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A COMPARISON OF MENTALLY RETARDED CHILDREN TO NORMAL CHILDREN AND OF DISABLED READERS TO NORMAL READERS: AN EVALUATION OF A SIMILAR SEQUENCE HYPOTHESIS AND A DEFICIT HYPOTHESIS.

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A COMPARISON OF MENTALLY RETARDED CHILDREN TO NORMAL CHILDREN AND OF DISABLED READERS TO NORMAL READERS: AN EVALUATION OF A SIMILAR SEQUENCE HYPOTHESIS AND A DEFICIT HYPOTHESIS

by

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ABSTRACT

This study was designed to evaluate a similar sequence and a deficit hypothesis by comparing mentally retarded children to normal children, and disabled readers to normal readers. A total of 167 male children were compared on 16 dependent measures. Thirty-three normal children (age 7-8) were compared to 23 young mentally retarded children (mean age = 10.7), and 15 old mentally retarded children (mean age = 12.5). Twenty-four normal readers (age 7-8) were compared to four groups of disabled readers (ages 9-10, 10-11, 11-12, and 12-13, each group, n = 24).

The normal and mentally retarded children were equated on mental age using the Wechsler Intelligence scales (mean mental age = 8.4). The normal and disabled readers were equated on reading level (Grade Two) using the Wide Range Achievement Test.

Each subject was tested on three categories of dependent measures: Motor tactile-perceptual, Non-verbal cognitive and Verbal cognitive. Multivariate analyses of variance were computed for the normal children versus the mentally retarded children for each of the three categories. Pair-wise mean comparisons were then computed using Scheffé's F test. Also, multivariate analyses of variance were computed in the comparison of the normal readers with the disabled readers, followed by a Neuman-Keuls procedure for pair-wise comparisons.

In the comparison of the normal children to the mentally retarded children, the mean performances of the two groups were, for the most part,

non-significant, thus adding support to the similar sequence hypothesis. The results of the comparison between the normal and disabled readers indicated a performance pattern for the disabled readers that was similar to the chronological age-appropriate norms on Motor, Non-verbal cognitive tests, and the following Verbal tests, the WISC vocabulary subtest and the Peabody Picture Vocabulary subtest. There were no mean performance differences between the normal readers and disabled readers on Tactile Finger Recognition and those verbal tests requiring auditory processing skills, i.e., Auditory Closure, Speech Sounds Perception and Verbal Fluency tests. On the Sentence Memory test, the only performance differences were between the nine-year old and twelve-year old disabled readers. The overall performance of the disabled readers was then contrasted to that of the mentally retarded children on the same dependent measures. The variable performance of the disabled readers, in contrast to the consistently even performance of the mentally retarded children, was interpreted as inconsistent with the similar sequence hypothesis and more in accord with a deficit or difference hypothesis.

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CHAPTER I

INTRODUCTION

During the past decade the area of developmental disabilities (more particularly learning disabilities and mental retardation), has been the focus of considerable theoretical speculation. The theoretical models have predictably taken two rather divergent paths. The first is a model that views developmental disability in the context of neuropsychological deficits, i.e., the structure of the brain is different. The second attempts to explain developmental disability within the context of normal population variation.

Interestingly, both models have served a heuristic purpose for research in the areas of learning disabilities and mental retardation. A unique opportunity exists to compare directly learning disabled (more specifically, reading disabled) and mentally retarded children with normal children because of the availability of an extensive research population. Thus, the present study was designed to compare these two populations in the context of both deficit and similar sequence (i.e., developmental lag) models. The following section describes the basic definitions and assumptions underlying these models.

Similar Sequence Hypothesis. One essential feature of this hypothesis is that all development may be explained within the context of normal population variation. Also inherent in this hypothesis is the notion that cognitive development proceeds along an invariant path regardless of the population under consideration, i.e., development proceeds through the same sequence of cognitive stages. Thus, individuals adopting this model will tend to view both learning disabled and mentally retarded children as developing along the same invariant continuum as do normal children (Fletcher & Satz, 1980b); Zigler, 1969).

In the area of mental retardation, theorists postulate that the difference between the course of cognitive development in familially retarded and normal children is entirely quantitative. Thus, the retardate differs from the normal child only in rate of development and the cognitive stage or level attained at maturity. At any stage of development, the retardate would be assumed to be comparable in cognitive functioning to a chronologically younger normal child who has attained the same stage of development.

Several researchers in the area of learning disabilities have adopted the essential aspects of the above hypothesis (Fletcher & Satz, 1980b; Satz & Van Nostrand, 1973). During the last 10 years, Satz and his colleagues have continued to modify their original proposition. It is because of these modifications that the model has been termed both a "developmental lag" or "maturational lag" hypothesis and a "similar sequence" hypothesis. Noting lack of empirical support for the hypothesis that a delay in brain maturation contributed to learning disabilities, they began to emphasize the predictive and concurrent validity of their test battery in differentiating reading groups. Currently, they have offered the "similar sequence" hypothesis as a heuristic means to organize developmental data for children with learning disabilities (Fletcher & Satz, 1980b). Basically, proponents of the model predict that the reading disabled child will differ in rate of development, and may or may not reach the same stage or level of development as the normal reader. Regardless of the level reached, however, she/he will follow the same cognitive-developmental sequence and thus the same developmental stages in reading acquisition as does the normal reader (Fletcher & Satz, 1980b; Fletcher, Satz, & Morris, 1981a; Satz & Sparrow, 1970).

Deficit model. The essential aspect of this model implies a qualitative difference between reading disabled and normal children and mentally retarded and normal children, a difference that lies outside that expected for behaviours within the normal distribution. The qualitative difference is usually attributed to a known or hypothesized physiological deficit (e.g., Ellis, 1963; Luria, 1963; Rourke, 1975, 1976a; Silver, 1971) or based on behavioural observations that support a qualitative difference (e.g., Milgram, 1969, 1971, 1973; Zeamon & House, 1963).

Mentally retarded children are, therefore, said to vary in rate and level of cognitive development because the child is assumed to have a "different" brain and "different" cognitive structures (Ellis, 1969; Luria, 1963) or at least, to assume these differences exist based on behavioural observations (Milgram, 1971, 1973; Zeamon & House, 1963).

When the deficit-or difference model is applied to the reading disabled, adherents to this model state that reading disabled children may also differ in rate, level and sequence of cognitive development when compared to normal children. Rourke (1981b) summarizes the principal corollary of the neuropsychological position as follows: "...the child with a reading disability is likely to exhibit a qualitatively distinct manner of dealing with the processing of print. Among other things, the deficit position of the neuropsychologist implies that the reading disabled child, in order to adapt to his (school) environment, will adopt different means for handling information." (p. 19)

It is the evaluation of the above models that is the focus of this research. Because the issue of variant or invariant cognitive sequencing in both mental retardation and reading disability and, consequently variant or invariant sequencing in the acquisition of reading skills, is a primary area of contention between the two models, patterns of abilities for a reading disabled and a mentally retarded population will be compared to the same normal population. The following review will discuss the status of both the similar sequence hypothesis and the deficit model in the area of mental retardation and reading disabilities.

Mental Retardation

Mental retardation is a collective term that covers many heterogeneous groupings. Because of this heterogeneity, mental retardation may be viewed as a medical, legal, psychological, educational, and social concept. This complicates the problem of classification and is still not resolved at the present time. However, the one common feature that unites these conditions is that the person afflicted shows significant general intellectual disability existing concurrently with adaptive behavioural deficits that are manifested during the developmental period (Baumeister & Muma, 1975; Benton, 1970; Hutt & Gibby, 1976; Matarazzo, 1972).

Two systems of classification are, however, frequently employed for grouping mental retardates. One group includes individuals with known physiological abnormalities, e.g., microcephalus, phenylketonuria, etc. (Crome, 1960), the other includes individuals who are retarded as a result of normal variations in the genetic pool in our population (Zigler, 1969). The reason for making this distinction here is that Zigler originally addressed his similar sequence hypothesis to this latter group. More recently, Weisz and Zigler (1979) have attempted to extend, at least in theory, this model to include those who are retarded because of physiological defects. Deficit theorists, on the other hand, have traditionally not separated the two groups when doing research. A review of research that is representative of these models will be presented in the next section.

Mental Retardation: Similar Sequence Hypothesis. Zigler (1966a, 1966b, 1967, 1969, 1973) and Weisz and Zigler (1979) employ a stage or levels approach to cognitive development. They assert that...
"the cognitive development of the familially retarded is characterized by a slower progression through the same sequence of cognitive stages (a rate phenomenon) and a more limited upper stage of cognition (a levels phenomenon) than is characteristic of the individual of average intellect." p. 537 (Zigler, 1969)

Within this approach, a cognitive level or stage represents all of the formal cognitive processes attained by an individual. A sequence is defined as an ordered series of events and the rate is the time taken to go through the process (see Figure 1).

For example, a child with an IQ = 66 would have attained the same cognitive level at 14 years that a child with an IQ = 150 would have attained at 6 years. The difference in Zigler's model refers only to a difference in the rate of development and its upper limits, a difference dictated by the normal variation inherent in the gene pool. According to this model, the cognitive performance of individuals of differing IQs, who are at the same cognitive level and, therefore, at different chronological ages, should be the same.

The following, while not a complete review of cognitive characteristics of mentally retarded children, is a review of research specifically testing the similar sequence hypothesis. For example, Iano (1971), in a review of learning research in mental retardation, found that, when retardates and normals were matched on chronological age, the retarded were almost always inferior in learning. However, when matching was based on mental age, there was little evidence for inferior learning. Iano concluded that the evidence supported a similar sequence hypothesis.

Weisz (1977) tested subjects at three levels of IQ and three levels of mental age on hypothesis-testing behaviour using two stimuli that varied on four dimensions (shape, colour, size, and letter). He found no significant effect of IQ and concluded that, although not definitive, his findings were consistent with Zigler's position. In another study, Taylor and Achenbach (1975) looked at moral judgment and cognitive development using themes developed by

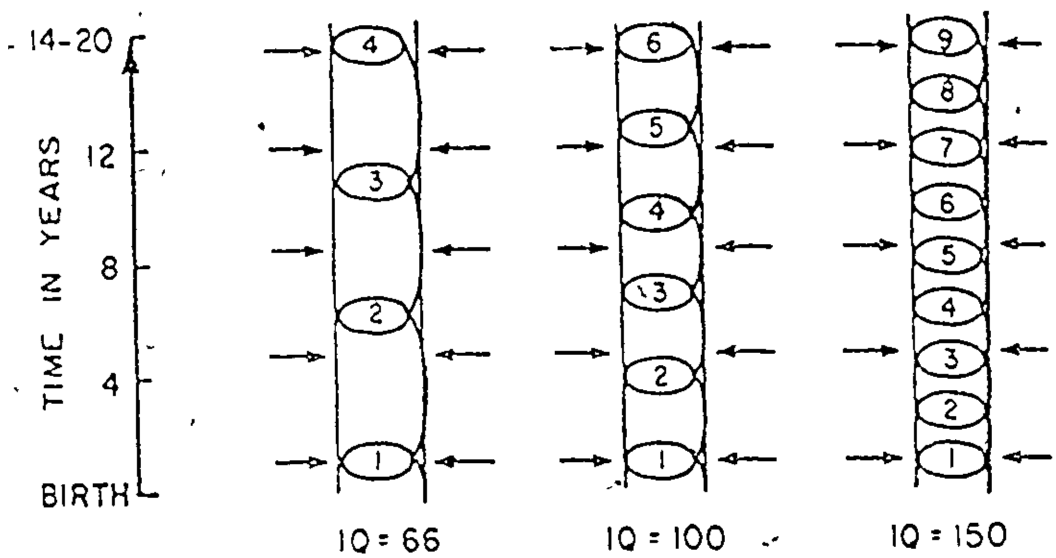

Figure 1. Developmental model of cognitive growth. The single vertical arrow represents the passage of time. The horizontal arrows represent environmental events impinging on the individual who is represented as a pair of vertical lines. The individual's cognitive development appears as an internal ascending spiral, in which the numbered loops represent successive stages of cognitive growth. (From "Developmental versus difference theories of mental retardation and the problems of motivation" by E. Zigler, American Journal of Mental Deficiency, 1969, 73, 536-556.)

Lawrence Kohlberg. They found that retarded and normal children, who differed in chronological age but were matched for mental age, did not differ in level of moral judgment or on their performance on cognitive tasks (i.e., categorical classification, awareness of qualitative invariance, awareness of quantitative invariance, conceptual reciprocity, relativity of physical perspective, and role taking ability). They also found developmental changes, i.e., performance for both groups improved with mental age.

Morelan (1976) investigated the performance of normal and retarded children in a reaction time experiment and with respect to the relative effects of mental age and IQ on information processing. The assumption was that latency is a function of the amount of information to be processed. He found that all subjects (mental ages 7 and 9) improved with practice on the reaction time task and that latency increased as a function of the amount of information to be processed. What is relevant to the similar sequence hypothesis is his finding that mental age, not intelligence, was an indicator of better performance in processing increasing amounts of information. He concluded, therefore, that the cognitive level of an individual (mental age) irrespective of the length of time required to reach that level (IQ), can be considered an index of information processing efficiency.

Weisz and Zigler (1979) recently reviewed a series of Piagetian studies (3 longitudinal and 28 cross-sectional) done with the mentally retarded. Based on this critique, they concluded that the majority of the evidence supported the similar sequence hypothesis.

In addition to rate and level differences, many researchers (e.g., Hargis et al., 1975; Weisz, 1976; Zigler, 1969, 1973) have noted that differences between normals and retardates could be based on factors other than cognitive functioning. Some of the factors believed to influence performance include motivation, institutionalization, personality, and socio-emotional variables. Some writers (e.g., Balla, 1973; Zigler, 1966b, 1976; Zigler & Balla, 1971) present a critique of previous research and argue that future research must control for the above variables prior to claiming support for either the deficit or similar sequence hypothesis.

