RIGHT (Count)	31.06	41.15	19.56	30.16	2.37**
MZE LEFT	52.45	63.30	19.34	27.83	2.01*
MZE R - L	-20.69	-21.60	22.24	33.31	0.17
MZE PREF. (Speed)	114.84	108.81	37.36	27.28	0.69
MZE N. PREF.	109.48	113.57	27.43	33.57	0.50
MZE P-NP	4.39	-5.33	20.59	30.75	1.47
MZE Total	224.33	222.18	62.31	52.26	0.13
MZE RIGHT (Speed)	115.31	109.75	37.02	26.76	0.63
MZE LEFT	108.48	112.87	28.11	34.26	0.52
MZE R - L	5.72	-3.93	20.26	30.96	1.45
PEG PREF. (Time)	37.15	41.96	6.72	8.31	2.51***
PEG N. PREF.	38.75	42.45	7.19	7.88	1.81*
PEG P-NP	-1.96	-0.75	6.86	6.61	0.70
PEG Total	75.90	84.72	12.33	14.89	2.45**
PEG RIGHT (Time)	37.00	41.54	6.60	8.06	2.45**
PEG LEFT	38.24	42.57	6.32	8.33	2.34**
PEG R - L	-2.27	-1.00	6.76	6.58	0.81

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Table 14 Continued

Measure	Mean NR	Mean RR	S.D. NR	S.D. RR	$\underline{t}$ Ratio
PEG PREF. (Errors)	0.15	0.37	0.43	0.64	2.20**
PEG N. PREF.	0.19	0.19	0.38	0.38	0.00
PEG P-NP	-0.09	0.18	0.50	0.62	2.70***
PEG Total	0.27	0.54	0.43	0.85	1.92*
PEG RIGHT (Errors)	0.12	0.33	0.31	0.58	2.10**
PEG LEFT	0.15	0.21	0.34	0.46	0.60
PEG R - L	-0.03	0.12	0.52	0.64	1.07

*** $P < .01$
** $P < .025$
* $P < .05$

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nonpreferred, right, left, or totalled hand performance. In addition, speed, counter, and time measures of differential right minus left hand performance (R - L) described no significant differences between the NR and RR groups.

The Pegboard Test, described in Appendix A, contains two measures of tactile-motor coordination, time (PEG Time) to complete the task and the number of times the subject drops the pegs (PEG Errors). Results for these two measures are noted in Table 14. Significant differences are indicated between NR and RR groups for Time measures for the preferred, nonpreferred, right, and left hands and for summary measures of right and left hand performance. In addition, significant differences are noted on Error measures of preferred and right hand performance, preferred minus nonpreferred hand performance, and summary measures of right and left hand performance. In each of the above instances, the NR group performed significantly better than did the RR group.

It is appropriate at this point to summarize the important general findings of the assessment procedures for pure motor and complex motor skills. NR and RR groups were not significantly different on performance measures of pure motor strength with the right and left hand. NR and RR groups were not significantly different on performance measures of writing speed except on one measure of left hand performance. On tests of pure motor speed with the right and left hand and foot, the only significant differences found were related to motor speed with the nonpreferred hand and summary measures of right and left hand performance, in

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which case the NR subjects performed significantly better than did the RR subjects. On the Holes Test of motor steadiness no significant differences in right and left hand performance were found between RR and NR subjects. On two out of three measures of visual-motor coordination and motor steadiness with the preferred and non-preferred hand, NR subjects performed significantly better than did RR subjects. On a test of fine tactile-motor coordination with the right and left hand, NR subjects performed significantly better than did RR subjects. Only one (HOL R - L) out of eleven measures of differential performance between the right and left limb for NR and RR subjects was found to be statistically significant.

The results of the assessment procedures for hand, foot, and eye preference which constitutes the Harris Test of Lateral Dominance (Appendix A) are reported in Table 15. The results indicate that NR and RR subjects did not differ with respect to right and left hand, foot, or eye preference. However, on the Miles ABC Test of Ocular Dominance some significant differences between NR and RR groups on measures of left eye preference and on measures of the absolute difference between the number of times one eye was preferred over the other (R - L No Sign) were in evidence. The latter measure reflects the prevalence of mixed-eyedness in the NR and RR groups. On the ABC Test, NR subjects tended to prefer their left eye significantly less frequently than did the RR subjects. In addition, the NR subjects shifted eye preference less frequently than did RR subjects. The number of right- and

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Table 15

MEANS, STANDARD DEVIATIONS, AND t RATIOS
FOR THE NR AND RR GROUPS ON TESTS
OF EYE, HAND AND FOOT PREFERENCE

Measure	Means NR	Means RR	S.D. NR	S.D. RR	t Ratio
Harris - Hand Right	6.54	6.15	1.10	2.13	1.05
Hand Left	0.45	1.06	1.10	2.37	1.52
Hand R - L	6.09	4.87	2.20	4.74	1.52
Harris - Eye Right	1.36	1.54	0.84	0.70	1.05
Eye Left	0.63	0.45	0.84	0.70	1.05
Eye R - L	0.72	1.09	1.69	1.40	1.00
Harris - Foot Right	1.67	1.83	0.64	0.56	1.14
Foot Left	0.30	0.15	0.62	0.48	1.07
Foot R - L	1.40	1.68	1.24	1.00	0.93
ABC Right	6.72	5.69	4.63	4.44	1.07
ABC Left	3.27	4.90	4.63	4.49	1.73*
ABC R - L	3.45	0.78	9.26	8.95	1.33
R - L No Sign	9.87	8.78	0.46	1.90	3.20***

*** $P < .01$
* $P < .05$

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Table 16

NUMBER OF RIGHT- AND LEFT-HANDED, RIGHT- AND LEFT-FOOTED AND RIGHT- AND LEFT-EYED SUBJECTS IN THE NR AND RR GROUPS

Measure	NR		RR	
	Left	Right	Left	Right
Hand	4	29	5	28
Foot	4	29	2	31
Eye	8	25	10	23

Table 17

MEANS, STANDARD DEVIATIONS AND *t* RATIOS FOR THE NR AND RR GROUPS ON PIAGET'S TEST OF RIGHT-LEFT AWARENESS

Measure	Mean (Correct)		S.D.		*t* Ratio
	NR	RR	NR	RR	
R - L Aware 1	3.87	3.37	0.69	1.36	1.78*
R - L Aware 2	2.96	2.00	1.74	1.90	2.18**
R - L Aware 3	3.34	2.78	1.16	1.42	1.69
R - L Aware 4	1.15	1.09	0.93	0.97	0.25
R - L Aware 5	4.12	3.09	1.65	1.50	2.86***
R - L Aware 6	4.37	3.18	1.78	1.62	2.90***
Total	20.03	15.67	5.05	4.08	3.63****

**** p .001
*** p .01
** p .025
* p .05

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Table 18

MEAN NUMBER OF ITEMS CORRECT, STANDARD DEVIATIONS, AND t RATIOS FOR NR AND RR GROUPS ON DOEHRING'S UNDERLINING TESTS OF PERCEPTUAL SPEED

Measure	Means NR	Means RR	S.D. NR	S.D. RR	t Ratio
Single No. -4	28.39	27.54	4.63	7.94	0.54
Single Geom. Fm.	33.27	28.54	6.13	6.45	3.52****
Single Nonsense Letter	20.33	17.24	3.80	5.15	2.73***
Gestalt Figure	8.00	6.15	5.59	6.05	1.21
Single Letter	26.57	21.36	4.94	5.72	3.83****
Single Letter Syll.	18.24	15.24	4.43	5.19	3.37***
Two Letters	17.27	16.12	3.62	5.28	1.21
Seq. Geom. Fms.	9.90	7.63	3.52	4.32	2.52**
Nonsense Syll. Unpron.	8.90	8.00	3.68	3.28	1.15
Nonsense Syll. Pron.	16.75	9.15	5.11	3.82	6.66****
Four Letter Word	17.72	8.03	5.38	4.98	9.31****
Unspaced Word	9.36	5.63	2.05	3.15	5.92****
Single No. -5	25.87	25.51	5.81	8.32	0.19
Total	240.48	196.33	29.32	45.05	5.16****

**** $P < .001$
*** $P < .01$
** $P < .025$

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left-handed, right- and left-footed, and right- and left-eyed people in the NR and RR groups is contained in Table 16. As noted previously, the NR group contained only one less subject with left hand preference than did the RR group.

The results for NR and RR subjects on the subtests of Piaget's test of Right-Left Awareness are contained in Table 17. On four out of the six measures requiring right-left discrimination, NR subjects had significantly fewer errors than did RR subjects. On one test, R - L Aware 3, NR subjects performed noticeably better than did RR subjects, although the results were not statistically significant. The summary measure of performance on this test (R - L Aware Total) indicates that the overall performance of the NR group was better than that of the RR group.

The performance measures for NR and RR subjects on Doehring's Test of Perceptual Speed are reported in Table 18. The test is fully described in Appendix A. Seven of the thirteen subtests yielded significant differences. In all of these cases, the NR subjects performed better than did the RR subjects. A summary measure also yielded significant differences in favour of the NR group. It would appear that the two subtests which contained numerical items did not significantly differentiate between the two groups, whereas subtests involving geometric forms and language materials did tend to differentiate NR and RR groups.