A similar criticism has also been proposed by Goldstein and Myers (1980). They have advanced a cognitive lag hypothesis as a rationale for the lower intelligence scores obtained by lower class children as compared to middle class children. This hypothesis ascribes the lower intelligence scores of lower class children to the developmentally delayed expression of the same intellectual competence as that shown by middle class children. What is pertinent to the present research is the methodology used to support their hypothesis. They analyzed (and re-analyzed published data) for patterns of IQ test item success and failure for groups of children of the same mental age and found the same patterns of skills for both groups, with the lower class children showing a less advanced level of skill. Their research offers support for a similar methodology in the current study. Criticisms and limitations of this model will be better understood after presentation of the deficit model which will be dealt with in the next section.

Mental Retardation: Deficit Model. Theorists within this model represent both adherents to the neurophysiological deficit position (e.g., Luria, 1963; Ellis, 1963) and behaviourists who support qualitative differences in the cognitive functioning of the mentally retarded (e.g., Milgram, 1969, 1971, 1973; Zeamon & House, 1963).

An early influential and widely accepted defect position was the cognitive rigidity formulation of Kurt Lewin and Jacob Kounin (Zigler, 1966b, 1973). This theory views the retarded child as different because she/he is less differentiated cognitively, i.e., has fewer regions in the cognitive structure than a normal child of the same chronological age. In addition to this lack of differentiation in cognitive structures, they also postulated a rigidity between regions in the cognitive structures that hindered mental transfer and growth. Zigler (1966b) has reviewed the supporting research and offered conflicting findings for the cognitive rigidity formulation. In particular, he questions the equation of behavioural persistance on boring tasks to a "rigid" state of mind.

Another deficit theory that attributes mental retardation to pathological processes was proposed by Luria (1963). He suggested that those processes that modify the cerebral substratum occur before or during birth, and result in defective development of the child. He hypothesized that the basic underlying mechanism is a pathological inertia of the nervous process which then gives rise to secondary behavioural manifestations, especially speech dysfunction, With a failure to acquire proper speech, there is a resulting lack of co-ordination or dissociation between the motor and verbal systems. He maintained that this accounts for the retarded person's failure to develop higher cognitive processes.

Ellis (1963) has conducted extensive work on stimulus trace deficiency in the mentally retarded and considers himself to be more of a behaviourist than a "deficit" theorist. However, he does suggest that there is a physiological basis for the behavioural deviations found in his research. Zeamon and House (1963) also follow a behavioural tradition in their work on attention in retardate learning. In their visual discrimination learning tasks, they found that learning required attending to a relevant stimulus dimension, as well as approaching the correct cue of that dimension. It was the former aspect of the task that presented difficulty to retardates.

Milgram (1969, 1971, 1973) is one of the most outspoken critics of the similar sequence hypothesis. He, too, considers himself a behaviourist and does not agree with Zigler's (1969) referral to him as a deficit theorist. He suggests that Luria is a true example of a deficit theorist but that North American deficit theorists might be more properly viewed within the behavioural tradition, i.e., observing functional differences without postulating underlying physiological mechanisms.

Milgram supported his position of functional differences with his research on discrimination learning and reversal shift tasks in normals and retardates. He concluded that mentally retarded subjects evidenced a verbal production deficiency that impeded learning on tasks that require verbal mediation. This deficiency, he believes, is above and beyond the performance level dictated by their general cognitive level.

Zigler (1969) has questioned the differences found by Milgram as being more likely attributable to motivational factors or a failure to sample the population using a two-group approach. In response to this criticism, Milgram (1973) suggests that it may be cognitive variables that affect performance on tasks that are ostensibly measuring social, emotional or motivational variables.

Milgram (1971, 1973) has also provided evidence that, when the learning task minimizes the contribution of the verbal medium, then equivalent performances of retardates and mental age-matched normals would occur. For example, he found that only at mental age six was the poor verbal expression of the retarded matched by the immature development of the normal six year old. Furthermore, he noted that the greater the IQ difference between subjects equated for mental age, the more likely a deficit in performance will be observed. Overall, he concluded that there is considerable support for a verbal production deficiency in the mentally retarded that interferes with learning.

Other examples of cognitive differences in retardates has been provided by Das (1972) who demonstrated not only a level but a process difference between retarded and mental age-matched non-retarded persons on cognitive tasks. He used both memory and reasoning tasks, and based his conclusions on significant mean group differences and differential factor loadings for the factors representing memory and reasoning.

At present, then, there is variable and inconclusive evidence offered to support both positions in mental retardation. It may help to clarify both positions by summarizing the major differences between the two models. One obvious area of contention is the meaning attached to the label of deficit theorist. Milgram contends that American behaviourally oriented researchers cannot be subsumed under the same umbrella as obvious deficit theorists like Luria. However, he and others (Ellis, 1963; Zeamon & House, 1963) are convinced that cognitive differences or deficiencies are present in the mentally retarded, as contrasted with normals, whatever the underlying etiological considerations.

Another controversy arises over sampling procedures. Similar sequence theorists argue for a two-group approach in sampling, and deficit theorists argue for inclusion of all retardates in one population. Thus, a one-group approach may not allow for a fair test of Zigler's hypothesis, which currently applies only to the familially mentally retarded.

Also, some deficit theorists equate their groups on either mental age, chronological age or intelligence. Zigler claims that a proper test of the theory requires equating on cognitive ability (roughly determined by mental age). He believes that it is cognitive level that determines the nature of performance on a task while deficit theorists maintain that other factors (e.g., verbal mediation difficulties) determine the difference.

It might be appropriate to conclude this section with limitations to the similar sequence hypothesis that were proposed by

Zigler (1969) himself. These limitations have yet to be addressed in the research and may be posed as a series of questions. Is cognitive sequentiality inevitable? How do environmental events interact with internal events? What precipitates movement from one cognitive level to the next? At what age does the highest level for each isolatable cognitive process occur? Is cognitive development a single progression or independent processes developing at different rates because of different environmental and nativistic factors?

The limitations of the deficit model are considerably fewer because their claims are less numerous. However, one major criticism applies to those theorists who, with no supporting evidence, attribute neurophysiological deficits to a majority of retardates. On the other hand, behavioural researchers might be criticized for not attempting to organize their findings of functional deficits within a larger theoretical model. Both models must certainly take into account the etiological sources of mental retardation in their research population before generalizing their findings to the majority of mental retardates. In the next section, the deficit and similar sequence models in the area of learning disabilities will be presented prior to organizing a means of evaluation for both models in both areas.

Learning Disabilities

At the outset, it is important to note that the definition of the learning disabled child has not met with concensus, nor has that of the specifically reading disabled child (e.g., Critchley, 1970; Ingram, 1969; Jansky, 1979; Masland, 1979; Rutter, 1978). The recent literature on the heterogeneity of reading disabilities and the existence of subtypes in the "specifically" reading disabled population adds to the difficulty of classification (e.g., Fisk & Rourke, 1979; Fletcher, Satz, & Morris, 1981a; Petrauskas & Rourke, 1979).

The child with a specific reading disability or specific developmental dyslexia has typically been defined via exclusionary means. A widely accepted definition is one proposed by a research group of the World Federation of Neurology. According to this group, specific developmental dyslexia is identified as follows:

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

Problems with this mode of classification are discussed frequently. (e.g., Rutter, 1978; Satz & Morris, 1980). These problems include circularity and ambiguity in the definition and unproven meaningfulness of the concept.

In addition to these problems, Taylor, Satz, and Friel (1979) challenged the traditional notion of dyslexia as easily dissociated from other reading disorders. They compared two groups of disabled readers (dyslexic and non-dyslexic) with a group of normal readers. There were no demonstrated differences between the two reading disabled groups on multiple dimensions. They concluded that the results raise serious doubts as to the clinical value of the diagnosis of specific developmental dyslexia.

However, it is beyond the scope of this paper to deal critically with the many problems involved in classification. Rather, we want only to establish that the population of disabled readers under study have been chosen by the conventional method of exclusion, albeit with an awareness of the critiques of this method. Thus, the reading disabled population has been limited to those children who are severely delayed in reading, but of normal intelligence, who are not suffering emotional or social deprivation, who have been exposed to regular schooling, who are not visually or hearing impaired, and who do not suffer from serious physical handicaps (Rourke, 1975, 1976a, 1981b; Satz & Sparrow, 1970). The following theories of reading disability are addressed to this specific population.

Learning Disabilities: Similar Sequence Hypothesis. The primary exponents of this model have been Paul Satz and his colleagues. Unlike the similar sequence hypothesis as applied to mental retardation, their model has undergone some significant changes since its inception in 1970 (Satz & Sparrow, 1970). It has developed from a maturational or developmental lag theory (Satz & Sparrow, 1970), to a stress on age-linked predictors of reading disability (Satz, Friel, & Rudegair, 1974), to a refutation of the original "maturational lag" hypothesis (Fletcher & Satz, 1980b; Fletcher, Satz, & Morris, 1981a), and finally to the development of a "similar sequence" hypothesis (Fletcher & Satz, 1980b; Fletcher et al., 1981a; Satz, Fletcher, Clark, & Morris, 1981). At this point their primary research thrust is in the analyses of the existing data from the Florida longitudinal study for meaningful dyslexic subtypes (Fletcher et al., 1981a).

The development of the model may be best presented within a brief historical perspective. A primary contributor to this way of thinking was Orton (1928). He believed that the underlying mechanism contributing to reading disability was a delay in the maturation of the left hemisphere. This delay in maturation resulted in competition between hemispheres when recognizing symbols. The result of this competition was a condition Orton termed strephosymbolia (twisted symbols) i.e., images perceived equally in both hemispheres interfered with each other and created difficulties such as letter reversals, mirror writing, etc.

Bender (1957, 1975), a student and colleague of Orton's, continued to utilize the concept of maturational delay in learning disorders. Her emphasis was primarily in the area of visual organization, pattern perception and figure-ground perception. More recently, Money (1966) presented an argument for a functional maturational lag hypothesis based on his conclusion that there is not strong enough evidence to support a specific relationship between abnormal brain functioning and reading disability. However, he does agree that, even though some cases may be a sequel to brain pathology, the great majority are representative of a lag in functional development of the brain and nervous system that subserves the learning of reading.

During the last decade, Paul Satz and his colleagues (Satz & Sparrow, 1970; Satz, Rardin, & Ross, 1971; Satz & Friel, 1973; Satz & Van Nostrand, 1973; Satz & Friel, 1974; Satz et al., 1974; Satz, Friel, & Goebel, 1975; Satz, Taylor, Friel, & Fletcher, 1978) have expanded this hypothesis and proposed a developmental lag model as an explanation for the underlying mechanism contributing to specific developmental dyslexia. Satz & Sparrow (1970) began by reviewing the pattern of deficits that have been found to exist in children with reading disabilities. They concluded that each of these deficits, e.g., left-right confusion, calculation difficulties, finger differentiation problems, spontaneous writing and spelling impairment, impairment in form perception, impairment in verbal intelligence and, difficulties in intermodel association (believed to be dependent on the left parietal lobe) are comparable to those deficits observed in adults after structural alteration of the dominant left hemisphere. In addition, they noted Geshwind's (1962) "disconnection" syndrome as further support for the importance of the left cerebral hemisphere. In this syndrome, a left occipital lobe lesion with destruction of the white matter in the splenium of the corpus callosum (disconnecting the right visual cortex from the left angular gyrus) results in the person suffering from pure word blindness, i.e., an inability to recognize words while retaining the ability to write them. After reviewing this research, Satz and Sparrow concluded that the left hemisphere, which, when lesioned, is involved in the loss of language abilities of adults, might also be involved in the acquisition of language abilities in children.

Therefore, Satz and Sparrow argued (as does Critchley, 1970) that, because neurological studies fail to document any structural alteration to the left hemisphere, then a functional lag in brain maturation may be a more viable hypothesis. The process of brain maturation is defined by Satz and Sparrow (1970) as: "...successive and overlapping changes in growth that take place in the physiological and psychological sectors of the organism. This conceptualization also presupposes an overlapping and interrelated fusion of operations directed ultimately towards the integration of intersensory (motor-sensory-speech) modality systems." (p. 29)

Thus, reading disability was conceived as a lag in hierarchical levels of maturation, i.e., the lag represents a more diffuse lateralization and differentiation of motor, somatosensory and language functions that should be subserved exclusively by the dominant left hemisphere. They concluded that delays in the cerebral lateralization process might well retard the acquisition of developmental skills relating to language, just as acquired lesions in adults might well cause the loss of these skills.

To summarize, their model was based on the following two premises:

> the first premise postulates that hemispheric specialization in language stems from a basic difference in sensorimotor organization in the brain which developmentally precedes the lateral differentiation of speech and language. The second premise postulates that, in normal development, behaviour proceeds from grossly diffuse and unmodulated operations to greater differentiation and hierarchical integration of motor, somatosensory and symbolic language function. (Satz & Sparrow, 1970, p. 29)

Vellutino (1979a, 1979b) has questioned the second premise of linear or stage theories of development. In particular, he criticized their concept of perception as an organismic entity that matures like any other structure or function of the body (e.g., motor and physical development). He also questioned the implication that perceptual functioning is characteristic of a particular "stage" in cognitive growth, midway between sensorimotor and cognitive development. Vellutino asserted that this understanding of perception is based on a misinterpretation of Piaget's theory. He believes that the relationship between perceptual and conceptual functioning is probably reciprocal, i.e., our percepts are always referred to existing concepts, and our concepts may be altered by perceptual differentiation.

In spite of the limitations of the basic premises, Satz and Sparrow (1970) went on to predict that:

> ...the pattern of deficits observed in dyslexic children, rather than representing a unique syndrome or disturbance, should resemble the behavioural patterns of chronologically younger children who have not yet developed acquisition of certain skills. Moreover, the pattern of deficits within dyslexic groups should vary as a function of the age at which certain skills are undergoing primary development. Because motor and somatosensory skills are established ontogenetically earlier, one might expect to find this pattern of difficulties in the younger dyslexic child. Conversely, those functions which develop ontogenetically later (e.g., language and formal operations) might be expected to occur in much older dyslexic children who are maturationally delayed. (p. 31)

Their primary data base was derived from a longitudinal study of 497 caucasian kindergarten boys in the Alachua County Florida public school system and the University of Florida laboratory school (20 schools: 14 urban, 6 rural). Twenty predictor variables are described by Satz and Friel (1973). The original criterion was third year reading achievement. This was subsequently extended to sixth year reading achievement (Fletcher & Satz, 1980a).

Over a series of studies, using this data base, as well as other subjects, Satz and his colleagues (Fletcher & Satz, 1980a;

Fletcher et al., 1981a; Satz et al., 1971; Satz & Friel, 1973; Satz & Van Nostrand, 1973; Satz & Friel, 1974; Satz et al., 1974; Satz et al., 1975; Satz et al., 1978) typically predicted that early emerging abilities (visual-perceptual, visual-motor, directional-spatial) would differentiate younger dyslexics from younger normals and that language related differences would differentiate older dyslexics from older normals.

As the research effort progressed, support for the maturational lag hypothesis weakened when catch-up occurred on some abilities and not on others and when the predicted age-linked disability did not occur consistently in the dyslexic group (in particular, the younger dyslexics). For example, in a study by Satz, Rardin, & Ross (1971), visual motor integration differentiated the younger dyslexic and normal readers but auditory-visual integration did not. Although, older dyslexics were almost consistently behind normal readers in reading and language development (in line with the theory), these language differences were often present in younger readers but to a lesser degree.

Vellutino et al. (1977) have questioned Satz's premise that only older dyslexics will show language related disabilities. They noted that language is well developed by ages four to six (i.e., before the child is ready to read). It might then be expected that a maturational delay would have a significant impact on language development that would be as evident in younger as it would in older dyslexics.

Fletcher, Satz, and Sholes (1981b), in response to this type of criticism, introduced linguistic measures derived from Gibson's

(1966, 1975) analyses of reading skills. In keeping with the lag model, they predicted that early developing skills, processing graphological and phonological correlates of single words, will contribute more to differences between disabled and nondisabled younger readers, while later phases of reading acquisition are more dependent on higher order linguistic skills (e.g., syntactic and semantic strategies). They found that developmental changes for tasks supposedly sensitive to earlier developing language skills were not apparent, i.e., no differences occurred on two morphology measures (i.e., the Illinois Test for Psycholinguistic Ability, Grammatic Closure Test and the Beery-Talbot test) for normal and disabled readers at 5.5, 8.5 and 11 years of age.

Further evidence that the "catch-up" predicted in the maturational lag hypothesis is not supported for all developmental abilities was provided by Satz and Morris (1980). They established that a subtype of dyslexia, termed visual-perceptual-motor, existed in eleven year old disabled readers. This finding conflicted with the lag model which would have predicted a catch-up on this ability by age eleven.

Rourke (1976b) also demonstrated that some abilities "catch-up" and others do not. To do this, he evaluated data derived from the Alachua longitudinal study and from a study undertaken with his colleagues. To this end he devised seven paradigms that attempt to characterize various types of lag and deficit results that are obtained in developmental studies of learning disabled children. (see Figure 2). These paradigms illustrate age-performance interactions over time that can accommodate both longitudinal and cross-sectional data. Briefly, 1, 2, and 3 represent "lag" paradigms, 5, 6, and 7 represent "deficit" paradigms, and 4 represents an

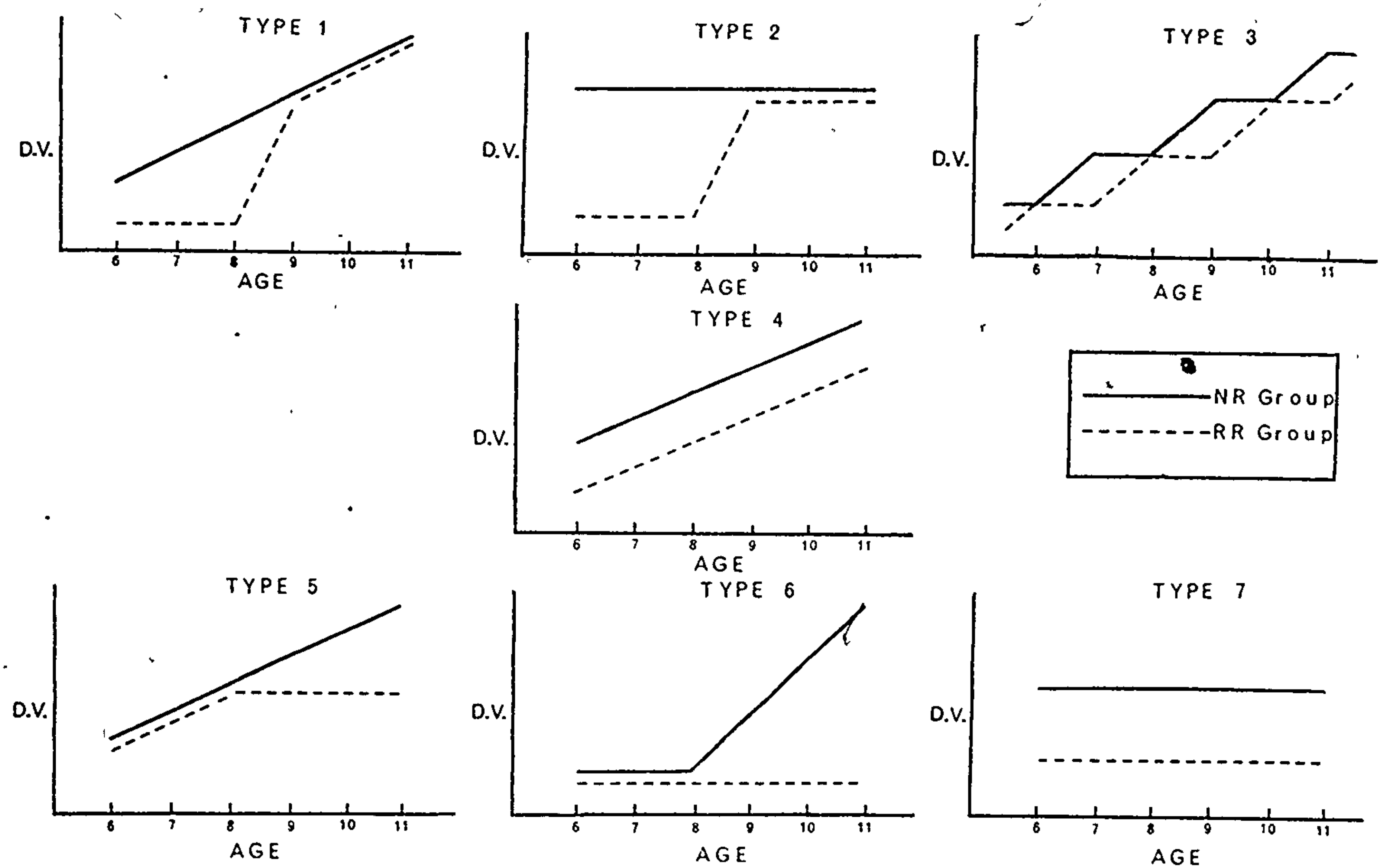

Figure 2. Graphic illustration of age x performance interactions in normal and retarded readers (Rourke, 1976b).

ambiguous state of affairs. Rourke concluded that the developmental lag position is tenable in the case of early emerging abilities thought to be subserved by the right cerebral hemisphere whereas the deficit position is tenable in the case of later emerging verbal-conceptual abilities thought to be subserved by the left hemisphere. Rourke suggests, however, caution in interpreting results as fitting either model in the case of tests with inadequate floors and ceilings. For example, the catch-up on Finger Localization and the Alphabet Recitation tests (by the end of Grade Two) in Satz's longitudinal study may be due to inadequate ceilings, thus assuring a developmental lag interpretation.

Additional evidence for lack of catch-up is provided by Rourke and Orr (1977). In a longitudinal study, they found that only 20% of dyslexic children improved by Grade Four. Also, Fletcher and Satz (1980a) found a 12% to 20% increase in the severely disabled reading group (derived from the Alachua population) between Grades Two and Five. Furthermore, evidence exists that reading difficulty (as well as problems in writing, arithmetic and spelling) can continue into late adolescence and adulthood (Herjanic & Penick, 1972; Koppitz, 1972-73; Perlo & Rak, 1971).

In response to this evidence, the developmental lag model was modified to include the concept of "permanent delay". That is, if the lag persists after puberty, when maturation of the central nervous system is supposedly complete, then a permanent delay is predicted for that ability. However, the model does not offer a basis for predictions as to when this might occur and with what developmental abilities (Satz et al., 1974).

Usprich (1976) offered a cogent criticism in remarking that without the catch-up expectation, the theory loses not only its most generally understood meaning but also its predictive value for later development. She claimed that Satz and his colleagues do not answer questions about permanent sequelae and do not deal with the evidence that some reading and writing disabilities persist until the third decade of life. She also suggested that the concept of permanent delay ignores findings that brain development may continue into later life.

Another important aspect of the developmental lag theory was the stress on developing early predictors for later reading disability, the critical postulate being that the dyslexic is handicapped on a number of developmental skills which are not directly related to the reading process (Satz & Von Nostrand, 1973). Encouraging results were reported from the longitudinal study for the success of predictor variables related to subsequent reading achievement. The best predictors were those representing somatosensory-perceptual-mnemonic functions, i.e., Finger Localization, Recognition-Discrimination Test and Alphabet Recitation. The predictive ability of these traits for subsequent reading achievement, however, was confined to the extreme reading groups (severely disabled and superior readers). Predictive ability for mildly disabled and average readers was less accurate (Fletcher & Satz, 1980a; Satz et al., 1975).

Recently, Satz et al. (1981) have attempted to clarify terms that were used interchangeably in earlier papers. For example, they now define developmental lag as: "the actual performance of the child, while maturational lag refers to the same performance but also makes an inference to a hypothesized state of the central nervous system." (p. 2) However, Fletcher and Satz (1980b), Satz et al. (1981) and Fletcher et al. (1981a) have concluded that the maturational lag model is no longer a viable construct to explain the data. Consequently, they have offered a general developmental model similar to that proposed by Zigler (1969). This "similar sequence" hypothesis was proposed by Fletcher and Satz (1980b) as a more viable construct to organize the developmental data on dyslexia.

The similar sequence hypothesis, however, has many similarities to their earlier formulations. For example, Satz and Van Nostrand (1973) equated the maturational lag hypothesis to Lenneberg's (1967) model for mental retardation, a model that is similar to Zigler's similar sequence hypothesis. In both models, cognitive sequences are deemed invariant for both normal and mentally retarded children, but the rate and absolute level of cognitive ability attained is different for the mentally retarded.

In the similar sequence hypothesis, three sets of component hypotheses are proposed: 1) a chronological age component; 2) a degree of development component, and; 3) a reading level component (Fletcher & Satz, 1980b; Fletcher et al., 1981a).

Chronological age component. One premise of this component is that cognitive performance differences will emerge on any comparison of same aged disabled and non-disabled children. However, within the framework of the similar sequence hypothesis, the magnitude of these differences are predicted to vary with chronological age according to the developmental rate of the attribute processed (Fletcher et al., 1981a). Herein, developmental abilities are no longer referred to as "lagging" but as "variable". However, specific developmental rate differences are not predicted, nor are normal variations of developmental abilities discussed in terms of normal readers and dyslexics.

Degree of development component. This component addresses the catch-up phenomenon. As previously discussed, the concept of delay and subsequent catch-up on developmental abilities has not been supported for reading and language related abilities. Fletcher and his colleagues respond to this unsatisfactory state by suggesting that catch-up in a particular ability can occur if the upper level of development of that ability is not limited, i.e., occurs past adolescence. No catch-up is predicted, however, when the rate of development of a specific ability diminishes at or before adolescence (Fletcher & Satz, 1980b; Fletcher et al., 1981a). Unless this concept of catch-up is clarified and specific areas of developmental abilities are referred to, the hypothesis has little more predictive value than the earlier formulation of "permanent delay."

Reading level component. This component refers to comparisons between older disabled and younger normal readers. Predictions derived from the similar sequence hypothesis suggest that no cognitive performance differences will be found when older disabled and younger normal children are compared, after being matched for reading level

(Fletcher & Satz, 1980b; Fletcher et al., 1981a). This proposal seems quite similar to that proposed earlier by Satz and Sparrow (1970) i.e., that older learning disabled children will perform like younger normal children. The difference, of course, is the exclusion of any reference to underlying etiology.

In summary, the differences between the maturational lag hypothesis and the similar sequence hypothesis regarding learning disabilities is compromised by the lack of clarification as the models evolved. The similar sequence hypothesis does not appear to be an "alternate" model, but one that has evolved from the original maturational lag model. Although the underlying mechanism (delay in brain maturation) is no longer utilized, other differences are less clear. For example, the similar sequence hypothesis still adopts the major constructs of the earlier model, i.e., rate, catch-up and invariant sequence. Evaluations of this hypothesis and its utility in reading disability research will necessitate further research relating to these three concepts. However, before addressing the evaluation process, it is necessary to review the deficit model which offers alternative interpretations to those discussed above (some of which have been addressed in the above section).

Reading disabilities: Cerebral deficit model. There has been and continues to be considerable, if inconclusive, support for the deficit model as an explanation for learning disabilities in general and specific reading disability in particular (Doehring, 1968; Reed, 1968; Rourke, 1975, 1976a, 1978, 1981a, 1981b). The basis of this model is in a neuropsychological approach that assesses brain-behaviour relationships through measures that are presumed to reflect these relationships. The assessment of the intactness of the cerebral hemispheres via this approach has been well documented (Reitan, 1974; Rourke, 1975, 1976a, 1981a), but will be briefly reviewed here.