Table 19 contains a rank ordering according to the magnitude of the $\underline{t}$ ratios of those measures on which NR subjects performed significantly better than did RR subjects. Inspection of Table 18

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Table 19

MEASURES ON WHICH NORMAL READERS WERE SIGNIFICANTLY SUPERIOR TO RETARDED READERS RANK ORDERED ACCORDING TO THE SIZE OF THE *t* RATIO

Measure	Rank	*t* Ratio
MAT Reading	1	22.09
MAT Wd. Discr.	2	10.72
MAT Wd. Know.	3	10.28
Underl. Four Letter Wd.	4	9.31
WRAT Reading	5	8.96
WRAT Spelling	6	6.75
Underl. Pronoun Syll.	7	6.66
Underl. Unspaced Four Letter Wd.	8	5.92
Underl. Total	9	5.16
Speech Perception	10	4.65
Verbal Fluency	11	4.05
Underl. Single Letters	12	3.83
WISC FSIQ	13	3.77
WISC Information	14	3.69
Auditory Closure	15	3.70
WRAT Arithmetic	16	3.69
Right-Left Total Awareness	17	3.63
WISC PIQ	18	3.58
Underl. Single Geometric Fms.	19	3.52
Underl. Single Letter in Syll.	20	3.37
ABC R-L (Absolute Diff.)	21	3.20
Sentence Memory	22	3.18
Aphasia Dyslexia	23	3.13
Hols R-L CNT.	24	3.04
Rhymes	25	2.77
Underl. Single Nonsense Letter	26	2.73
Matching Pictures	27	2.73
Pegboard P-NP Errors	28	2.70
Seashore Rhythm	29	2.66
Finger Agnosia Left	30	2.61
WISC Digit Span	31	2.54
Underl. Seq. Geom. Fms.	32	2.52
Pegboard Dom. Time	33	2.51
WISC Coding	34	2.50

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Table 19 Continued

Measure	Rank	$\underline{t}$ Ratio
Finger Agnosia Total	35	2.46
Pegboard Total	36	2.45
WISC Arithmetic	37	2.45
Pegboard Right Time	38	2.45
Maze N. Perf. CNT.	39	2.44
Peabody Vocab. IQ	40	2.43
S.D. WISC Subtests	41	2.39
Colour FM. Time	42	2.38
Maze Right CNT.	43	2.37
Maze Total CNT.	44	2.35
Pegboard Left Time	45	2.34
Reversals	46	2.29
WISC VIQ	47	2.29
TPT Both Hands	48	2.21
Pegboard Pref. Error	49	2.20
Target	50	2.20
Pegboard Right Error	51	2.10
Tap N. Pref. Hand	52	2.08
Maze Left CNT.	53	2.01
TPT Memory	54	1.96
Pegboard Total Error	55	1.92
Tap Left Hand	56	1.85
Pegboard N. Pref. Time	57	1.81
Aphasia Total	58	1.79
WISC Object Assembly	59	1.76
Maze Pref. CNT.	60	1.76
Maze P-N.P. CNT.	61	1.73
ABC Left	62	1.73

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indicates that, for the most part, measures which received the highest rank (i.e. measures with largest ratios) were related directly to reading. However, some of Doehring's (1968) tests of perceptual speed also had relatively large $\underline{t}$ ratios. These were followed by measures of general language and auditory-verbal skills and WISC performance measures. Measures of right-left awareness also ranked relatively high. It would appear from an inspection of Table 19 that tests of tactile perception, nonverbal auditory discrimination skills and motor abilities tended to rank lower than did other assessment procedures.

Table 20 contains information related to the comparison of Doehring's (1968) findings with the findings of the present study. It includes only those tests which were employed both by Doehring and in the present investigation. These tests have been rank-ordered according to the magnitude of the $\underline{t}$ ratio and $\underline{F}'$ ratios. It should be noted that Doehring employed the WB-I in his assessment procedures and matched normal reading and poor reading groups for PIQ. The present study employed the WISC and subjects were not matched for PIQ. However, for comparison purposes, the WB-I and WISC subtest ranks have been included in Table 20. In addition, the Category Test contains different items for the different age ranges of children employed in Doehring's study and in the present investigation.

Although the above mentioned factors make a direct comparison of the two studies somewhat difficult, an inspection of Table 20 suggests that there is a great deal of similarity between the results of the two studies. Tests of general language abilities

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Table 20

TESTS EMPLOYED IN THE PRESENT STUDY AND IN DOEHRING'S INVESTIGATION ON WHICH THE NR GROUP PERFORMED SIGNIFICANTLY BETTER THAN DID THE RR GROUP, RANK ORDERED ACCORDING TO THE MAGNITUDE OF THE *t* and *F'* RATIOS

Test	Present Study Rank (*t*)	Doehring Rank (*F'*)
Underlin. 4 Letter Word	1	9
WRAT Reading	2	1
WRAT Spelling	3	2
Underlin. Pronoun Syllable	4	5
Underlin. Unspc'd 4 Letter Word	5	11
Speech Discrimination	6	7
Underlin. Single Letters	7	19
WISC Information* (WB-1 Info.)	8	4
Underlin. Geom. Forms	9	24
Underlin. Letter in Syllable	10	17
Rhymes	11	3
Underlin. Single Nonsen. Letters	12	14
Seashore Rhythm	13	13
Finger Agnosia Left	14	27
WISC Digit Span* (WB-1 Digit Span)	15	21
Underlin. Geom. Fms.	16	15
WISC Coding* (WB-1 Digit Symbol)	17	18
WISC Arithmetic* (WB-1 Arith.)	18	6
Peabody P.V.T.- I.Q.	19	16
Colour Form	20	NS
Reversals	21	12
TPT Both Hands	22	NS
TAP NPref. Hand	23	NS
TPT Memory	24	NS
WISC Similarities* (WB-1 Simil.)	NS	8
WISC Vocabulary* (WB-1 Vocab.)	NS	10
WISC Comprehension* (WB-1 Comp.)	NS	20
Underlin - 1 Single Number	NS	22
Category*	NS	23
Underlin - 13 Single Number	NS	25
Dynamometer Pref.	NS	26
Dynamometer NPref.	NS	28

* Tests containing items which differ between the two studies.

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received high rankings in both studies (i.e. these tests have large _t_ or _F'_ ratios and are ranked close to one another). Doehring's (1968) tests of perceptual speed also received relatively high rankings, whereas tactile and motor tests have been ranked lowest in the two studies. It should also be noted that, out of 24 tests which significantly differentiated NR and RR groups in the present study, 20 of these 24 tests also differentiated NR and RR groups in Doehring's study.

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Chapter IV
DISCUSSION

Selection Procedures

As noted previously in Chapter III the NR and RR groups contained 33 subjects each. It was possible to match-pair subjects in the NR group with subjects in the RR group within 33 days of age. The mean difference in age between the two groups (Table 2) was effectively zero. In addition, the age range was restricted to 7 yrs., 2 months to 8 yrs., 4 months. This represents a relatively tight control for age in the population of children assessed in the present study. A comparison by inspection of the raw data of the performance skills of older and younger children within the NR and RR groups indicated a marked superiority of older children even within this restricted age range. The results of the present work indicate that tight controls for age are necessary in studies of the ability structure of young children.

The question arises as to whether or not the subjects in the RR group actually were retarded readers and whether subjects in the NR group were normal or average readers rather than superior readers. Table 1 contains data which indicates that the RR group, with a mean percentile score of 10.06 on the Reading subtest of the MAT, were in fact retarded in reading. In addition, as indicated in Table 1, normal readers performed significantly better than did retarded readers on the other two subtests of the MAT

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which are directly dependent on reading abilities.

The mean percentile score of only 67.96 obtained by NR subjects on the Reading subtest of the MAT indicates that the NR subjects did, in fact, represent a population of close-to-average readers. It should also be noted that the percentile difference of 57.90 between the mean percentile score of NR subjects and RR subjects on the Reading subtest of the MAT approximates the mean percentile differences of 58.76 and 48.76 which exist between groups on the Word Knowledge and Word Discrimination subtests, respectively. As noted earlier, it was the aim of this study to investigate a common, non clinical school problem, retarded reading. In this respect, the objectives of this study have been fulfilled through the selection of subjects who are still attending normal grades in school and who represent two populations of students, viz., one retarded in reading, and one normal but not superior with respect to reading abilities.

The fact that the RR and NR groups did not represent subjects at the extreme ends of the continuum of reading ability is an important consideration in the level of confidence set for the interpretation of statistical differences in performance measures between groups. The comparative closeness of the two groups with regards to reading skill decreased the likelihood of statistical differences between NR and RR subjects. For this reason, it is not as necessary for the level of confidence to be set as high as it would be set if NR and RR subjects represented superior and severely impaired readers, respectively.

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The present study attempted to control for intelligence by selecting subjects whose obtained WISC FSIQ fell within the approximately normal range of 90 to 115. Unfortunately, the shortage of subjects necessitated the inclusion of three subjects with FSIQs of 117. All subjects in the NR and RR groups obtained FSIQs within the range of 9 to 117. The restriction imposed on subject selection with regards to roughly normal intelligence is consistent with the purpose of this study which was to compare the ability structure of children attending school who had no major intellectual deficits except those related to reading with children who were relatively average with respect to intelligence and reading skills.

Unlike Doehring (1968) who employed subjects with a WB-I FSIQ above 90 and match-paired these subjects on PIQ, the present study required only that subjects have WISC FSIQs within the range of 90 to 117. By matching for PIQ, Doehring (1968) wished to investigate possible differences between retarded and normal readers on verbal-language skills which may have been diagnostic of left cerebral encephalopathy. For the most part, the present investigation regarded the WISC as a dependent variable (i.e., another neuropsychological test). Except for the initial requirement that subjects obtain a FSIQ in the range of 90 to 117, no other attempt was made to control for between-group differences on the various aspects of the WISC. Consequently, the results obtained represent a relatively unbiased pattern of WISC performance for subjects retarded in reading as compared with those who were normal with regards to reading skills.

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Despite the control placed on FSIQ, Table 3 indicates that the NR group obtained a mean FSIQ significantly higher than that of the RR group. This finding suggests that retarded readers do significantly less well than normal readers on a measure of general intelligence. These results are in accordance with the findings of Belmont and Birch (1966) and Doehring (1968) who assessed WISC performance in older subjects. The results indicate that, on general measures of intelligence, retarded readers display a notable impairment in their adaptive abilities.

It has been suggested that a deficit contributing to lowered FSIQ in retarded readers relates to a general impairment in verbal and language skills as measured by the WISC VIQ. The results of the present work indicated that normal readers performed significantly better than retarded readers on measures of VIQ. Retarded readers appear to suffer from a number of deficits related to general verbal and language abilities. This finding is also in direct accord with the work of Belmont and Birch (1966) and Doehring (1968).