This model has a long history in neurology and psychology dealing with both adults and children, as well as with loss of speech and reading skills versus failure to acquire reading (Critchley, 1970; Doehring, 1968). Prior to 1900, W. Pringle Morgan described congenital word blindness and postulated a deficit in the left angular gyrus as a contributing factor. Other deficits were postulated to exist over the years, e.g.: Gerstman's syndrome of right-left disorientation, calculation difficulties, finger localization difficulties, and writing difficulties which were associated with lesions in the dominant cerebral hemisphere in the region of the angular gyrus (Doehring, 1968); a disconnection syndrome (described earlier), Geshwind (1962); neurochemical disturbances that were postulated to contribute to learning disabilities (Silver, 1971); and disturbances in the reticular formation that were thought to contribute to reading disability and learning disorders (deHirsch, 1966).

More recently and more relevant to specific developmental dyslexia is the work done by Reitan (1974) and Boll (1974) on documenting brain-behaviour relationships through the use of a neuropsychology test battery, developed originally for use with adults (Reitan, 1966a). Knowledge of the brain-behaviour patterns of those children with known cerebral damage has been extended to those suspected of cerebral damage or dysfunction specifically in the area of learning disabilities.

Rourke (1975, 1976a, 1978), in particular, has extended the use of the neuropsychological battery to the evaluation of reading disabled children. The theoretical question that he posed and has attempted to answer with subsequent research is:

> Is it the case that some or all of the deficits exhibited by children who are classified as learning disabled are the result of cerebral impairment? (Rourke, 1976a, p. 90)

In answering this question Rourke and his colleagues have employed an extensive neuropsychological battery adapted for use with children (further description can be found in Reitan & Davison, 1974). With this battery, they have attempted to assess the following: the levels of performance between normal and learning disabled children; clinical signs and symptoms thought to be characteristic of the learning disabled population, e.g., attentional deficits, EEG patterns; the performance comparisons between two sides of the body; and; the differential score patterns for learning disabled children.

In addition, they, as does Satz, have considered the developmental variations that occur in the differential score patterns, with an emphasis on demonstrated strengths and weaknesses observed in these patterns. Occurrences of developmental variations are hypothesized to be the result of maturation of, and compensation within, the central nervous system. At present, they have begun to explore possible subtypes that exist within the learning disabled population in response to the increasing evidence for the heterogeneity of the reading disabled population (Fisk & Rourke, 1979; Petrauskas & Rourke, 1979; Satz & Morris, 1980). Thus, in light of his findings over the years in his own lab and that of others (e.g., Doehring, 1968; Reed, 1968), Rourke (1975, 1976a, 1978, 1981b) offers continuing support for the deficit or cerebral dysfunction model.

As previously discussed, Rourke (1976b) has investigated the merits of the "developmental lag" versus "deficit" position via his seven paradigms. In conjunction with this evaluation he stressed that, "...the most important aspect of the results of this exercise was that it was a developmental context that served to highlight the neuropsychological significance of the results of these studies." (Rourke, 1981b, p. 17)

Furthermore, the determination of the relative predictive accuracy of various measures that support evident differences between normal and disabled readers is viewed by Rourke (1981b) as support that some form of cerebral dysfunction underlies learning deficiencies. In particular, he points to the success of the Underlining Test in predicting eventual achievement levels in reading and spelling (Rourke & Orr, 1977). More generally, Rourke (1981b) states his position as follows:

> ...one would not expect the disabled reader to develop his/her skills in a manner that would parallel developments in her/his normal age mates. Quite the contrary, one would expect that a "normal" pattern of development would be the exception rather than the rule, that advances in reading and at least some reading-related skills would take place only with very

> special attention and then only with considerable effort and good fortune, and that there is no guarantee that such disabled readers would ever catch up in either reading-related skills or in reading itself. (p. 18)

Thus, one viable deficit position that seems deducible relative to the similar sequence hypothesis may be summarized as follows. a) The rate of acquiring a developmental ability may vary for some children and still be within the normal variation. However, in the case of specific reading disability the rate of acquisition of reading related skills is predicted to differ markedly from that of normal readers. b) No catch-up is predicted on reading and reading related skills for disabled readers. c) The ability patterns of disabled readers is predicted to vary from those of normal readers because the normal developmental sequence is permanently disrupted.

In conclusion, a notable difference between the deficit model and similar sequence model is that the deficit model was formulated after a gradually increasing data base was collected (Rourke, 1981b). The lag model, on the other hand, was proposed prior to the acquisition of supporting data and its usefulness has been seriously questioned by subsequent research (Fletcher, et al., 1981a). The strength of the deficit model is in this considerable data base that supports differential abilities in reading disabled and normal readers. However, as stated previously, actual neurological proof to which the differences can be attributed has not been obtained (Critchley, 1970).

Summary and Conclusions

The previous sections have outlined the similar sequence hypothesis and deficit model as they are conceptualized in the research in mental retardation and learning disabilities. Limitations for both models were discussed and the supporting evidence was shown to be variable, especially for the similar sequence hypothesis in the research on learning disabilities. Methodological concerns were also addressed, e.g., classification difficulties concerning both the mentally retarded and reading disabled, narrowly defined measures testing cognitive abilities in the mentally retarded (e.g., hypothesis testing behaviour), etc.

In addition, the argument was made that the current "similar sequence hypothesis", as it has been adapted to the field of reading disability, has not been developed independently of the original maturational lag hypothesis. The failure of Satz and his colleagues to clarify their position as it developed, including research findings to support propositions related to the similar sequence hypothesis, is a serious omission. On the other hand, the model has been consistently presented in the mental retardation research, but little definitive research has been undertaken as a direct test of the model.

Finally, the major constructs in the similar sequence hypothesis (rate, catch-up, sequence) were reviewed from both a similar sequence and a deficit position. It is clear that different developmental rates in reading ability are predicted by each model, albeit for differing reasons. It is difficult to test this proposition empirically, however, until more normative data is gathered on the rates of acquiring developmental abilities essential to reading. In the mental retardation literature, both models suggest a slower or impeded rate of acquiring developmental milestones.

The evidence for the catch-up phenomenon, as it relates to reading disability, suggests that catch-up may occur in early developing abilities subserved by the right hemisphere but not on later developing abilities subserved by the left hemisphere. The deficit model clearly predicts no catch-up on reading and reading-related abilities in developmental dyslexics. The similar sequence hypothesis is unspecific about abilities that may or may not catch up in the reading disabled child as compared to the normal child. Support for the deficit position may be strengthened if reading ability is not demonstrated to catch-up. However, as long as permanent sequalae are postulated for some "undefined" abilities in the similar sequence hypothesis, this issue is difficult to test as to its support for one model or the other. Of course, in the field of mental retardation, no catch-up is predicted by either model.

The one clearly defined position for both models in both areas (learning disabilities and mental retardation) is that of variant and invariant cognitive sequences. The similar sequence hypothesis predicts that the pattern of cognitive abilities for the reading disabled and the mentally retarded will be the same if they are equated on, for the former, reading ability, for the latter, cognitive ability. Fletcher et al. (1981a), referring to reading disabilities, have stated:

> If disabled readers differ in rate but not sequence of acquisition, older disabled children should display cognitive performance patterns similar to those characteristic of younger normal children. Consequently, older disabled and younger normal children matched on reading level should display similar patterns on other reading-related skills. (p. 14)

The deficit model predicts, for both populations, that the cognitive ability patterns, for normals, retardates and dyslexics will differ because of underlying neurological differences.

It will be the assessment of ability patterns that is the primary focus of this research in evaluating the two models. To this end, we will compare different children on a series of neuropsychological tests tapping a broad spectrum of abilities. The following is a brief rationale for the choice of dependent measures thought to best represent a range of cognitive abilities that will enable us to compare normals, reading disabled, and mentally retarded children in terms of the deficit model and similar sequence hypothesis.

Dependent measures. It was apparent in reviewing the support for both models in the area of mental retardation that most research has been based on narrowly defined measures of behaviour, e.g., stimulus trace hypothesis, simple discrimination tasks, and unidimensional Piagetian tasks. It would seem wise, in evaluating these models, to extend the measures to include a broader spectrum of abilities than those previously assessed. The crucial question to be answered requires the comparison of a normal and a mentally retarded population equated on cognitive level. This comparison might best be undertaken by knowing what neuropsychological abilities are evident in each group as a means of making a statement about cognitive abilities.

Boll (1974), Matthews (1963, 1974), Matthews & Reitan (1963-64), Reitan (1966b, 1973) and Benton (1970) have provided some exploratory work with neuropsychological measures with the mentally retarded. The results indicate that the comparison of ability patterns between normals and mental retardates offer possibilities for testing the similar sequence hypothesis.

Even though extensive neuropsychological measures have been used in the research in learning disabilities, most evaluations of the similar sequence hypothesis and the deficit model have used somewhat different measures. Thus, a proper evaluation of the two models requires the use of similar dependent measures with the normal readers and the reading disabled population.

Recently, Gates (1981) has factor analyzed (using a R-type analysis) most of the neuropsychological test battery utilized by Rourke and his colleagues. Variables not included in the analyses were those suspected of being unreliable or highly skewed (e.g., aphasia screening test, sensory-perceptual exam). In the interest of parsimony, for this study we have selected tests representing factors that were consistently represented across the ages (years 7-8, 9-10 and, 11-12) and were reflective of a broad range of neuropsychological abilities. Another consideration in the choice of tests was the decision to use raw scores in the data analyses. Because some of the tests change in character between the ages 5-8 and 9-15, only those tests that remain the same across the ages were chosen.

The factors, and tests chosen that loaded highly on the factors, are: 1) Simple motor - grip strength and finger tapping speed; 2) Complex motor - maze co-ordination test; 3) Incidental learning - Tactual Performance Test, memory component; 4) Somato-sensory - Tactile Finger Recognition; 5) Visual-perceptual - Object Assembly and Block Design subtests of the Wechsler Intelligence Scale for Children (WISC) (Wechsler, 1949) Tactual Performance Test, total performance time; 6) Verbal-réceptive-expressive - Sentence Memory, Peabody Picture Vocabulary Test IQ, Vocabulary subtest of the WISC; 7) Verbal-auditory attention and concentration - Verbal Fluency, Auditory Closure and Speech Sounds Perception. These measures were then organized into three categories, a) motor-tactile perceptual, b) non-verbal cognitive and c) verbal cognitive (Table 1).

Expectations

In summary, two models have been presented that attempt to explain the differential patterns of abilities between normal children and reading disabled children, and between normal children and mentally retarded children.

Adherents to the similar sequence model would argue in support of the following expectations:

1) In a mentally retarded population, the patterns of cognitive abilities, as measured by a series of neuropsychological tests, are predicted to be the same for normal children and mentally retarded children when they are equated on mental age. In essence, the rate of acquiring a developmental skill and the final level of ability will differ , but the sequences of cognitive development will be

TABLE 1

CATEGORIZATION OF DEPENDENT MEASURES

Motor Tactile-Perceptual	Non-Verbal Cognitive	Verbal Cognitive
Grip Strength	Object Assembly	Sentence Memory
Finger Tapping	Block Design	Peabody Picture Vocabulary Test Raw Score
Maze Co-ordination	Tactual Performance Test Memory	Vocabulary
Tactile Finger Recognition	Tactual Performance Test Total Time	Auditory Closure
		Verbal Fluency
		Speech Sounds Perception

similar for both normal and retarded children.

2) In a reading disabled population, the patterns of cognitive ability, as measured by a series of neuropsychological tests, are predicted to be the same for older disabled readers and younger normal readers when they are equated for reading ability. The rate of acquiring a developmental skill and the magnitude of any observed differences are predicted to vary with chronological age and the developmental rate of the attribute processed. The final level attained is dependent upon the child's ability to catch-up before the developmental rate diminishes at adolescence. However, the sequences of cognitive development are expected to be similar for both normal and disabled readers. Thus, the older disabled reader will read in a manner similar to that used by the younger normal reader.

Adherents to the cerebral deficit model would argue in support of the following expectations:

1) In a mentally retarded population, the patterns of performance on a series of neuropsychological tests are predicted to be different than the patterns of performance for normal children, i.e., not only the rate of acquiring a developmental ability and its final level will differ but the cognitive development sequences in the retarded child will vary from that expected within a normal population.

2) In a reading disabled population the patterns of performance on a series of neuropsychological tests are predicted to be different than the patterns of performance predicted for normal readers. (Particularly on those complex abilities, reading and language-related, thought to be subserved by the left hemisphere). Thus, rate and

level of a developmental ability may vary from that expected within a normal population, especially for more complex language related abilities. Also, cognitive stages or sequences are predicted to differ in the learning disabled child (assuming an underlying cerebral dysfunction) from those observed in the normal child.

Based on these considerations, some differential predictions may be derived that would provide support for one or the other model. The research on familial, non-institutionalized retardates strongly indicates that the performance of these children is similar to that of the normal child (e.g., Rourke, 1981a; Weisz & Zigler, 1979; Zigler, 1969). Thus, normal and mentally retarded children who are equated on mental age are expected to perform similarly on cognitive tasks when they are equated on cognitive ability, i.e., mental age.

However, comparisons between normal children and mentally retarded children on motor measures are expected to differ, i.e., motor measures will reflect age dependent developmental gains. Clausen (1966) found that Strength of Grip was closely related to chronological age. He also found that performance for different chronological aged retardates (ages 8-10, 12-15, 20-24) on other motor variables, e.g., finger tapping speed, closely approximated the control sample who were between 8-10 years of age. Because Clausen's data was collected on institutionalized retardates of differing etiologies, his results may not be applicable to non-institutionalized, familial retardates.

Furthermore, there is no viable basis for making a specific prediction about the performance of the familially mentally retarded on Tactile Finger Recognition. However, it is expected that their performance will be equal to the normal children.

In reference to the normal and disabled readers, it is also expected that motor measures will reflect developmental gains, i.e., there is no evidence that disabled readers will perform poorer on these measures than normal readers. There is variable evidence for predictions concerning performance on Tactile Finger Recognition. Fletcher, Taylor, Morris, and Satz (1981c) found that normal readers were superior to dyslexic children in kindergarten on Tactile Finger Recognition. However, by the end of Grade 2 (usually at age 7-8), there were no significant group differences on Tactile Finger Recognition. On the other hand, Reed (1968) found that children at age 10 with predominantly right-handed errors on finger agnosia were poorer readers than were those children with predominantly left-sided errors. In addition, Fisk and Rourke (1979) established that certain subtypes of disabled readers were differentiated by poor performance on Tactile Finger Recognition. Moreover, Rourke (1976b) has suggested that findings on Tactile Finger Recognition may be influenced by inadequate test ceilings. Thus, no specific predictions are made for the disabled readers in the present study. Hopefully, the findings may shed some light on the relationship of Tactile Finger Recognition, chronological age and reading level.

It is also expected that comparisons of normal and disabled readers on non-verbal cognitive tasks that are not dependent on reading related skills will also reflect developmental gains related to age (Rourke, 1976b). Finally, verbal cognitive measures are expected to be variable and non-linear, reflecting the different cognitive abilities underlying the dyslexic readers' means for handling information (Rourke, 1981b).

The following hypotheses were tested using 3 groups of children. One normal group of children, (age 7-8) were used as a comparison group. These normal children were compared to young mentally retarded (mean age = 10.73), and old mentally retarded children (mean age = 12.52), after equating for mental age (mean mental age = 8.49). The same normal children (age 7-8) were also compared to disabled readers at 9-10, 10-11, 11-12 and 12-13 years of age, after equating for reading level at grade 2.

Statement of Hypotheses

Mentally Retarded Children Compared to Normal Children

Hypotheses: 1) Motor, Tactile-perceptual. It is predict that significant differences will occur on motor measure scores as a function of developmental gains associated with chronological age, i.e., normal children, < young mentally retarded children, < old mentally retarded children. No significant differences are predicted for tactile finger recognition, i.e., normal children = young mentally retarded children = old mentally retarded children.

2) Non-verbal cognitive. It is predicted that the scores obtained on the non-verbal measures will not significantly differentiate between the groups, thus reflecting their equation for mental age, i.e., normal children = young mentally retarded children = old mentally retarded children.

3) Verbal-cognitive. It is predicted that the scores obtained on the verbal measures will not significantly differentiate between the groups, thus reflecting their equation for mental age, i.e., normal children = young mentally retarded children = old mentally retarded children.

Reading Disabled Children Compared to Normal Readers

Hypotheses: 1) Motor, Tactile-perceptual. It is predicted that significant differences will occur on motor measure scores as a function of developmental gains associated with chronological age, i.e., normal readers (age 7-8), < 9-, < 10-, < 11-, < 12-year-old-disabled readers. No specific predictions are made for scores on tactile finger recognition.

b) Non-verbal cognitive. It is predicted that significant differences will occur on non-verbal measure scores as a function of developmental gains associated with chronological age, i.e., normal readers (7-8 years), < 9-, < 10-, < 11-, < 12-year-old-disabled readers equated on reading level.

c) Verbal-cognitive. It is predicted that significant differences will occur on verbal measure scores. However, the performance of the disabled readers of varying ages is expected to be reflected in variable scores which do not increase as a function of developmental gains associated with age.

CHAPTER II

METHOD

Data Collection

Mentally retarded and reading disabled subjects were drawn from the clinical files of a neuropsychology service in a large urban childrens' mental health clinic serving a catchment area of three counties. Children are referred to this clinic for neuropsychological assessment because of academic difficulties or other adaptive problems suspected to be due largely to some form of cerebral impairment. Each subject had received a standardized comprehensive battery of neuropsychological measures, administered in a standardized manner, by highly trained psychometrists (Rourke, 1976a, 1978).

The normal readers were not part of the above data base referred to the center. They were part of a longitudinal study begun in 1969 in which a population of normal readers (ages 7-8) were drawn from an urban school system and administered the same comprehensive battery noted above, also by trained psychometrists (Ridgley, 1970).

Because the administration and scoring of the test battery takes approximately eight hours per subject, it was decided to use this well documented and carefully collected data base in the present study.

Subjects

Thirty-three normal readers (ages 7-8 yrs, males) were selected from the longitudinal data collected by Ridgley (1970). The mentally retarded children (n = 38) and the reading disabled children (n = 24 for each age group, all males) were drawn from the above mentioned data base.

All children included in the study met the following criteria:

1) they were not in need of psychiatric intervention because of socio-emotional disturbances;

2) they spoke English as their primary language in home and school;

3) they did not suffer from uncorrected visual acuity problems or significant hearing losses;

4) they did not have a history of medically documented cerebral trauma or neurological dysfunction;

5) they had attended school regularly since approximately the age of six years;

6) they were not judged to be culturally deprived.

Mentally retarded. In addition, the mentally retarded children were further defined as non-institutionalized, with a full scale IQ (Wechsler, 1949) $\leq$ 80 but $\geq$ 55. The mentally retarded children were matched for mental age (derived from the Wechsler scales) with the normal children.

Reading disabled. The reading disabled children had a full scale IQ between 90 and 115, and were equated for reading level (using the Wide Range Achievement Test) with the normal readers. Four age-groups of reading disabled children (ages 9-10, 10-11, 11-12, 12-13) were compared to the normal readers (age 7-8).

Normal readers. All normal readers were rated as average with respect to school performance by their teachers and principals. They also had obtained a percentile score of 50 or more on the Reading subtest of the Metropolitan Achievement Test (Ridgley, 1970). Their IQs ranged from 90-117, with two children having IQs above 115.

Criterion Measures for Subject Selection

Wide Range Achievement Test (WRAT). This is a widely used test for evaluation of academic achievement and consists of three parts: Reading (word recognition), Spelling, and Arithmetic. Scores may be obtained in three ways, grade-equivalent scores, percentile scores and standard scores (Jastak & Jastak, 1965). Grade-equivalent scores were chosen as a means of equating normal readers with the different age groups of disabled readers.

Wechsler Intelligence Scale for Children (WISC). This test is widely used and needs no introduction here. The formula for calculating mental age (MA) was based on a method described by Wechsler, i.e., $MA = \frac{IQ \times CA}{100}$ (Wechsler, 1949).

Test Measures

Motor Tactile Perceptual

Grip strength (GRIPM). Measurements of grip strength were made with each hand for each subject using a Smedley Hand Dynamometer. Two trials were given for each hand and a mean score obtained for each hand (Reitan & Davison, 1974). Mean scores in kg. for both hands were obtained for each subject.

Finger tapping (FTAPM). This test is a measure of finger-tapping speed using a specially mounted, adapted, manual tapper. The apparatus is modified slightly for younger children (5-8 years) using an electronic counter and tapping key that does not traverse as wide an arc as that used for older children. Measurements are taken first with the index finger of the preferred hand and then with the non-preferred hand (Reitan & Davison, 1974). Mean number of taps in 10 seconds (3 trials each hand) were obtained for all subjects.

Maze co-ordination test (MAZCM). A modified maze is used (Lafayette Instrument Company, #2706A) so that blind alleys have been eliminated. The maze is placed on a stand in a vertical position directly in front of the subject. The test is administered in essentially the same way to younger children (5-8 years) except that the board is placed in a horizontal position. The subject is required to go through the maze with an electric stylus, trying not to touch the sides (Reitan & Davison, 1974). Scores were recorded for two right- and two left-hand trials. Mean scores for both hands were obtained for cumulative time of contact with the sides of the maze for all subjects.

Tactile Finger Recognition (TFR). This procedure tests the ability of the subject to identify individual fingers on each hand following tactile stimulation of each finger. The test is given without the subject's use of vision for identification. Four trials are used for each finger on each hand, yielding a total of 20 trials on each hand. The score is recorded as the number of errors for each hand (Reitan & Davison, 1974). Mean error scores were obtained for all subjects.

Non-Verbal Cognitive

Object Assembly (OBJASS). This subtest of the WISC requires the subject to manipulate the disarranged parts of four formboards. It is necessary to arrange the parts in a spatially meaningful way to make a whole. The total score depends on speed and accuracy of block placement (Wechsler, 1949). The total number correct was obtained for each subject.

Block Design (BLKDES). This subtest of the WISC required the subject to arrange coloured blocks to form designs which match those on printed cards. The stimuli are 10 printed geometric designs. The score obtained depends on speed and accuracy of block placement (Wechsler, 1949). The total number correct was obtained for all subjects.

Sentence Memory (SENMEM). This test consists of a series of 25 sentences, the first being just one word but then the sentences get progressively longer. The sentences are presented on a tape recorder. After presentation, the subject must repeat the sentence. Total scores for the number of correct sentences repeated were obtained for each subject.

Tactual Performance Test (TPTMEM, TPTTT). The Tactual Performance Test utilizes a modification of the Seguin-Goddard form board. The subject is blindfolded before the test begins and is not permitted to see the form board or blocks at any time. His/her task is to fit the blocks into their proper spaces on the board using only her/his preferred hand. After having completed this task and without having been given prior warning, he/she is asked to perform the same task using her/his nonpreferred hand only. Finally, she/he is asked to do the task a third time using both hands. After the board and blocks have been put out of sight, the blindfold is removed; and, the subject is asked to draw a diagram of the board representing the blocks in their proper spaces. This drawing is scored according to Memory and Localization components. The Memory component is based upon the number of blocks correctly reproduced in the drawing (Reitan & Davison, 1974). Memory component scores were obtained for each subject. Total time recorded is the time taken to complete the task with the dominant hand plus the non-dominant hand plus both hands. Mean total time scores were obtained for each subject.

Verbal Cognitive

Peabody Picture Vocabulary Test (PPVTRS). This test measures vocabulary by requiring the subject to identify the picture named by the examiner (Dunn, 1959). The total number correctly named was obtained for all subjects.

Vocabulary (VOCAB). This subtest of the WISC requires the subject to define 40 spoken words. The score depends on the number of correct definitions. The total number correct was obtained for each subject.

Verbal Fluencey (VFLU). In this test the subject is required to name as many words as she/he can which start with the sounds "P" and

"C". For each sound there is a 60-second time limit. Scores for the total number of correct words produced for both sounds were obtained for each subject.

Auditory Closure (AUDCLO). This is a test of sound blending. The purpose is to present progressively longer chains of sound elements which the subject must blend into words. Sounds are presented on a tape recorder. Scores for the total number of correctly reproduced words were obtained for each subject.

Speech Sounds Perception (SSPER). The Speech-sounds Perception Test consists of 60 spoken nonsense words, the beginning and ending consonant sounds of which vary while their "ee" vowel sound remains constant. The test is played from a tape recorder with the intensity of sound adjusted to meet the subject's preference. The subject's task is to underline the spoken syllable, selecting from the three alternatives printed for each item of the test form. This test requires the subject to maintain attention through 60 items, to perceive the spoken stimulus-sound through hearing, and to relate the perception through vision to the correct configuration of letters on the test form (Reitan & Davison, 1974). The number of correct sounds perceived were obtained for each subject.

Selection of Subjects

Study I. All 33 normal children were included in the comparison between normal and mentally retarded children. The mental ages for the normal children ranged from 7 years to 9 years 6 months, with a mean age of 8 years 2 months. The accuracy of the formula MA x CA/100 was compared to an alternate method recommended by Wechsler (1949), i.e., comparing the raw score obtained on each subtest to subtest age-equivalent scores. Both methods were used on a sample of 19 subjects; a pearson product moment correlation of .976 was obtained.

The mentally retarded children were selected from over 3000 cases to meet the criterion for mental age as well as the previously stated criteria for subject selection. Of these, 55 met the criteria for ages 9-11 (the younger group), and 24 met the criteria for ages 12-14. Subjects with missing test scores were deleted from the younger group. Thirty-three children were chosen randomly from the remaining 43 cases.

In the older group, those subjects with 3 or more missing test scores were deleted, narrowing the group to 15. Of these 15, six had 1 to 3 missing test scores.

Because three WISC subtests were used as dependent measures, the FSIQ was calculated on a pro-rated basis excluding Vocabulary, Block Design and Object Assembly. Mental age was then calculated for each subject using the pro-rated IQ. Means and standard deviations are presented for the three groups on the pro-rated IQ and the criterion value of mental age (Table 2).

Homogeneity of variance was evaluated for all pairwise comparisons on mental age and IQ using Hartley's Fmax statistic (Winer, 1962). The hypothesis of homogeneity of variance was achieved for all pairs. However, even though not statistically significant, the mean mental age for the young mentally retarded children was almost a year lower than the mean mental age for the older mentally retarded children, 7.954 for the former and 8.893 for the latter. Ten children in the younger group with mental ages of

TABLE 2

MEANS AND STANDARD DEVIATIONS (S.D.) FOR THE NORMAL CHILDREN, YOUNG MENTALLY RETARDED CHILDREN (MR) AND THE OLDER MENTALLY RETARDED CHILDREN (MR) ON PRO-RATED FULL SCALE INTELLIGENCE QUOTIENTS (FSIQ) AND MENTAL AGE (M.A.)

Group	FSIQ	M.A.
	Mean (S.D.)	Mean (S.D.)
Normal (n=33)	107.303 (6.735)	8.263 (0.647)
Young MR (n=23)	77.478 (5.221)	8.326 (0.643)
Old MR (n=15)	71.666 (6,837)	8.893 (0.856)

7.3 and below were dropped. The remaining 23 children had a mean mental age of 8.326.

Study II. Twenty-four normals were selected from the normal reading group. Those with WRAT reading grade levels of 2.0 and below and 5.0 and above were excluded to reduce the variation in the sample. Twenty-four subjects remained with WRAT reading grade scores between 2.6 and 4.7.