Belmont and Birch (1966) found that, in normal and retarded readers with WISC FSIQs in the normal range (90 to 109), "retarded readers were characterized in general by better functioning on task demands of the Performance Scale and relatively poorer functioning on the task demands of the Verbal Scale of the intelligence test (p. 814)." However, in contrast to this finding, the results contained in Table 3 indicated that NR subjects in the present study obtained a significantly higher PIQ than did RR subjects. Consequently, from this

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information alone, it would appear that the presence of deficits related to nonverbal visual-motor and nonverbal visual-conceptual skills also contribute to lowered measures of WISC FSIQ. The findings of the present study do not support any hypothesis which holds that the WISC PIQ obtained by normal readers is not significantly different from the WISC PIQ obtained by retarded readers.

Doehring (1968) has suggested that retarded readers may be suffering from left sided encephalopathy so as to depress measures of the VIQ more than measures of the PIQ. If this suggestion is correct, RR subjects as compared to NR subjects should have performed significantly more poorly on measures of VIQ than they did on measures of PIQ. This hypotheses was directly related to individual subject discrepancies in WISC VIQ and PIQ. The finding, noted in Table 4, that VIQ-PIQ discrepancies in favour of the VIQ between NR and RR subjects was not statistically significant fails to support this contention. In addition, this finding is not consistent with the previous statement of Belmont and Birch with regards to the differential performance of retarded and nonretarded readers on the Performance items vs the Verbal items of the WISC. However, the present findings are consistent with the findings of Reed (1967) who found that poor reading was associated with WISC VIQ-PIQ discrepancies in favour of the PIQ in a population of older children, aged ten, but not in a population of younger children, aged six. Reed (1967) notes that it is likely that "the significance to reading achievement of differences between

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verbal and performance disparities is dependent upon stages of development (p. 835)." It appears from the results of WISC measures taken in the present work that visual-perceptual and perceptual-motor deficits may contribute more to reading retardation at the younger than at the older age levels.

The generally low performance of retarded readers on summary measures of WISC performance supported the hypothesis that retarded readers may be suffering from a number of deficits related to cerebral dysfunction. However, the WISC profiles of retarded readers with regards to the VIQ-PIQ discrepancies did not resemble the profile expected of adults suffering from left sided cerebral encephalopathy. (It should be noted, once again, that it may not be appropriate to make inferences about the cerebral integrity of children based on information gained from research with adults.)

The additional measure noted in Table 4, VIQ minus PIQ (Absolute Diff.) was not statistically significant. This finding indicates that the RR group did not display any more VIQ-PIQ discrepancies on the WISC in either direction than were dispalyed by the NR group. The findings of this study suggest that VIQ-PIQ discrepancies on the WISC of any nature may not be useful in predicting school reading performance at these age levels.

Reported in Table 4 is a measure of subtest scatter on the WISC. The measure (S.D. WISC Subtest) indicated to what degree individual subjects in the RR group tended to obtain WISC

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profiles which were more scattered than those for subjects in the NR group. The results indicate that subjects in the RR group had subtest profiles which were significantly more scattered than those for subjects in the NR group. This finding would appear to indicate that the performance of retarded readers on the WISC subtests tends to fall more frequently above or below test norms than does the performance of normal readers, i.e. the performance of retarded readers tends to be more uneven than that of normal readers.

Table 3 indicates that NR subjects were significantly better than RR subjects on the Information, Arithmetic, Digit Span, Object Assembly, and Coding subtests of the WISC. The significant difference between NR and RR groups on the Information subtest is generally in accord with most of the findings in the literature (Belmont & Birch, 1966; Doehring, 1968; Reed, 1968). Doehring (1968), who employed the WB-1, has suggested that lowered Information scores in populations of retarded readers "may largely reflect a retardation of educational achievement secondary to reading retardation (p. 47)." Specifically, it may reflect a difficulty in the ability of retarded readers to understand, store, and recall common verbal information.

Doehring (1968) found that both the Information subtest and the Arithmetic subtest ranked high with respect to the tendency of these tests to differentiate the NR and RR groups. This finding is consistent with the results of the present

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study and the results noted by Belmont and Birch (1966). Further reference to arithmetic reasoning deficits in NR and RR subjects will be mentioned later in this presentation.

The results contained in Table 3 indicate significant differences between groups on the Digit Span subtest of the WISC. This finding is also in accord with the work of Belmont and Birch (1966) and Doehring (1968), who found that older normal readers performed significantly better on the Digit Span subtest than did older retarded readers. The subtest itself is a verbal input-output task which is said to tap short term memory and organization.

It should be noted that Doehring (1968) found statistically significant differences between NR and RR groups in favour of the NR group on all subtests of the WB-I Verbal Scales. However, it will be recalled that Doehring (1968) matched retarded and normal readers for PIQ. This procedure may have increased the likelihood of obtaining a large number of significant differences between groups on the Verbal subtests. Doehring's (1968) research and Reed's (1968) work suggest that the Vocabulary and Similarities subtests are highly sensitive to differential performance of NR and RR groups. Belmont and Birch (1966) also indicated that poor performance on the Vocabulary subtest of the WISC may be diagnostic of retarded reading. In the present study, significant differences were not established between groups on the Similarities and Vocabulary subtests. The differences on the Similarities subtest

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1.41 and the Vocabulary subtest did not approach significance. It is difficult to explain the discrepancy in the findings of the previous studies and the present work except to note that Belmont and Birch (1966) and Doehring (1969) assessed the performance of older readers and Reed (1968) did not control for intelligence. In addition, the Vocabulary abilities of NR and RR children may be strongly influenced by experience and age variables which were tightly controlled in the present study. In summary, the present work indicates that normal readers and retarded readers do not suffer from Vocabulary deficits and Verbal-related abstract thinking deficits as they are measured by the Vocabulary and Similarities subtest of the WISC, respectively.

Doehring's (1968) procedure of match-pairing subjects for PIQ precludes a very legitimate comparison between the WISC Performance scale measures obtained in the present study and the WB-1 Performance scale measures in his investigation. Doehring (1968) found that performance on the Object Assembly and Digit Symbol subtests differentiated the NR and RR groups. However, the difference favoured the retarded readers on the Object Assembly subtest. This finding is in direct contrast to the findings of the present work with younger children. The results noted in Table 3 indicate that NR subjects performed significantly better than did RR subjects on the Object Assembly subtest of the WISC. Based on his work, Doehring (1968) has suggested that retarded readers may perform better

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than normal readers on tasks such as the Object Assembly subtest which require some tactile-kinesthetic skills. This suggestion is not supported by either the present findings or the work of Belmont and Birch (1966) and Reed (1968) who found that retarded readers have more difficulty than normal readers with tactile-kinesthetic skills.

Belmont and Birch (1966) found that normal readers performed significantly better than retarded readers on the Picture Arrangement, Block Design, and Object Assembly subtests of the Performance Scale of the WISC. In the present study there were no significant differences between NR and RR groups for the Block Design and Picture Arrangement subtests. Only the t ratio for the Block Design subtest approached statistical significance.

It is interesting to note that Belmont and Birch (1966) and Reed (1968) did not find significant differences between NR and RR groups on the Digit Symbol or Coding subtests. However, significant differences on these subtests have been reported frequently in other investigations. Doehring (1968), for example, reported significant differences and the NR group in the present study performed significantly better than did the RR group on the Coding subtest of the WISC. Doehring (1968) noted that the Coding subtest is primarily a test of perceptual-motor speed, a skill which consistently appeared to be deficient in the ability profiles of retarded readers.

In summary, it would appear that the WISC subtest results of the present study are in direct accord with many of the findings in the literature. However, there are some main differences.

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Most of the other studies yielded more significant differences between NR and RR groups on the various subtests of the WISC than were found in the current investigation. In addition, the NR group in this study performed significantly better than did the RR group on the Object Assembly and the Coding subtests of the WISC. These findings are not in accord with those of Belmont and Birch (1966) and Reed (1968) for the Coding subtest and Doehring (1968) for the Object Assembly subtest. The aforementioned discrepancies may be attributable to the fact that other studies may not have controlled for FSIQ (e.g., Reed, 1968). In addition, some investigators compared subjects who were actually poor readers with very good readers. These subjects represented very wide differences in reading skills between groups (Belmont & Birch, 1966; Doehring, 1968; Reed, 1968). Other studies assessed the WISC or WB-1 performance of children who were older than those employed in the present study.

If the "adult model" is employed to interpret the profile of mean WISC subtest scores obtained by the RR groups, the results do not lend support to the hypothesis that retarded readers suffer from left cerebral dysfunction. The neuropsychological profiles of adults with known left-sided encephalopathy reflect deficits in the Information, Similarities, and Vocabulary subtests. Performance measures of the Similarities subtest did not differentiate the groups in the present study, whereas this test is found to be especially sensitive to left cerebral dysfunction in adult populations. In addition, the significant between-group

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differences on a number of the WISC Performance subtests argues against an exclusively left-sided cerebral encephalopathy theory of reading difficulty in young children. However, it is possible that an inspection of the individual profiles of retarded readers will yield results supportive of a left cerebral dysfunction interpretation of reading disability.

The WISC results of the present study also have a direct bearing on the concept of reading retardation or dyslexia as a specific deficit not related to measures of intelligence. The finding that retarded readers had lower FSIQs, VIQs and PIQs than normal readers gives little credence to the suggestion that dyslexia is a deficit confined to reading abilities and not coincidental with any general impairment in adaptive abilities or intelligence.

Doehring (1968) found that normal readers performed significantly better than retarded readers on the Peabody Picture Vocabulary Test (PPVT). Table 5 reports identical results for the present study. It is probably the case that the task requirements of the PPVT are somewhat less than those of the WISC Verbal Scales. The test requires a motor response indicating which of four pictures represents the vocabulary word spoken orally by the examiner. The PPVT is essentially a vocabulary test and it is somewhat difficult to explain why it significantly differentiated NR and RR groups when the Vocabulary subtest of the WISC did not differentiate groups. It is possible that this

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inconsistency is related to deficits in the abilities of retarded readers tapped by the visual discrimination and visual-verbal association items contained in the PPVT which are not present in the WISC Vocabulary subtest.

The results of the Wide Range Assessment Test (WRAT) presented in Table 5 indicate that, on the Reading and Spelling subtests of the WRAT, NR subjects performed significantly better than did RR subjects. The significant difference found in the Reading subtest of the WRAT provides some concurrent validity for the Reading subtest of the MAT which, in this study, was the main criterion test of reading ability. The WRAT Reading subtest relates specifically to oral reading; the Reading subtest of the MAT relates mainly to silent reading and comprehension. The results suggest that there is a strong association between silent reading and comprehension skills on the one hand, and oral reading skills on the other. In addition, the superior performance of normal readers over retarded readers on the Spelling subtest of the WRAT further expands the constellation of verbal deficits associated with reading difficulty.

For the most part, the WISC Arithmetic subtest consists of oral answers to oral arithmetic questions, whereas the main task involved in the Arithmetic subtest of the WRAT involves a written response to printed mathematical questions. The results presented in Table 3 and Table 5 indicate that, on both the Arithmetic subtest of the WISC and the Arithmetic subtest of the WRAT, normal readers performed significantly better than did

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retarded readers. It would appear that deficits in reading in young children are related to deficits in mathematical reasoning and the use of mathematical symbols, regardless of how this skill is measured.

Table 6 reports the results for the Halstead-Wepman Aphasia Screening Test (HWAT). As noted previously, the results of the individual sections of the HWAT should be interpreted with some caution in view of the fact that some of these sections contain only three items and, for the most part, subjects in both the NR and RR groups found the items of the HWAT very easy. Table 6 notes significant differences between NR and RR groups in favour of the NR group on the Dyslexia (reading) items of the HWAT. It is interesting to note that a very simple three-item test of reading skills was sensitive to the reading deficit of retarded readers.

The data contained in Table 6 also indicates that retarded readers did significantly better than did normal readers on the Constructional Dyspraxia items of the HWAT. These items required subjects to reproduce graphically a simple geometric form. The items are said to be related to visual-spatial organization skills which, in adult populations, are subsumed by the right cerebral hemisphere (Reitan, 1955). Doehring (1968) found no significant differences between NR and RR groups on summary measures of the Construction Dyspraxia items of the HWAT, but he did find that retarded readers had significantly more difficulty than did normal readers on one of the four items

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of the HWAT which required subjects to copy a Greek cross. The findings of the present investigation are somewhat difficult to interpret in the light of Doehring's work. It is probably not appropriate to make conclusions on the findings of a three-item test which are not supported by other assessment proceudres, although it should be noted that if retarded readers suffer from severe deficits in visual-spatial organization the results are not in the expected direction.

Summary measures of performance on the items of the HWAT indicated significant differences in favour of the NR group. This would seem to indicate that young retarded readers have a broad spectrum of language deficits related to naming, writing, and following simple verbal instructions.

On tests for deficits in the perception of simple touch applied to the right and left hands under conditions of unilateral stimulation and bilateral simultaneous stimulation, no significant differences were found between NR and RR groups. Doehring (1968) also reported no significant differences between NR and RR groups with regards to measures of tactile suppression under conditions of bilateral simultaneous stimulation. As noted in Chapter III, the items of this assessment procedure are very easy and may only be sensitive to cerebral dysfunction in populations of children whose abilities are more severely impaired than those currently attending school with normal FSIQs.

Benton (1959) has suggested that dyslexia exists in close association with directional confusion as it is measured by tests

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of finger localization. Reed (1967) has found that, at the chronological age of ten, children with a predominance of left-handed errors on a test of Finger Agnosia read significantly better than did children with predominantly right-handed errors. The results of the assessment procedure for Finger Agnosia in the present study indicate that, in general, retarded readers may have more difficulty perceiving stimuli delivered to their finger tips than do normal readers. However, as is noted in Table 8, significant differences are only indicated for the left hand measure and not for right hand or the right minus left hand measures. Although Reed's (1967) design was different from that of the present work, the results of the present study appear to differ from those of Reed's (1967) with older children. The finding that RR subjects exhibited left hand finger agnosia rather than right hand finger agnosia is consistent with Doehring's (1968) results. However, Reed (1967) did not find any relationship between right handed finger agnosia or left handed finger agnosia and reading abilities in a population of children aged six (C.A. 6). In a later study, Reed (1968) found that good readers performed significantly better than did poor readers on tests of finger agnosia. This difference was only significant for younger children (C.A. 6) and not for populations of older children (C.A. 10). In addition, Reed (1968) made no reference to right versus left hand performance in his study. In summary, it would appear that retarded readers probably have more difficulty with tasks involving finger localization than do

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normal readers. The results of Doehring's (1968) and the present investigation would indicate that the deficit is more marked with the left hand.

The remaining assessment procedures for tactile-somesthetic deficits did not yield significant differences between NR and RR groups. On tests for the discrimination and identification of X's and O's written on the finger tips of the right and left hands (FTWR, Table 8) and the discrimination of familiar objects placed in the right and left hands (TACF) there were no differences in performance between NR and RR groups. The latter test is an assessment procedure for astereognosis. Doehring (1968) and Reed (1968) have both found similar results for the test of Finger Tip Writing. However, Doehring (1968) found that retarded readers performed significantly better than normal readers on performance measures of astereognosis with the right and left hand.

Doehring (1968) hypothesized that retarded readers may have superior tactile-kinesthetic skills as compared to normal readers because they are at a developmental stage behind normal readers in which great attention is given to tactile skills. The results of the present study did not indicate significant differences between groups in favour of retarded readers on the above mentioned test of tactile skills and the results do not support the interpretation of reading retardation as a developmental lage in reading ability characterized by relatively superior tactile-kinesthetic abilities.

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On a test for gross visual field defects under conditions of unilateral and bilateral simultaneous stimulation within the right and left visual fields, the performance of retarded readers did not significantly differ from that of normal readers. Very few subjects in either the NR or RR group displayed difficulties with this task. Retarded readers with normal WISC FSIQs and attending school probably do not suffer from visual field defects noticeable with this assessment procedure.

As noted in Table 9, the Progressive Figures, Matching Figures, and Matching V's Test did not describe significant differences between NR and RR groups. In general, these tests require subjects to discriminate various printed stimuli which vary in content, shape, and size in order to make a simple motor response indicating their discriminations. One task of this nature, Matching Pictures, did indicate that normal readers are superior to retarded readers, but the significance of subject performance on the matching tasks is uncertain. Although these tasks are included in the Indiana-Reitan Battery of neuropsychological tests for experimental reasons, they have not been shown to be effective discriminators of brain-damaged and normal populations. Doehring (1968) did not employ these tasks in his study and there are no references to these items in other studies related to reading retardation.

The Target Test of visual-spatial organization and memory did discriminate NR and RR groups in favour of normal readers. This finding suggests that retarded readers suffer from

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visual-spatial organization and visual memory deficits. The results also suggest that retarded readers suffer from deficits in visual-spatial organization and memory even when the visual content is not of a verbal nature.

It is interesting to note that tasks which are similar to the Constructional Dyspraxia items on the Halstead-Wepman Aphasia Screening Test did not yield significant between-group differences. The deficit in graphic copying skills apparent in normal readers for the dyspraxia items of the HWAT was not apparent in the copying skills related to the Star and concentric Squares subtests.

The results (Table 9) indicate that NR group performed significantly better than did the RR group on the Reversals Test. Primarily, this test taps visual discrimination and organization skills. It was included in the assessment battery because Doehring (1968) found highly significant differences between retarded and normal readers on the Reversals Test. These findings suggest that visual discrimination and organization deficits are apparent in the ability structure of both older and younger retarded readers. Table 9 also indicates significant differences for the Colour Forms test which is said to tap both the ability to follow serial instructions as a problem in visual discrimination unfolds and the subject's ability to shift from one visual clue to another. Doehring (1968) found no significant differences between NR and RR groups on this measure, whereas in the present study normal readers performed better than did retarded readers.

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Reed (1968) also found significant differences on this test in favour of good readers for both older and younger populations.

In summary, the superior performance of normal readers versus retarded readers on tasks of nonverbal visual-spatial organization and memory, visual discrimination and organization, and the discrimination and use of visual cues indicates that there is a notable visual-spatial and visual-perceptual component contributing to the deficit structure of retarded readers. However, this deficit is not apparent in all measures of visual-perceptual abilities, especially those measures related to the simple matching of visual stimuli.

On tests of complex conceptual learning, the Category Test (CA 5-8) and the Cognitive Perceptual Task, the performance of retarded readers did not differ significantly from that of normal readers. With respect to the Category Test, the results of the present study are in accord with the findings of Reed (1968). However, Doehring (1968) found that retarded readers had significantly more difficulty than did normal readers on this task. In addition, Reitan (1966) notes that, in adult populations, the Category Test is sensitive to cerebral dysfunction regardless of locus and, as such, the test is an excellent measure of cerebral integrity. It was unusual to find no between-group differences in the present study, especially when retarded readers performed poorly on a large number of other neuropsychological tests. These inconsistencies may be explained by the fact that the stimulus figures in the Category

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Test for children in the age range five to eight years (CA 5-8) are different from the stimulus figures in the older children's test employed by Doehring (1968) and Reitan (1966). Perhaps the Category Test (CA 5-8) is not as sensitive to cerebral dysfunction in young children as the form of the Category Test (CA 9-15) is to cerebral dysfunction in older populations. An alternative explanation is that retarded readers do not differ from normal readers on performance measures of the Category Test because retarded readers are not suffering from a general impairment in their adaptive abilities consequent to cerebral dysfunction.

Assessment procedures for gross auditory disturbances did not differentiate the NR and RR groups. There were a high number of perfect performances in both the NR and RR groups and it would appear that this test of auditory discrimination is similar to tests for gross visual and tactile deficits with respect to the ease with which subjects obtained perfect scores.

However, on three tests of auditory-verbal discrimination, Speech Perception, Auditory Closure, and Sentence Memory, the NR group performed much better than did the RR group. These findings, which are in accord with Doehring's (1968) assessment with related tests, suggest that retarded readers have deficits related to the perception of auditory-verbal stimuli in addition to those associated with visual-verbal materials.

The NR group performed significantly better than did the RR group on the Seashore Rhythm Test in both Deohring's (1968) study and in the present investigation. This test is essentially

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an assessment procedure for auditory discrimination and memory of nonverbal stimuli. These results expand the constellation of deficits associated with reading difficulties to include impaired discrimination and memory of nonverbal auditory stimuli.