Reading disabled subjects who achieved at a WRAT reading grade level between 2.6 and 4.7, as well as meeting the previously stated criteria were selected from over 3000 cases. An additional selection criterion was added, i.e., that all WRAT scores be based on the 1965 norms. Twenty-four subjects were then selected randomly from 72 nine-year-olds, 59 ten-year-olds, and 52 eleven-year-olds. Only 24 twelve-year-olds met all the criteria. Because three WISC subtests, Vocabulary, Block Design and Object Assembly are dependent measures, the FSIQ was calculated on a pro-rated basis excluding the three subtests. Means and standard deviations for reading grade level and pro-rated IQ are presented in Table 3.

Homogeneity of variance was evaluated for all possible pairwise comparisons on IQ and WRAT reading grade level using Hartley's Fmax statistic (Winer, 1962). The hypothesis of homogeneity of variance was achieved for all pairs.

TABLE 3

MEANS AND STANDARD DEVIATIONS (S.D.) FOR ALL READING GROUPS (NORMAL READERS, NINE-, TEN-, ELEVEN-, AND TWELVE-YEAR-OLD DISABLED READERS) ON PRO-RATED FULL SCALE INTELLIGENCE QUOTIENT (FSIQ) AND READING GRADE LEVEL

Group	FSIQ	Reading Grade Level
	Mean (S.D.)	Mean (S.D.)
Normal (n=24)	107.583 (6.921)	3.837 (0.688)
Nine (n=24)	99.500 (6.206)	3.300 (0.602)
Ten (n=24)	96.291 (5.614)	3.450 (0.719)
Eleven (n=24)	96.625 (7.740)	3.870 (0.609)
Twelve (n=24)	96.125 (5.643)	4.016 (0.588)

CHAPTER III

RESULTS

The results of the comparison of the normal children with the younger and older mentally retarded children is presented first. Following this are the analyses resulting from the comparison of the normal readers (age 7-8) with the disabled readers at 9, 10, 11 and 12 years of age. A priori predictions were made for most dependent measures and thus, performance means were graphed whether or not significant mean differences occurred with the overall F test.

Combined on the same graph for each individual dependent measure are performance means for the normal children, disabled readers, and mentally retarded children. The same normal children were used as a comparison group for the disabled readers and mentally retarded children. Their performance means were graphed only once. In addition, normative data for the age groups represented in the study was presented as a meaningful reference point for the reader (Dunn, 1965; Knights, 1970; Wechsler, 1949). These means are presented in Appendix A and all means are graphed in Figures 3 to 9.

Comparisons Between Normal and Mentally Retarded Children

Summary statistics are presented for the normal and mentally retarded children in Table 4. All multivariate comparisons yielded significant group differences. Analyses of variance were then computed on the three categories of dependent measures, motor tactile-perceptual,

TABLE 4

MEANS AND STANDARD DEVIATIONS (SD) FOR NORMAL CHILDREN, YOUNG MENTALLY RETARDED CHILDREN (YOUNG MRS) AND OLD MENTALLY RETARDED CHILDREN (OLD MRS) ON AGE AND ALL DEPENDENT MEASURES[1]

Variable	Normal (n = 33)	Young MRS (n = 23)	Old MRS (n = 15)
AGE	7.710 (0.291)	10.738 (0.815)	12.527 (0.551)
GRIPM	12.175 (2.337)	12.953 (4.310)	17.651 (4.951)
FTAPM	31.265 (9.370)	30.103 (3.451	34.580 (5.047)
MAZCM	41.878 (16.526)	50.434 (23.128)	41.800 (18.186)
TFR	1.621 (1.494)	1.978 (1.360)	2.107 (2.202)
OBJASS	18.545 (3.401)	15.869 (4.975)	19.000 (5.529)
BLKDES	12.757 (7.750)	9.608 (4.933)	11.400 (4.404)
TPTMEM	4.454 (1.276)	3.608 (1.437)	3.800 (1.207)
TPTT	13.039 (5.146)	13.450 (7.088)	10.477 (5.389)
SENMEM	12.545 (2.476)	10.826 (2.534)	10.727 (2.649)
PPVTRS	69.757 (6.026)	69.217 (9.704)	75.333 (12.051)
VOCAB	22.090 (5.216)	23.260 (5.029)	26.333 (5.984)
VFLU	6.863 (2.359)	4.804 (2.579)	5.727 (2.04)
AUDCLO	13.454 (3.500)	10.086 (4.631)	9.727 (5.159)
SSPER	22.575 (3.509)	17.260 (5.840)	21.538 (4.254)

[1]Abbreviations are defined in the Method section under "Dependent Measures."

non-verbal cognitive, and verbal cognitive. Scheffé's multiple comparisons using the F test were performed on all means (Ferguson, 1959). The significant means are presented in Appendix B.

Motor tactile-perceptual measures. Significant group differences were found for Strength of Grip, F (2, 67) = 12.74, p = .0001. There were no significant differences found for the remaining three dependent measures in this category, i.e., Maze Stylus Contacts, Finger Tapping Speed and Tactile Finger Recognition (Table 5).

All performance means were then compared using Scheffé's F test for multiple pair-wise comparisons (Ferguson, 1959). Because of missing data, the number of old mentally retarded children was 14 in these pair-wise comparisons. Significant mean differences were evident between the old mentally retarded and normal children, and the old mentally retarded and young mentally retarded children on Strength of Grip. No other pair-wise comparisons were significant in this category (Figures 3 and 4, see also Appendix B).

Non-verbal cognitive. Analysis of variance resulted in a significant F for Object Assembly, F (2, 68) = 3.18, p = .04, and Tactual Performance Test-Memory Component, F (2, 68) = 3.11, p = .05. Neither Block Design nor Tactual Performance Test Total Time significantly differentiated the three groups (Table 6).

Again, all performance means were compared using Scheffé's F test. No significant differences resulted from all possible pair-wise comparisons (Figures 5 and 6, see also Appendix B).

Verbal cognitive. The following measures had significant F values: Sentence Memory, F (2, 62) = 4.16, p = .02; Verbal Fluency, F (2, 62) = 5.08, p = .009; Auditory Closure, F (2, 62) = 5.15, p =

TABLE 5

ANALYSIS OF VARIANCE FOR NORMAL CHILDREN, YOUNG MENTALLY RETARDED CHILDREN AND OLD MENTALLY RETARDED CHILDREN ON GRIP STRENGTH (GRIPM), FINGER TAPPING SPEED (FTAPM), MAZE CONTACT (MAZCM) AND TACTILE FINGER RECOGNITION (TFR)

Variable	df	*F* value	*p*
GRIPM	67	12.74	.0001
FTAPM	67	1.63	.2045
MAZCM	67	1.46	.2393
TFR	67	0.58	.5647

TABLE 6

ANALYSIS OF VARIANCE FOR NORMAL CHILDREN, YOUNG MENTALLY RETARDED CHILDREN AND OLD MENTALLY RETARDED CHILDREN ON OBJECT ASSEMBLY (OBJASS), BLOCK DESIGN (BLKDES), TACTUAL PERFORMANCE TEST MEMORY COMPONENT (TPTMEM) AND TACTUAL PERFORMANCE TEST TOTAL TIME (TPTTT)

Variable	df	F value	p
OBJASS	68	3.18	.04
BLKDES	68	1.67	.19
TPTMEM	68	3.11	.05
TPTTT	68	1.30	.27

.008; and Speech Sounds Perception, F (2, 62) = 9.40, p = .0003. Peabody Picture Vocabulary Test Raw Scores and WISC Vocabulary did not significantly differentiate the three groups (Table 7).

Scheffé's pair-wise comparisons were performed on all means using the F test. Because of missing data, the number of old mentally retarded children was nine in this category. Significant mean differences were found between the normal children and the young mentally retarded children on Verbal Fluency, and the normal children and the young mentally retarded children on Speech Sounds Perception (Figures 7 to 9, see also Appendix B).

Comparisons Between Normal and Disabled Readers

The following are the comparisons of the normal reading group, at 7-8 years of age, with the disabled readers, at 9, 10, 11 and 12 years of age (all groups, n = 24). Means and standard deviations are presented in Table 8 for age and all dependent measures for the five groups. All multivariate comparisons yielded significant group differences. Analyses of variance were then computed for all categories of dependent measures, motor tactile-perceptual, non-verbal cognitive, and verbal cognitive. Mean differences on all dependent measures were compared using a Neuman-Keul's procedure (Winer, 1962). The significant means are graphed in Appendix C.

Motor tactile-perceptual. Significant mean group differences were found for Strength of Grip, F (4, 115) = 12.19, p = .0001; Finger Tapping Speed, F (4, 115) = 3.62, p = .008; and Maze Stylus Contacts, F (4, 115) = 6.75; p = .0001. Mean group differences were not significant for Tactile Finger Recognition (Table 9).

TABLE 7

ANALYSIS OF VARIANCE FOR NORMAL CHILDREN, YOUNG MENTALLY RETARDED CHILDREN, AND OLD MENTALLY RETARDED CHILDREN ON SENTENCE MEMORY (SENMEM), PEABODY PICTURE VOCABULARY TEST RAW SCORES (PPVTRS), VOCABULARY (VOCAB), VERBAL FLUENCY (VFLU), AUDITORY CLOSURE (AUDCLO), AND SPEECH SOUNDS PERCEPTION (SSPER)

Variable	df	*F* value	*p*
SENMEM	62	4.16	.02
PPVTRS	62	0.55	.57
VOCAB	62	2.20	.11
VFLU	62	5.08	.009
AUDCLO	62	5.15	.008
SSPER	62	9.40	.0003

TABLE 8

MEANS AND STANDARD DEVIATIONS (SD) FOR NORMAL READERS, NINE-, TEN-, ELEVEN-, AND TWELVE-YEAR-OLD DISABLED READERS ON AGE AND ALL DEPENDENT MEASURES[1]

Variable	Group: Normals	Nine	Ten	Eleven	Twelve
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age	7.705 (0.279)	9.510 (0.268)	10.503 (0.313)	11.458 (0.284)	12.385 (0.287)
GRIPM	12.034 (2.426)	13.882 (3.573)	14.658 (3.612)	17.714 (4.838)	18.801 (4.627)
FTAPM	32.170 (10.829)	32.647 (3.493)	33.610 (5.083)	35.919 (5.144)	38.173 (5.176)
MAZCM	42.354 (16.732)	40.229 (23.618)	35.375 (16.324)	28.270 (14.176)	20.895 (9.311)
TFR	1.645 (1.363)	1.250 (1.687)	1.375 (2.173)	0.812 (0.975)	1.062 (1.603)
OBJASS	18.625 (3.372)	19.750 (4.618)	22.083 (4.373)	24.625 (3.281)	25.541 (3.230)
BLKDES	13.250 (7.355)	19.416 (8.642)	21.583 (9.969)	27.458 (12.321)	32.666 (9.540)
TPTMEM	4.333 (1.372)	4.166 (1.239)	4.250 (1.073)	4.458 (1.444)	5.083 (0.775)
TPTT	13.394 (5.319)	9.673 (3.581)	8.747 (3.60)	7.095 (3.342)	6.617 (3.646)
SENMEM	12.541 (1.999)	11.416 (2.668)	12.166 (2.371)	13.00 (2.085)	13.375 (2.481)
PPVTRS	69.333 (5.806)	75.414 (8.642)	79.250 (7.803)	85.458 (7.040)	85.208 (6.317)

Continued

TABLE 8 CONTINUED

	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
VOCAB	21.833 (5.813)	29.875 (4.693)	32.458 (3.488)	34.250 (4.793)	36.250 (3.602)
VFLU	6.708 (2.047)	7.029 (2.432)	7.437 (2.237)	7.312 (2.510)	7.645 (2.783)
AUDCLO	13.250 (3.151)	13.750 (3.590)	12.333 (3.305)	14.125 (3.369)	14.00 (4.549)
SSPER	22.00 (3.587)	21.125 (3.468)	20.708 (2.911)	22.625 (2.715)	21.833 (3.737)

[1]Abbreviations are defined in the Method section under "Dependent Measures."

TABLE 9

ANALYSIS OF VARIANCE FOR NORMAL AND DISABLED READERS ON GRIP STRENGTH (GRIPM), FINGER TAPPING SPEED (FTAPM) MAZE CONTACT (MAZCM), AND TACTILE FINGER RECOGNITION (TFR)

Variable	df	*F* value	*p*
GRIPM	115	12.19	0.0001
FTAPM	115	3.62	0.0081
MAZCM	115	6.75	0.0001
TFR	115	0.92	0.4556

Pair-wise comparisons were conducted on ordered means using the Neuman-Keuls method (Winer, 1962). On Strength of Grip, significant mean differences occurred for ages 12 and 8, ages 12 and 9, and ages 12 and 10; and for ages 11 and 8, ages 11 and 9, and ages 11 and 10. On Finger Tapping Speed, significant mean differences were found for ages 12 and 8, ages 12 and 9, and ages 12 and 10. On Maze Stylus Contacts, significant mean differences were found for ages 12 and 8, 12 and 9, and ages 12 and 10; also for ages 11 and 8, and ages 11 and 9. No mean differences were found for any mean comparisons on Tactile Finger Recognition (Figures 3 and 4, see also Appendix C).

Non-verbal cognitive. Significant mean group differences were found for Object Assembly, $\underline{F}$ (4, 115) = 14.71, $\underline{p}$ = .0001; Block Design, $\underline{F}$ (4, 115) = 14.21, $\underline{p}$ = .0001; and Tactual Performance Test-Total Time, $\underline{F}$ (4, 115) = 11. 10, $\underline{p}$ = .0001. Mean group differences were not significant for Tactual Performance Test-Memory Component (Table 10).

Pair-wise comparisons using the Neuman-Keul's method (Winer, 1962) resulted in significant mean differences on Block Design for ages 12 and 8, ages 12 and 9, and ages 12 and 10; for ages 11 and 8, ages 11 and 9, ages 11 and 10; and finally, for ages 10 and 8. On Object Assembly, significant mean differences were found for ages 12 and 8, ages 12 and 9, ages 12 and 10; for ages 11 and 8, ages 11 and 9, ages 11 and 10; and for ages 10 and 8. On Tactual Performance Test Total Time, significant mean differences were found for ages 12 and 8, and ages 12 and 9; for ages 11 and 8; for ages 10 and 8; and for ages 9 and 8. No significant mean differences were found on Tactual Performance Test-Memory Component (Figures 5 and 6, see also Appendix C).

Verbal cognitive. Overall significant mean group differences

TABLE 10

ANALYSIS OF VARIANCE FOR NORMAL READERS AND DISABLED READERS ON OBJECT ASSEMBLY (OBJASS), BLOCK DESIGN (BLKDES), TACTUAL PERFORMANCE TEST MEMORY COMPONENT (TPTMEM) AND TACTUAL PERFORMANCE TEST TOTAL TIME (TPTTT)

Variable	df	*F* value	*p*
OBJASS	115	14.71	.0001
BLKDES	115	14.21	.0001
TPTMEM	115	2.21	.072
TPTTT	115	11.10	.0001

were found for Sentence Memory, $\underline{F}$ (4,115) = 2.53, $\underline{p}$ = .04; Peabody Picture Vocabulary Test Raw Scores, $\underline{F}$ (4, 115) = 21.63, $\underline{p}$ = .0001; and Vocabulary, $\underline{F}$ (4, 115) = 36.22, $\underline{p}$ = .0001. There were no significant mean differences found for Verbal Fluency, Auditory Closure and Speech Sounds Perception (Table 11).

All means for all dependent measures were compared using a Neuman-Keul's procedure (Winer, 1962). Mean differences were evident on Sentence Memory for ages 12 and 9. On Vocabulary, significant mean differences were found for ages 12 and 8, ages 12 and 9, and ages 12 and 10; for ages 11 and 8, and ages 11 and 9; for ages 10 and 8; and for ages 9 and 8. On Peabody Picture Vocabulary Test Raw Scores, significant mean differences were found for ages 12 and 8, ages 12 and 9, and ages 12 and 10; for ages 11 and 8, ages 11 and 9, and ages 11 and 10; for ages 10 and 8; and for ages 9 and 8. No significant mean differences were found for any pair-wise comparisons on Verbal Fluency, Auditory Closure and Speech Sounds Perception (Figures 7 to 9, see also Appendix C).

TABLE 11

ANALYSIS OF VARIANCE FOR NORMAL READERS AND DISABLED READERS ON SENTENCE MEMORY (SENMEM), PEABODY PICTURE VOCABULARY TEST RAW SCORE (PPVTRS), VOCABULARY (VOCAB), AUDITORY CLOSURE (AUDCLO), VERBAL FLUENCY (VFLU) AND SPEECH SOUNDS PERCEPTION (SSPER)

Variable	df	*F* value	*p*
SENMEM	115	2.53	.044
PPVTRS	115	21.63	.0001
VOCAB	115	36.22	.0001
VFLU	115	.55	.699
AUDCLO	115	.94	.442
SSPER	115	1.24	.296

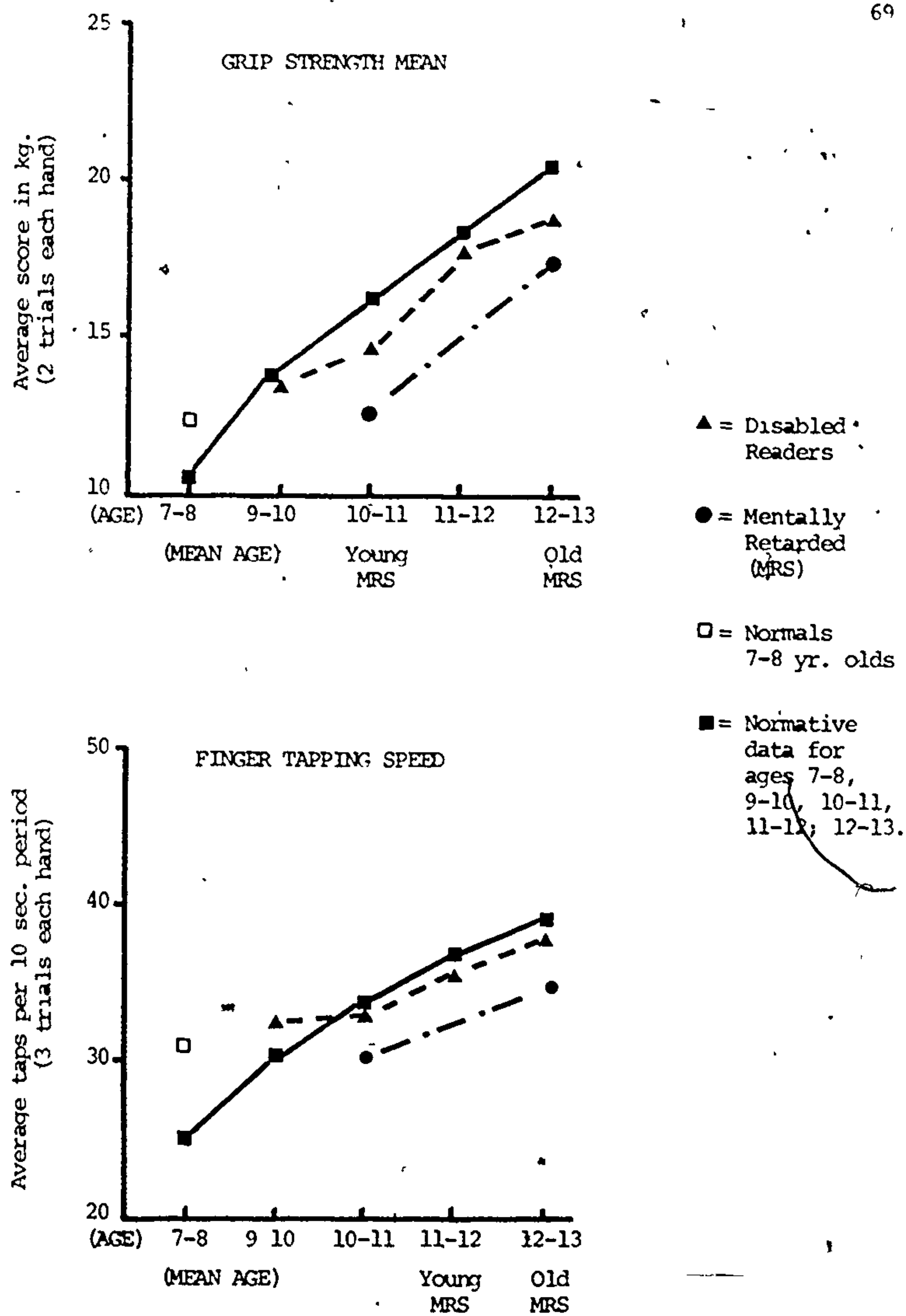

Figure 3. Mean performance scores for the normal (age 7-8), young mentally retarded (Mean age = 10.7), old mentally retarded (Mean age = 12.5) and reading disabled (ages 9, 10, 11, 12) children on Grip Strength and Finger Tapping Speed. Normative means for ages 7-8, 9-10, 10-11, 11-12 and 12-13.

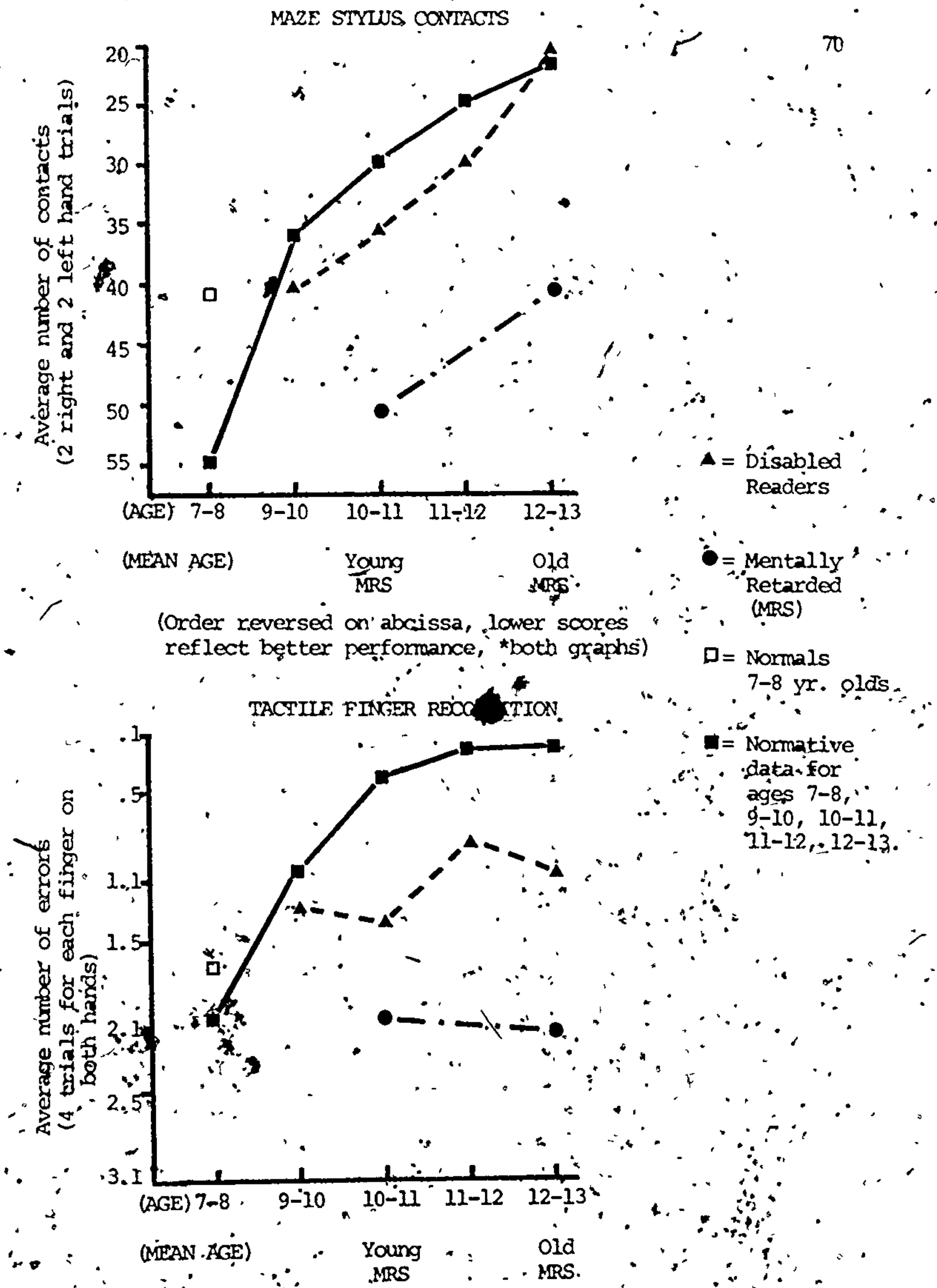

Figure 4. Mean performance scores for the normal (age 7-8), young mentally retarded (Mean age 10.7), old mentally retarded (Mean age = 12.5), and reading disabled (ages 9, 10, 11, 12) children on Maze Stylus Contacts and Tactile Finger Recognition. Normative means for ages 7-8, 9-10, 10-11, 11-12, and 12-13.

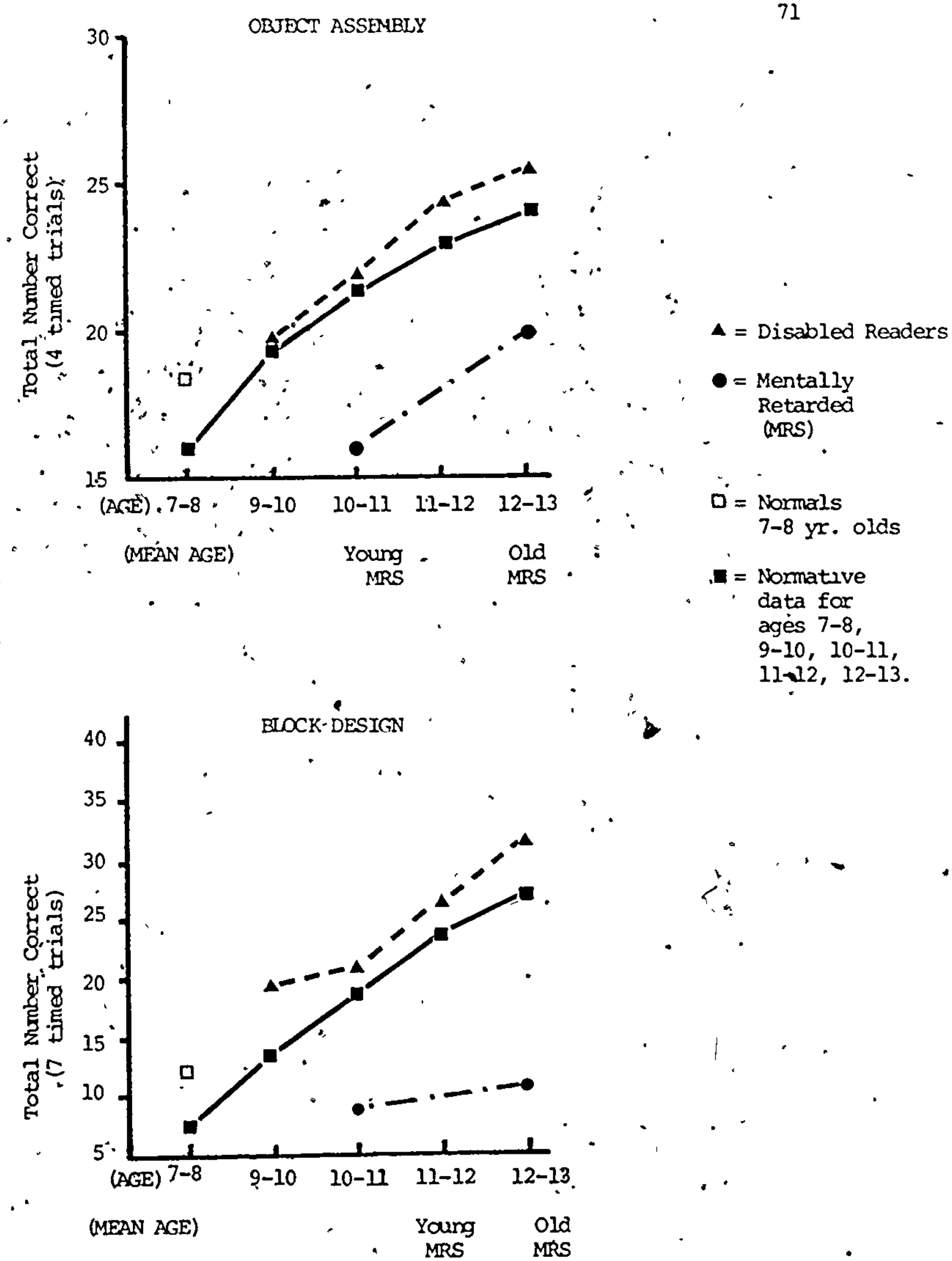

Figure 5. Mean performance scores for the normal (age 7-8), young mentally retarded (Mean age 10.7), old mentally retarded (Mean age = 12.5), and reading disabled (ages 9, 10, 11, 12) children on Object Assembly and Block Design. Normative means for ages 7-8, 9-10, 10-11, 11-12, and 12-13.