Two additional measures of speech and language skills, the Verbal Fluency and Rhymes test, described superior performance of normal readers as compared to retarded readers. The two tasks involve expressive vocabulary skills. The Rhymes test was included in the present study because Doehring (1968) found that it significantly differentiated normal and retarded readers. The results of the Rhymes and Verbal Fluency Tests, in conjunction with the results of the WISC Verbal subtests, the WRAT, and the Aphasia Screening test, indicate that young retarded readers have difficulty in a wide variety of verbal and language areas.

On the Tactual Performance Test no significant performance differences were found between the NR and RR groups when the preferred and nonpreferred hands were used alone. However, normal readers performed significantly better than did retarded readers when required to coordinate both hands simultaneously on this task. These results are somewhat consistent with Reed's (1968) findings that, in populations of young and older children, normal readers were superior to poor readers when required to employ the nonpreferred hand and both hands simultaneously on the Tactual Performance Test. In general, the results of these two studies suggest that retarded readers suffer at least

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moderate deficits in complex somesthetic skills. The results of the present study would indicate that retarded readers have difficulty coordinating right and left hand performance on this test.

However, Doehring (1968) found that older retarded readers performed significantly better than did older normal readers on perferred hand and simultaneous right and left hand measures of performance on this test. Doehring (1968) suggested that these findings support the hypothesis that retarded readers suffer from a developmental lag in visual-auditory skills with a consequent dominance of tactile or somesthetic skills. The findings of the present work suggest that retarded readers exhibit poorer skills than do normal readers on tactile-kinesthetic tasks. In explanation, it is possible that the presence of superior somesthetic skills in retarded readers depends on practice and that it is not apparent until a child becomes older, perhaps aged 10. Up until this age it is possible that retarded readers suffer from somesthetic deficits as well as visual and auditory deficits. Although this explanation is consistent with the differing results of Doehring's (1968) work and the present study, this explanation is not consistent with Reed's (1968) suggestion that the neuropsychological deficits of retarded readers relative to other children remain with them as they grow older. An alternative explanation for the discrepancies between the two studies may be related to Doehring's (1968) procedure of matching subjects for WB-1 PIQ. It is possible that this matching procedure affected

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performance measure of somesthetic skills in his population of older retarded readers.

On the Memory subtest of the TPT, retarded readers also displayed significantly more difficulty than did normal readers. The Location subtest did not yield significant differences. The Memory section required subjects to draw the shape of the test items of the TPT from memory after having acquaintance with the items only through the tactile mode. Doehring's (1968) results did not describe significant differences between NR and RR groups. The results of the present study suggest that retarded readers have difficulty in interpreting the shapes of objects by touch, remembering the shapes, and graphically reproducing them.

Measures of relatively pure motor skills related to strength of grip and motor steadiness with the preferred and nonpreferred hand did not significantly differentiate the NR and RR groups in the present study. With respect to measures of motor strength Doehring (1968) found that normal readers were significantly stronger with both the right and the left hand than were retarded readers. The findings of the present study suggest that young retarded readers do not suffer neuropsychological deficits related to simple motor strength or motor steadiness.

The only significant results noted in relatively simple motor skills of finger or foot tapping with the preferred and nonpreferred foot and hand related to motor speed with the nonpreferred hand and summary measures of preferred and nonpreferred hand function. Normal readers were found to be superior to retarded readers on these measures. Neither Doehring (1968) nor Reed (1968)

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found between group differences on the Finger Tapping test. The present work suggests that young retarded readers suffer from some motor speed deficits with the nonpreferred hand.

On a simple test of motor speed with a language output, name writing, the performance of retarded and normal readers did not differ with preferred or nonpreferred hand performance. Similar findings are reported by Doehring (1968). When the data was regrouped to consider right, left, and right versus left hand performance retarded readers performed significantly better than nonretarded readers when required to employ their left hand. This finding is not consistent with other measures of motor performance which did not indicate that retarded readers perform better than normal readers. Consequently, it would be inappropriate to conclude that retarded readers have superior motor skills related to writing on the basis of the limited data available in the present study.

Part of the Motor Steadiness Battery employed in the present study included assessment procedures for complex visual-motor coordination and steadiness (Maze Test) and fine tactile-motor coordination (Pegboard Test). In general, normal readers performed significantly better than retarded readers when required to use their preferred and nonpreferred hand on the Maze and Pegboard Tests.

The results of the present study suggest that retarded readers display difficulties in motor skills when the motor task requires the integration of sensory-perceptual skills related

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to visual, tactile and/or auditory discrimination. Tests like the Bender-Gestalt and Frostig which require visual-perception in conjunction with motor skills have been shown to discriminate retarded and nonretarded reading populations (Connor, 1966; Doehring, 1968; Ferguson, 1967; Santor, 1967; Smith & Keogh, 1962; and Trussell, 1967). It is less likely that retarded readers suffer from pure motor deficits related to motor speed and motor strength.

The results for the Harris Test of Lateral Dominance indicate that normal and retarded readers do not differ with respect to right or left hand, foot, or eye preference, or with respect to mixed hand, foot, or eye preference. These findings are not consistent with Orton's (1928) formulations and Harris' (1967) work but they are consistent with the recent works of Belmont and Birch (1965), Cofeman and Deutsch (1964), Doehring (1968), and Silver and Hagan (1960). It does not appear that retarded readers display either mixed hand preference or a tendency to be left handed.

On the ABC Test of Ocular Dominance retarded readers tended to prefer their left eye more frequently than did normal readers. In addition, normal readers tended to be more stable in their choice of either their right or left eye for simple visual tasks. The significance of these findings is somewhat uncertain and future studies appear warranted. It is possible that retarded readers display deficits in visual-motor skills partly because they alternate right and left eye preference during visual tasks of this nature.

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Benton (1959) maintains that retarded readers suffer from confused directionality which seriously impedes their ability to sequence visual attention when reading. Belmont and Birch (1966) found that summary measures of right-left awareness on Piaget's test (Appendix A) did not significantly differentiate older retarded and nonretarded readers. However, these investigators found that retarded readers suffer from a right-left confusion on items related to their own body. The results of the present work suggest that young retarded readers are more severely impaired in right-left discrimination skills than was indicated by the work of Belmont and Birch (1966) and that, for the most part, this deficit is present when retarded readers are required to make right-left discriminations regardless of the reference point.

The above-mentioned results were somewhat unexpected. It is surprising to find children in Grade 1 and 2 classrooms with such marked deficits in what is usually an overlearned skill, differentiating right from left. The results confirm Benton's (1959) hypothesis concerning the involvement of directional confusion in reading retardation. The question arises as to whether or not this deficit in right-left awareness subsumes other deficits noted in this study. It is possible that retarded readers have difficulty with a large number of visual-spatial tasks when they are required to manipulate right-left concepts and two-dimensionality. However, the presence of this deficit does not explain the poor performance of retarded readers on tasks in which the

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visual input is minimal or very simple. It may be that right-left awareness deficits experienced by retarded readers represent one of a large constellation of deficits experienced by retarded readers on tasks related to visual-spatial organization and memory.

For the most part, the results of Doehring's Test of Perceptual Speed (Table 16) indicated that retarded readers experience marked difficulties in their ability to discriminate visual stimuli. This difficulty also appears to exist regardless of whether the content of the stimulus is of a verbal or geometric nature. Retarded readers displayed difficulties in appreciating visual items whether the items required reading skills or the differentiation of simple geometric forms. These findings parallel Doehring's (1968) results with older children and indicate that retarded readers display a marked deficit in abilities related to visual-perceptual discrimination regardless of the content of the visual stimuli.

When the performance measures taken in the present study are rank-ordered according to the magnitude of the t ratios, it appears that retarded readers have the most difficulty with tasks which tap general language abilities. To a lesser degree, retarded readers seem to display deficits in the visual perception of nonverbal stimuli and in complex motor tasks. In addition, an inspection of the comparison of Doehring's (1968) results with those of the present work suggests that the ability structure of young retarded readers is similar to the ability structure of older retarded readers. However, this inference would seem to

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require further investigation.

In the present study, only two measures of performance, Constructional Dyspraxia and Name Writing, Left Hand, yielded significant between-group differences in favour of the RR group. This finding is noteworthy in view of the fact that, with the large number of measures employed in the present study, a larger number of significant differences in favour of the RR group would have been expected by chance alone. It should also be noted that these results were obtained despite the fact that the two groups did not represent extreme ends of the continuum with respect to reading skills. It would appear that normal readers performed rather consistently at a level equal to or better than that of retarded readers.

The results of the present investigation provide considerable support for Hypothesis I which states that reading retardation is a complex disability related to a large number of motor, perceptual and language abilities and not a specific deficit. Not only did retarded readers display deficits in those areas directly related to reading, but also in abilities related to general verbal skills, auditory-verbal discrimination, visual-motor, and visual-perceptual skills. In addition, retarded readers displayed deficits in areas of neuropsychological functioning which appear to be completely unrelated to reading (e.g., on tests of tactile-motor coordination and motor steadiness). In many instances, retarded readers had more difficulty than normal readers regardless of whether the visual, auditory, and somesthetic input was of a

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verbal or nonverbal nature. Although retarded readers compared to normal readers tended to do more poorly on verbal related materials than nonverbal related items, there was compelling evidence that retarded readers also display deficits in nonverbal visual-perceptual and visual-motor skills.

Critchley (1964) has maintained that the etiology of reading retardation may be related to a developmental lag which affects only reading. The evidence provided in the present investigation indicates that reading retardation, as it appears in young children attending school with normal intelligence, is not a "specific disability". Rather, poor reading skills appear to be part of a large constellation of deficits, some of which have no obvious association with the skills necessary for reading. Critchley's (1964) formulation of "developmental dyslexia" as a deficit limited only to reading finds very little support in the present work.

Critchley (1964) has also suggested that children retarded in reading do not display neurological signs. Cohn (1961) and Doehring (1968) have reported neurological signs in populations of children retarded in reading. In addition, Ayes and Torres (1966), Benton and Birch (1963), and Muehl, Knott and Benton (1965) have found EEG abnormalities in children with reading deficits. In the present study normal readers performed significantly better than retarded readers on a broad number of neuropsychological tests. Retarded readers appeared to suffer from a notable impairment in their adaptive abilities. In this sense

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the results support Hypothesis II which states that children with reading retardation display significantly more neuropsychological deficits than do normal readers.

As noted previously, the present study also attempted to discover if young retarded readers display unilateral right-handed deficits in sensory and motor skills which are similar to those deficits present in adult populations with known left cerebral encephalopathy. Hypothesis III stated that the profile of sensory and motor deficits of retarded readers would be similar to the profile of deficits in adult populations with known left cerebral dysfunction. The results did not support this hypothesis. No differences were noted between groups on measures of comparative right-left function on tests of tactile sensitivity. The only performance measure of motor skills indicative of a right-handed deficit was related to simple motor steadiness, and this measure represented only one significant difference out of seven measures of comparative motor performance with the right and left hands. It should be noted that Hypothesis III was based on information derived from studies with adult populations with known cerebral dysfunction. It would appear that young retarded readers do not display unilateral deficits similar to those found in adult populations with acquired dyslexia. In addition, it is possible that the ability structure of young children is not comparable to that of adults, and that the profile of abilities displayed by young children with known localized cerebral injury differs extensively from the ability profile of adults with comparable damage.

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The results of the extensive assessment procedure employed in the present study for verbal, visual, and auditory skills explains to some degree why there is such marked confusion surrounding the deficit structure of poor readers in the literature. Investigators who wish to illustrate the contribution of a specific ability to retarded reading will probably find significant differences between groups of retarded and nonretarded readers on any one of a multitude of measures. However, a generalization based on results of this nature specific to one ability does not appear warranted. The present study indicates that retarded readers suffer from a broad spectrum of deficits and it seems somewhat arbitrary to claim that one deficit rather than another is the basis for reading difficulties. In addition, it is evident that any existing single theory of reading retardation (e.g., Gestalt, Visual-motor, Brain Damage) is not consistent with all the findings of the present study. What is required are more longitudinal studies examining the complex ability structure of young children retarded in reading and further studies concerned with the integration of these abilities and their relationship to such deficits as reading during the course of development.

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Chapter V

SUMMARY AND CONCLUSIONS

It has been estimated that somewhere between five percent to fifteen percent of children attending elementary school have a reading deficit which seriously impedes their academic progress. Difficulties in reading have been related to emotional disorder, developmental lag, disturbance in perceptual gestalt, genetic predisposition, disturbance in various sensory functions, and cerebral dysfunction. The present investigation was concerned with the neuropsychological abilities of young children with reading retardation. Previous investigators of the ability structure of retarded readers have frequently approached the problem with a specific theoretical bias and have restricted the assessment of children's behaviour to theory-specific abilities. A neuropsychological test battery (i.e. the Indiana-Reitan Battery) was employed in the present study because it taps a broad spectrum of language, motor, intellectual, and perceptual skills.

Doehring (1968) and Reed (1968) employed a neuropsychological test battery similar to the battery used in the present study to assess the ability structure of retarded and nonretarded readers. However, Reed (1968) did not control for intelligence and Doehring (1968) studied a retarded reading population of children in the

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age range of 10 to 14 who were referred to a clinic for remedial reading. In addition, Doehring (1968) controlled for age with statistical covariance techniques. The present study investigated the ability structure of younger children in the age range of seven years, two months to eight years, four months who, although they were retarded in reading, were of roughly normal intelligence and were not referred to a clinic for remedial procedures. The present investigation also employed a matched-pairs design to control for age. The general hypotheses under investigation were as follows:

Hypothesis I - Reading retardation is a complex disability related to a large number of motor, perceptual, and language abilities, and not a specific deficit.

Hypothesis II - Children with reading retardation display significantly more neuropsychological deficits than do normal readers.

Hypothesis III - The profile of sensory and motor deficits of retarded readers is similar to the profile of deficits displayed by adult populations with known left cerebral encephalopathy.

The teaching staff of seven schools which served middle income families were requested to select Grade 1 and 2 students having the most difficulty with academic subjects and those children rated as average with respect to school performance. 240 Grade 1 and Grade 2 subjects in these schools received three reading subtests of the Metropolitan Achievement Test (MAT). Retarded Readers (RR) were selected if teachers rated them as poor students, if they obtained a percentile score of 20 or less on the Reading

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subtest of the MAT, if they obtained a percentile score of 35 or less on one of the other two administered subtests of the MAT, and if they obtained a WISC IQ in roughly the normal range, 90 - 117. Normal Readers (NR) were selected if they were rated by the teaching staff as being at least average with respect to school performance, if they obtained a percentile score of 50 or more on the Reading subtest of the MAT, if they obtained a percentile score of 50 or more on one of the other administered subtests of the MAT, and if they obtained a WISC IQ between 90 and 117. All children with a medical history of known neurological impairment, serious limb injury, psychiatric illness, marked structural, visual or auditory defects were excluded from this study. In order to control for age, each student in the NR group was match-paired within 33 days of age with a subject in the RR group. A total of 66 subjects (33 normal readers and 33 retarded readers) were employed in this study. These subjects were assessed with the Indiana-Reitan Neuropsychology Battery and supplementary tests reported by Doehring (1968). In all, over 200 measures of performance were obtained for each subject.

The results of the present work supported Hypothesis I and II. Retarded readers, as compared to normal readers, displayed a large number of neuropsychological deficits across a broad spectrum of abilities. However, the results did not support Hypothesis III. Retarded readers displayed very few unilateral deficits which are comparable to those deficits noted in adult populations with known left cerebral encephalopathy.

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In addition to the above mentioned results which were related to the major hypotheses, the present investigation also yielded a number of additional findings which are relevant to future research. In the present study with young children, normal readers, as compared to retarded readers, obtained significantly higher WISC VIQs, PIQs and FSIQs. Contrary to some findings reported in the literature, measures of VIQ were not a more powerful discriminator of RR and NR groups than was the PIQ. There were no significant differences between groups on measures of VIQ-PIQ discrepancies. However, the WISC subtest scatter of the NR group was significantly smaller than that in the RR group. Other measures indicated that there is a strong nonverbal visual-perceptual component present in the deficit structure of retarded readers. Despite the finding that retarded readers did not differ from normal readers with respect to measures of hand and foot preference, retarded readers displayed marked deficits in right-left awareness. Measures of relatively pure motor skills did not consistently differentiate NR and RR groups. However, when retarded readers were required to integrate visual and tactile perception with motor skills, they did not perform as well as did normal readers. The results of the present study indicated that retarded readers exhibit a large number of deficits in many abilities other than reading.

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APPENDIX A

DESCRIPTION OF TESTS[1]

METROPOLITAN ACHIEVEMENT TEST PRIMARY - II (MAT)

WORD KNOWLEDGE. The Word Knowledge subtest of the MAT is a 35-item test that measures the child's sight vocabulary, or word-recognition ability. This ability is measured by means of picture vocabulary items in which the child demonstrates his recognition and understanding of the stimulus words by correctly associating each word with a picture.

WORD DISCRIMINATION. The Word Discrimination subtest of the MAT is a 35-item test that measures the child's ability to select an orally presented word from among a group of words of similar configuration. The child must be able to associate the sound of the word as read by the examiner with its printed form, and to distinguish the printed word from other words similar to it with respect to beginning, ending, or middle sounds. Since each item is presented orally by the examiner, children proceed through the test at a uniform rate, with every child having ample time to mark every item.

READING. The Reading subtest of the MAT consists of two parts. A 13-item section measures the pupil's ability to comprehend sentences. The child demonstrates his ability to read and to understand sentences by choosing from among three sentences the one that correctly describes a picture. The second section of the Reading Test is a 33-item measure of ability to comprehend materials of paragraph length. Each reading selection is followed by several questions designed to measure various aspects of reading comprehension--obtaining specific information, making inferences, etc.

WECHSLER INTELLIGENCE SCALE FOR CHILDREN (WISC)

FULL SCALE IQ. Composite score derived from total weighted subtest scores. Indicative of overall intellectual functioning.

VERBAL IQ. Composite score derived from total weighted scores of the 6 Verbal subtests (excluding the Vocabulary test). Indicative of overall verbal functioning.

PERFORMANCE IQ. Composite score derived from total weighted scores of the 5 Performance subtests. Indicative of overall nonverbal functioning.

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1. Most of the test descriptions in Appendix A are identical to those found in the works of Doehring (1968) and/or Knights (1966).

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VERBAL WEIGHTED SCORE. Total weighted scores of the 6 Verbal subtests before conversion to Verbal IQ.

PERFORMANCE WEIGHTED SCORE. Total weighted scores of the 5 performance subtests before conversion to Performance IQ.

Verbal Subtests

INFORMATION. 30 questions. Assesses elementary factual knowledge of history, geography, current events, literature, and general science. Score: number of items correct. Task Requirement: retrieval of acquired verbal information. Stimulus: spoken question of fact. Response: spoken answer.

COMPREHENSION. 14 questions. Assesses the ability to evaluate certain situations. Score: number of items correct. Task Requirement: evaluation of verbally formulated problem situations. Stimulus: spoken question of opinion. Response: spoken answer.

ARITHMETICAL REASONING. 10 arithmetic problems of increasing difficulty. Score: number of problems correctly solved, with time credit. Task Requirement: arithmetic reasoning. Stimulus: spoken (first 8 items) or printed (last 2 items) question. Response: spoken answer.

SIMILARITIES. 16 pairs of words. The most essential semantically common characteristic of word pairs must be stated. Score: number correct. Task Requirement: verbal abstraction. Stimulus: spoken question. Response: spoken answer.

VOCABULARY. (not included in Verbal IQ or Verbal Weighted Score) 40 words. Spoken definition of words. Score: number of words correct. Task Requirement: verbal definition. Stimulus: spoken word. Response: spoken definition.

MEMORY SPAN FOR DIGITS. Repetition in forward order of three-to nine-digit numbers and repetition in reversed order of two-to eight-digit numbers. Score: simple total of forward and reversed digit span. Task Requirement: short-term memory for digits. Stimulus: spoken numbers. Response: spoken numbers.

Performance Subtests

PICTURE COMPLETION. 20 pictures of familiar objects, each with a part missing. The missing part is identified in simple line drawings. Score: number of missing parts correctly identified. Task Requirement: location of missing part on the basis of memory of the whole object. Stimulus: picture. Response: spoken name of missing part.

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PICTURE ARRANGEMENT. 11 series of picture cards. Pictures are sequentially arranged to form story. Score: total credits for speed and accuracy of arrangement. Task Requirement: manipulation of the order of picture cards to form the most probable sequence of events. Stimulus: pictures. Response: simple motor manipulation.

BLOCK DESIGN. 10 designs. Arrangement of colored blocks to form designs which match those on printed cards. Score: total score for speed and accuracy of block placement. Task Requirement: arrangement of blocks to match a printed design. Stimulus: printed geometric design. Response: manipulation and arrangement of blocks.

OBJECT ASSEMBLY. 4 formboards. Parts of each formboard are to be arranged to form a picture. Score: total score for speed and accuracy of assembly. Task Requirement: spatial arrangement of parts to form a meaningful whole. Stimulus: disarranged parts of picture. Response: complex manipulation and arrangement of parts.

DIGIT SYMBOL. 93 digits, preceded by a code which relates digits to symbols. Symbols are to be written below digits as rapidly as possible. Score: number of symbols correctly written within a fixed time. Task Requirement: association of digits and symbols by direct visual identification or by short-term memorization. Stimulus: printed digits and symbols. Response: rapid co-ordination of visual identification with a complex writing response.

PEABODY PICTURE VOCABULARY TEST (PPVT)

PICTURE VOCABULARY, ORAL RAW SCORE. 150 sets of 4 line drawings, with which 150 words of increasing difficulty are to be associated. The words are those of Form A of the Peabody Vocabulary Test. Score: total correct picture-word associations. Task Requirement: selection of picture most appropriately related to the spoken word. Stimulus: 4 visual pictures, 1 spoken word. Response: simple pointing response.

PICTURE VOCABULARY, ORAL IQ. Transformation of oral raw score to an IQ score on the basis of test norms (Dunn, 1959).

WIDE RANGE ACHIEVEMENT TEST (WRAT)

READING. Standardized test of oral word reading achievement. Score: standard score based on total number of words correctly read aloud. Task Requirement: association of printed letters with spoken word. Stimulus: printed word. Response: spoken word.

SPELLING. Standardized test of written spelling achievement. Score: standard score based on total number of words correctly spelled. Task Requirement: written production of spoken word. Stimulus: spoken word. Response: written word.

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ARITHMETIC. Standardized test of written arithmetic achievement. Score: standard score based on total number of correct solutions to progressively more difficult arithmetic problems. Task Requirement: solution of arithmetic problems. Stimulus: printed arithmetic problems. Response: written answers.

INDIANA-KEITAN NEUROPSYCHOLOGICAL BATTERY (C.A. 5-8)

CATEGORY TEST. 80 sets of visual choice stimuli, mostly coloured geometric forms. On successive series of trials the abstraction of principles of colour, numerosity, oddity, spatial position, and relative extent is required for correct responding. Score: total errors. Task Requirement: concept attainment by abstraction of common attributes of visual figures. Response: choice among 4 response levers.

HALSTEAD-WEPMAN APHASIA SCREENING TEST (HWAT)

NAMING (DYSNOMIA). Four items which require the subject to name familiar objects. Score: number of errors.

WRITING (DYSGRAPHIA). Two items. The child is required to write a word or sentence which is presented to him orally. Score: number of errors.

READING (DYSLEXIA). Three items. The subject is required to read two words and one sentence. Score: number of errors.

REPRODUCTION OF GEOMETRIC FORMS (CONSTRUCTIONAL DYSPRAXIA). Three items. Child is required to copy a square, a triangle, and a greek cross. Score: number of errors.

ARITHMETIC (DYSCALCULIA). Four arithmetic problems which involve addition, subtraction, and multiplication. Score: number of errors.

BODY ORIENTATION. Four items which require the child to point to various parts of his body. Score: number of errors.

RIGHT-LEFT DISCRIMINATION. Two items. The child is required to discriminate his left from his right hand. Score: number of errors.

TESTS OF SENSORY-PERCEPTUAL DISTURBANCES

TACTILE SENSITIVITY, RIGHT SIDE. The blindfolded S is stimulated unilaterally and simultaneously on the left and right sides of the body by light touch. Various combinations of face and hand stimulation are presented. Incorrect localization or failure to perceive a stimulus is counted as an error. Score: number of errors for stimuli presented to the right side of the body. Task Requirement: correct identification and location of tactile stimuli. Stimulus: simultaneous unilateral and bilateral touch. Response: simple pointing response or simple verbal report of the body areas stimulated.

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TACTILE SENSITIVITY, LEFT SIDE. This measure is derived for the left side of the body from the procedure described above. Score: total errors for stimuli presented to the left side.

VISUAL PERCEPTION, RIGHT VISUAL FIELD. Right and left visual fields are stimulated unilaterally and simultaneously by a simple confrontation procedure. Simultaneous stimulation trials are interspersed among unilateral stimulation trials. Score: number of trials on which a simultaneously presented stimulus to the right visual field is not perceived. Task Requirement: correct perception of bilateral simultaneous visual stimuli. Stimulus: bilateral simultaneous stimulation of the upper, middle, and lower portions of the visual fields. Response: simple verbal naming of the visual field or fields stimulated.

VISUAL PERCEPTION, LEFT VISUAL FIELD. A measure of left visual suppression derived from the procedure described above. Score: total number of trials on which S fails to perceive the stimuli presented to the left visual field during bilateral simultaneous stimulation.

FINGER AGNOSIA, RIGHT HAND. The blindfolded S is required to identify the finger of his right hand that has been touched, with each of the 5 fingers stimulated 4 times in unsystematic order. Score: number of trials on which a finger is incorrectly identified. Task Requirement: correct localization by a simple verbal designation of the finger stimulated. Stimulus: light tactile stimulation of the dorsal aspect of single fingers of the right hand. Response: simple verbal statement of the number or the name of the finger stimulated.

FINGER AGNOSIA, LEFT HAND. Same as above except that the left hand is stimulated.

FINGER TIP NUMBER WRITING, RIGHT HAND. The examiner writes x's and o's on the finger tips of the blindfolded subject with a pencil, and subject is required to identify each symbol. Score: total incorrect identification in 20 trials (4 trials with each finger). Task Requirement: recognition of traced symbol. Stimulus: tactile-tracing of symbol on the fingertip. Response: spoken symbol, x or o.

FINGER TIP NUMBER WRITING, LEFT HAND. Same as above except that left hand is stimulated.

TACTILE FORM RECOGNITION (ASTEREOGNOSIS), RIGHT HAND. The blindfolded subject is required to identify familiar forms placed in his hand. Score: total incorrect identification in 6 trials. Task Requirement: recognition of form by its tactile properties only. Response: spoken name of object.

TACTILE FORM RECOGNITION (ASTEREOGNOSIS), LEFT HAND. Same as above except that the left hand is stimulated.

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PROGRESSIVE FIGURES TEST. This test consists of several figures of different shapes. The subject is required to draw a line from one figure to another. Inside each figure is a smaller shape which gives the subject the clue for drawing the line. Score: the time in seconds required for completion and the number of errors.

MATCHING PICTURES. In this test the subject is asked to match pictures at the bottom of a page with pictures at the top of the page which are in a different order. In the first item the pictures are the same but in subsequent items they become more abstractly related. Score: number correct.

INDIVIDUAL PERFORMANCE TEST, MATCHING FIGURES AND MATCHING "V'S". The subject is asked to match figures printed on little blocks with the same figures printed on a single card. These figures become progressively more complex along the card. The little blocks are presented to each subject in a standardized manner. Score: the time in seconds required to complete the task and number of errors.

INDIVIDUAL PERFORMANCE TEST, CONCENTRIC SQUARES AND STAR. The subject is required to copy the figure presented to him. The examiner points out specifically how the figure is made up, and the score is the time in seconds required to complete the drawing and the number of errors.

TARGET TEST. The Target Test is a test of visual organization and memory. The examiner taps out a pattern on a sheet with nine black dots on it. The subject has before him a paper with 20 boxes drawn on it and each box is a reproduction of the configuration of the nine dots. After the examiner has tapped out the pattern, he waits 3 seconds and then says "Go" and the subject must draw the pattern in the correct box on his paper. The test is discontinued after four consecutive mistakes and the score is the number of items correctly drawn.

COLOR FORM TEST. Subject is presented with groups of 3 visual stimuli which could differ from each other in color, shape, and size and is required to point to the figure that he judges to be most different among the 3 forms. There is no "correct" choice, since at least 2 of the 3 figures differ from the other figures by at least 2 attributes. Score: percent of trials out of 20 of which S's choice is based upon the attribute of shape. Task Requirement: an "oddity" problem, requiring a judgment of difference. Stimulus: group of 3 visual figures systematically differing in color, size, and shape. Response: simple pointing response.

RHYTHM TEST. 30 pairs of rhythmically patterned sounds. A judgment of "Same" or "Different" is required for each pair. Score: number of errors. Task Requirement: discrimination of rhythmic similarity in pairs of auditory sound patterns. Stimulus: pairs of patterned sounds. Response: written S or D to denote judgment of same or different.

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SPEECH PERCEPTION TEST. 30 tape-recorded monosyllabic nonsense words. Each word has a middle "ee" sound, and must be identified by means of a choice among 3 printed syllables. Score: number correct. Task Requirement: match the spoken syllable with a printed syllable. Stimulus: spoken syllable and 3 printed syllables, one of which matches the spoken syllable. Response: underline printed syllable chosen.

TACTUAL PERFORMANCE TEST (TPT). This test requires placement of blocks in a Seguin-Goddard formboard while blindfolded. A six-block formboard is used for children 5 to 8. The task is performed first with the preferred hand, next with the nonpreferred hand, and then with both hands. Finally, the subject draws a picture of the board, which he has never seen.

TPT, PREFERRED HAND. Score: number of seconds to correctly place all blocks. Task Requirement: place blocks in correct spaces on formboard. Stimulus: somesthetic perception of the formboard and forms. Response: complex somesthetic-motor coordination with preferred hand.

TPT, NONPREFERRED HAND. Same as above except that nonpreferred hand is used.

TPT, BOTH HANDS. Same as above except that both hands are used.

TPT, MEMORY. Score: number of forms correctly drawn from memory. Task Requirement: expression of somesthetic memory of drawing. Stimulus: instruction to draw formboard from memory. Response: drawing of formboard.

TPT, LOCATION. Score: number of forms in drawing correctly located with respect to position on formboard. Stimulus, task, and response same as above except that this aspect of the task requires memory of spatial location of forms.

MOTOR STEADINESS BATTERY

MAZE TEST. This is a test which measures gross steadiness. The subject is required to run a stylus along a maze with the blind alleys blocked. Each time he touches the sides of the maze a number is recorded electrically, as is the length of time the stylus rests against the sides. The subject performs this task first with his dominant hand and then with his non-dominant hand. Two trials with each hand are administered.

MOTOR STEADINESS. This is a measure of fine motor steadiness. The subject must fit the stylus into a series of holes which get progressively smaller. Each time the stylus touches the side of a hole a number is recorded and also the length of time of the touch against the side. This test is done first with the dominant hand and again with the non-dominant hand.

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PURDUE PEGBOARD. This test measures fine motor steadiness. The subject is asked to fit keyhole-shaped metal pegs into 5 rows of matching holes in a board. He does this as quickly as possible, using first his dominant hand and then his non-dominant hand. The time in seconds is recorded for each trial and each time that the subject drops a peg it is counted as an error. Children 8 years and under are given only the first two rows.

HAND PREFERENCE. The subject is required to demonstrate the hand used to throw a ball, hammer a nail, cut with a knife, turn a doorknob, use scissors, use an eraser, and write his name. Score: total number of acts performed with the preferred hand. Task Requirement: carry out the instruction by the use of one hand. Stimulus: verbal instruction, with object to be manipulated. Response: performance of a skilled act with one hand.

EYE PREFERENCE. The subject is given the Miles' ABC Test of Ocular Dominance, in which he must choose one eye or the other to look through a conical aperture to identify a visual stimulus. Score: number of trials out of 10 on which S looks with the eye corresponding to the preferred hand. Task Requirement: identification of picture (the subject is presumed not to realize that only one eye is used for this test). Stimulus: visual line drawing on a card, viewed through aperture. Response: spoken identification of picture.

FOOT PREFERENCE. The subject is asked to demonstrate how he would kick a football and step on a bug. Score: number of trials out of 2 on which subject uses the foot corresponding to the preferred hand. Task Requirement: use of a foot to carry out the verbal instruction. Stimulus: verbal instruction. Response: movement of a single foot.

STRENGTH OF GRIP, PREFERRED HAND. The subject is required to squeeze a hand dynamometer as hard as he can on 3 trials. Score: total pounds displacement of hand dynamometer dial on 3 trials. Task Requirement: exertion of maximum grip on hand dynamometer with preferred hand. Stimulus: spoken instruction. Response: gross flexor action of the preferred hand.

STRENGTH OF GRIP, NONPREFERRED HAND. Same as above except that 2 trials with the nonpreferred hand are given.

WRITING SPEED, PREFERRED HAND. The subject is required to write his name with a pencil as rapidly as possible with his preferred hand. Score: time in seconds to write name. Task Requirement: rapid verbal-motor performance. Stimulus: verbal instruction. Response: rapid, skilled hand coordination.

WRITING SPEED, NONPREFERRED HAND. Same as above except that the name is written with the nonpreferred hand.

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TAPPING SPEED, PREFERRED HAND. The subject taps a mechanical counter as rapidly as possible with the index finger on 4 trials of 10 seconds each. Score: mean taps per 10 seconds. Task Requirement: achievement of maximum speed. Stimulus: instruction to tap as rapidly as possible. Response: rapid repetitive movement.

TAPPING SPEED, NONPREFERRED HAND. Same as above except that the nonpreferred hand is used after completion of trials with the preferred hand.

OTHER TESTS EMPLOYED

DOEHRING'S TESTS OF PERCEPTUAL SPEED.

SINGLE NUMBER. The subject is required to underline the number 4 each time it appears on a printed page containing a random sequence of 360 single numbers. An example of the number to be identified is printed at the top of the page. A short practice test is given. Score: total numbers correctly underlined minus total incorrectly underlined in 60 seconds. Task Requirement: locating and underlining a particular number interspersed among other numbers. Stimulus: random sequences of printed numbers. Response: simple underlining response to identify single numbers.

SINGLE GEOMETRIC FORMS. The subject is required to underline a Greek cross with a pencil each time it appears in random sequence among a series of 235 geometric forms, including squares, stars, circles, triangles, etc. The forms are about ¼" in height. Score: total crosses underlined minus total errors in 30 seconds. Task Requirements: as in above, but for identification of a geometric form.

SINGLE NONSENSE LETTER. A single nonsense letter is interspersed among 10 structurally similar nonsense letters in a random sequence of 126 letters. Score: total correct minus incorrect underlined letters. Task Requirement: as above, but for identification of a nonsense letter.

GESTALT FIGURE. The figure to be identified is a diamond about 1½" in height containing a square which in turn contains a diamond. This figure is interspersed among similar figures in a random sequence of 168 figures. Score: total correct minus incorrect underlined figures in 60 seconds. Task Requirement: as in above, but for identification of a complex figure.

SINGLE LETTER. The letter "s" is interspersed among 360 randomized letters. Score: number underlined minus number of errors in 30 seconds. Task Requirement: as above, but for a single letter.

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SINGLE LETTER IN SYLLABLE CONTEXT. 162 four-letter nonsense syllables are presented, 47 of which contain the letter "e". The subject is required to underline each syllable containing "e". Score: total correct minus incorrect in 45 seconds. Task Requirement: as above, but for a letter in syllable context.

TWO LETTERS. This task is same as above, except that the subject is required to underline 2 letters ("b" and "m") instead of a single letter in the context of other single letters. The time limit is 45 seconds.

SEQUENCE OF GEOMETRIC FORMS. 4 geometric forms (triangle, Greek cross, circle, crescent) are presented in various orders for a total of 65 "syllables." The subject is required to underline only the groups with the order triangle, cross, crescent, and circle. Score: total groups correctly underlined minus errors in 60 seconds. Task Requirement: same as above but for groups of geometric figures.

FOUR LETTER NONSENSE SYLLABLE, UNPRONOUNCEABLE. The subject is required to underline a four-letter nonsense syllable (fsbm) interspersed among 146 four-letter nonsense syllables. All syllables are made up of consonants, which renders them unpronounceable. Score: total correct minus incorrect in 60 seconds. Task Requirement: same as above but for nonsense syllables.

FOUR LETTER NONSENSE SYLLABLE, PRONOUNCEABLE. This task is the same as above except that it involves the identification of a pronounceable nonsense syllable (narp) instead of an unpronounceable nonsense syllable. This syllable is interspersed among other nonsense syllables made up of the letters n, a, r, p. The time limit is 60 seconds.

FOUR LETTER WORD. The word "spot" is interspersed among 146 four-letter syllables made up of the letters s, p, o, t. Score: total correct minus incorrect in 60 seconds. Task Requirement: same as above but for a four-letter word.

UNSPACED FOUR LETTER WORD. The word "spot" is interspersed among the letters s, p, o, t, in various orders, with no syllabic spacing. Score: total correct minus incorrect. Task Requirement: same as above but for an unspaced word.

SINGLE NUMBER. This task is exactly the same as that involved in Single Number above except that the number to be underlined is 5 instead of 4.

THE THURSTONE REVERSALS TEST. The subject is shown 88 pairs of line drawings. About half of the pairs contain identical drawings, while the other half consist of mirror-image figures. The subject is required to designate which pairs are the same and which pairs are different. Score: total errors. Task Requirement: determination of the

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right-left orientation of drawings in relation to each other. Stimulus: pairs of visual figures. Response: simple verbal statement of same or different.

VERBAL AND LANGUAGE TESTS

SPEECH PERCEPTION. This test measures the ability to match a spoken sound to the correct alternative among a group of similar printed sounds. The double vowel "ee" is the middle part of every syllable spoken. An accurate performance is thus determined by discrimination and matching of the consonants at the beginning and end of each syllable. The test is presented on a tape recorder to the subject. Score: number correct.

AUDITORY DISCRIMINATION. This test examines auditory discrimination of similar sounding words. Twenty-five pairs of words are presented on a tape recorder and the subject is required to indicate whether the words are both the same or whether they are different.

AUDITORY CLOSURE. The auditory closure test is a test of sound blending. The purpose is to present progressively longer chains of sound elements which the subject must blend into words. Care was taken to select low level (high familiarity) words that all subjects would know when the component sounds were blended. The test is presented on a tape recorder.

SENTENCE MEMORY. This test consists of a series of 25 sentences, the first being just one word but getting progressively longer. The sentences are presented on a tape recorder and the subject must repeat each sentence after the examiner.

VERBAL FLUENCY. In this test the subject is required to name as many words as he can which start with certain sounds. For each sound there is a 60-second time limit. In the first part the sound "P" is used as in the words play or pig. The sound "C" as in the words cat or cake is used in the second part of the test.

WORD FINDING: RHYMES. The subject is required to emit as many words as he can think of that rhyme with each of 4 simple spoken words (go, tree, car, write.) Score: total words correctly rhymed up to a limit of 5 rhymes per word. Task Requirement: formulation and emission of a series of rhyming words. Stimulus: spoken word, with instruction to emit rhyming words. Response: spoken words.

RIGHT-LEFT AWARENESS ITEMS

Twenty-six items of increasing difficulty designed to assess right-left order and memory with respect to parts of the subject's body and objects arranged before him. Score: number correct.

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Cognitive Percpetual Task (CPT)

CPT. This task requires the subject to pick out the odd figure from among three figures. These figures are simple geometric forms, varying along one or more of the following four attributes: shape, colour, shading and size.

There are 40 items in this test. Score: number correct.

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