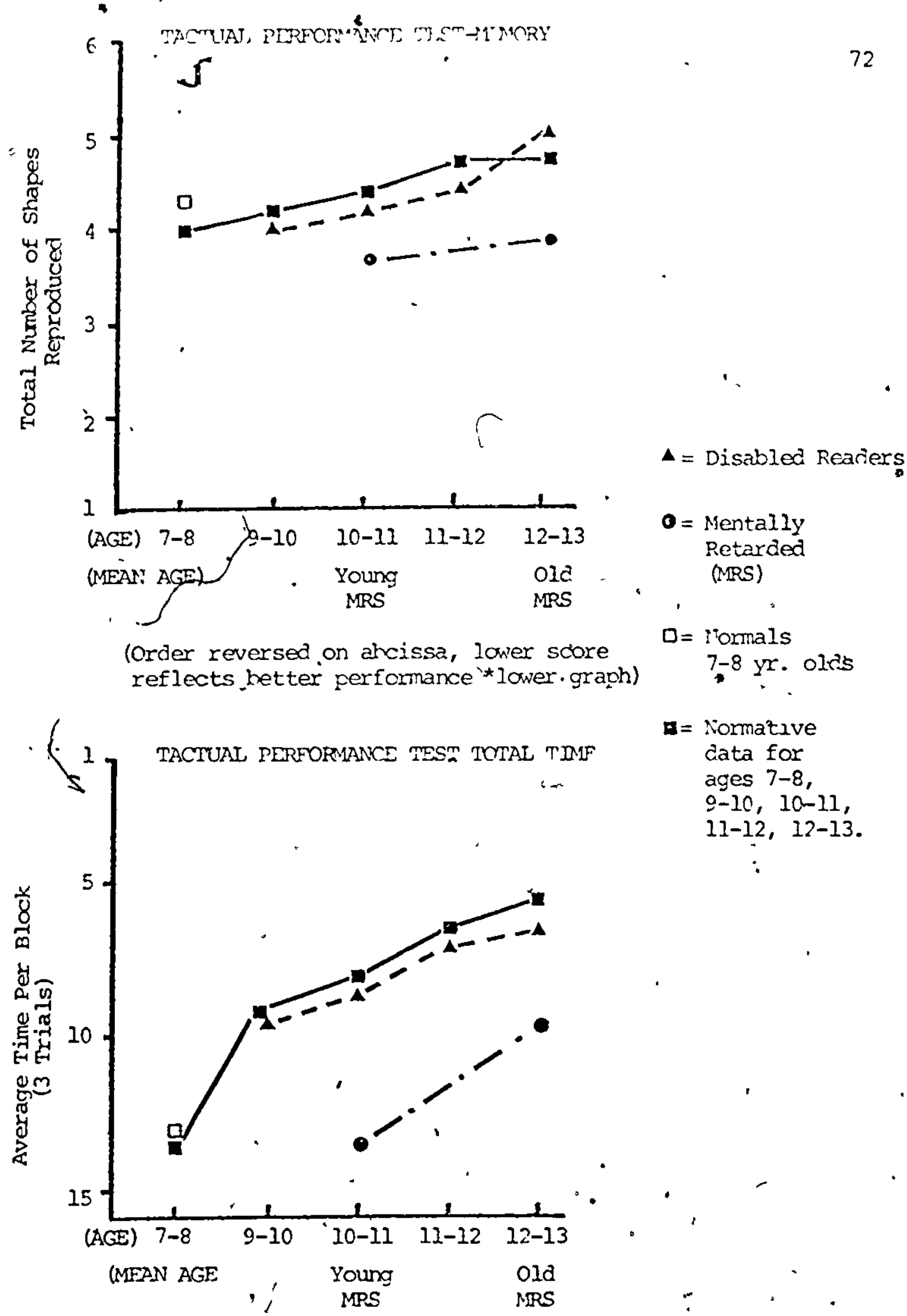

Figure 6. Mean performance scores for the normal (age 7-8), young mentally retarded (Mean age 10.7), old mentally retarded (Mean age = 12.5), and reading disabled (ages 9, 10, 11, 12) children on Tactual Performance Test-Memory Component, and Total Time. Normative means for ages 7-8, 9-10, 10-11, 11-12, and 12-13.

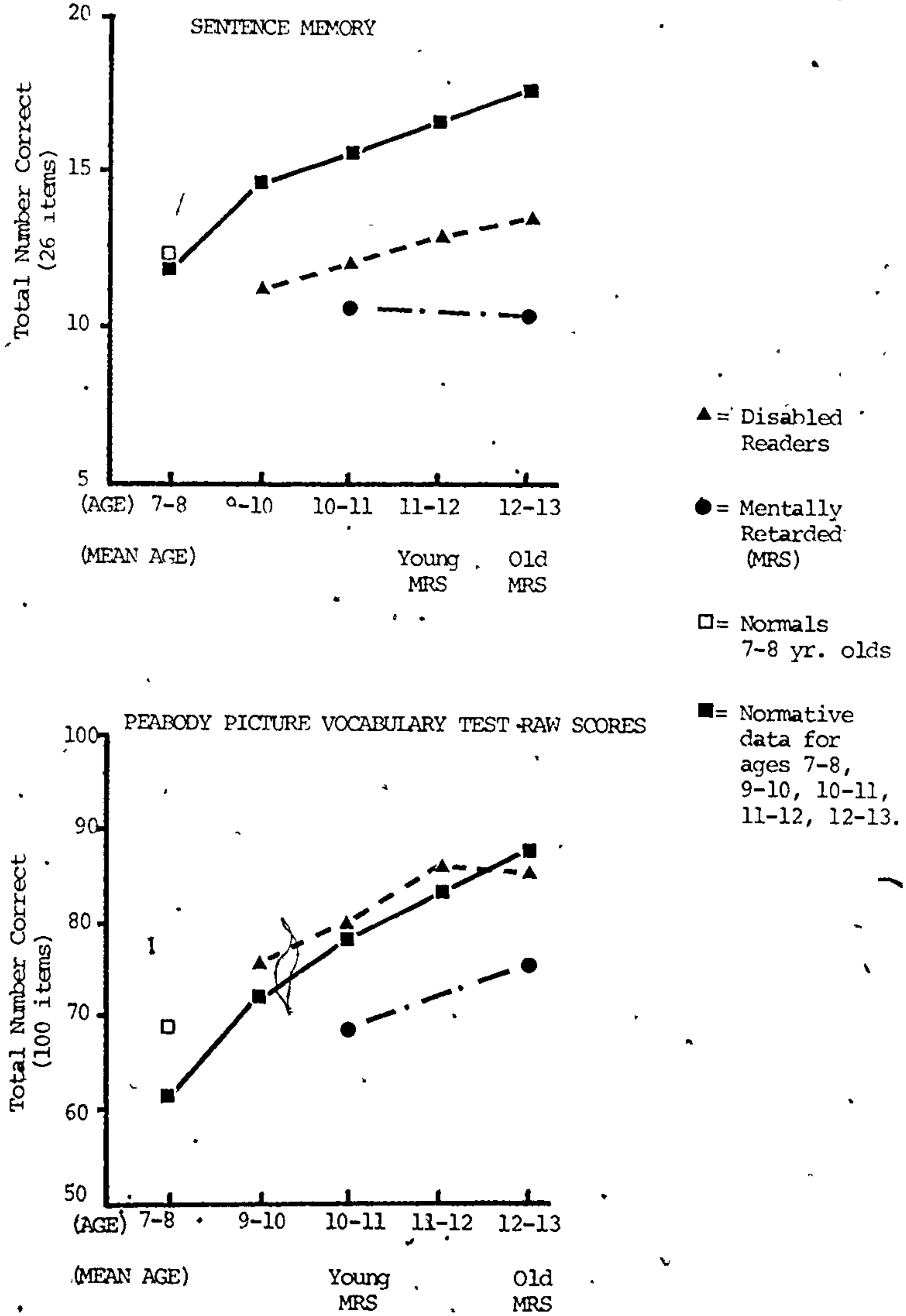

Figure 7. Mean performance scores for the normal (age 7-8), young mentally retarded (Mean age 10.7), old mentally retarded (Mean age = 12.5), and reading disabled (ages 9, 10, 11, 12) children on Sentence Memory and Peabody Picture Vocabulary Test Raw Scores. Normative means for ages 7-8, 9-10, 10-11, 11-12, and 12-13.

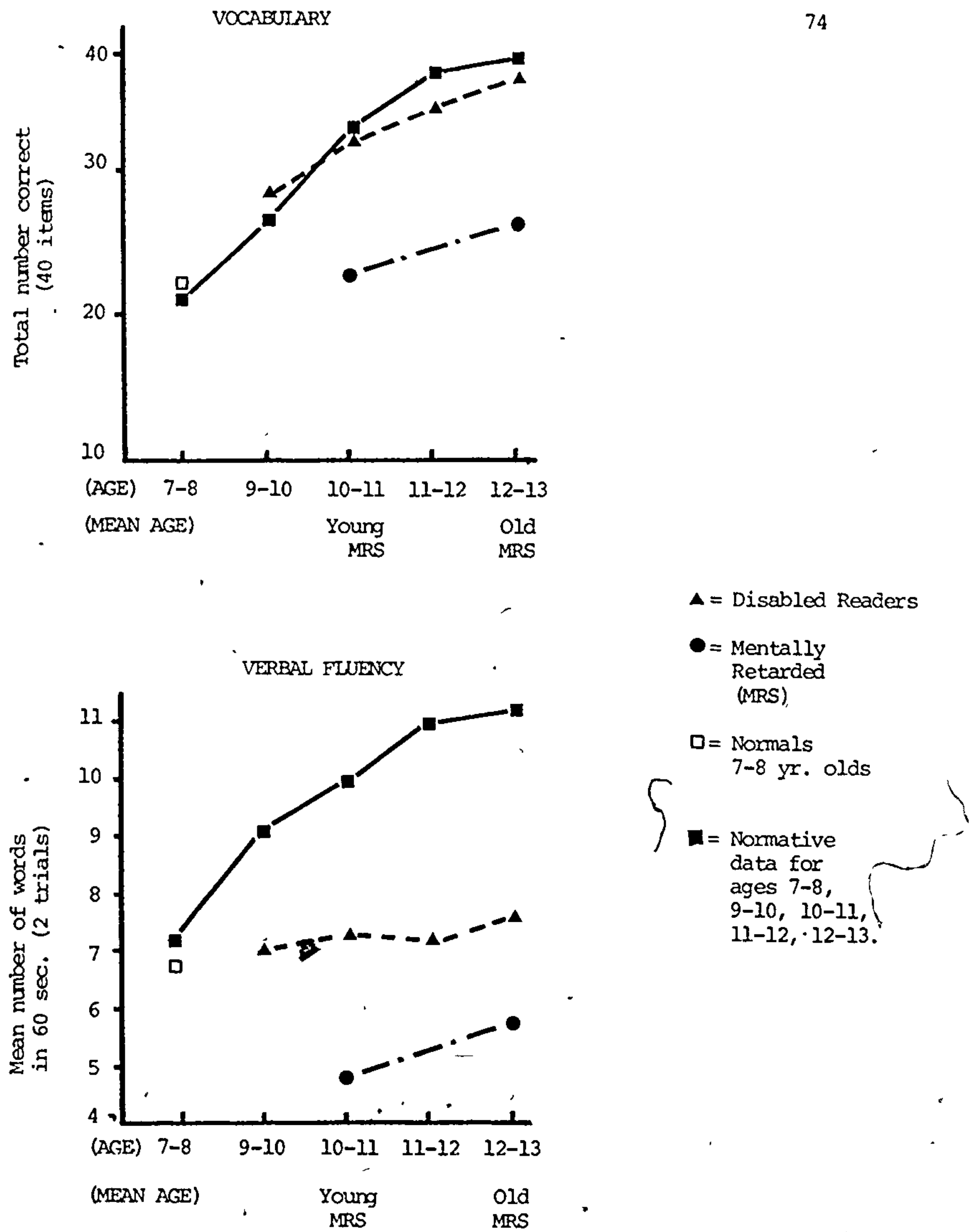

Figure 8. Mean performance scores for the normal (age 7-8), young mentally retarded (Mean age = 10.7), old mentally retarded (Mean age = 12.5) and reading disabled (ages 9, 10, 11, 12) for children on Vocabulary and Verbal Fluency. Normative means for ages 7-8, 9-10, 10-11, 11-12 and 12-13.

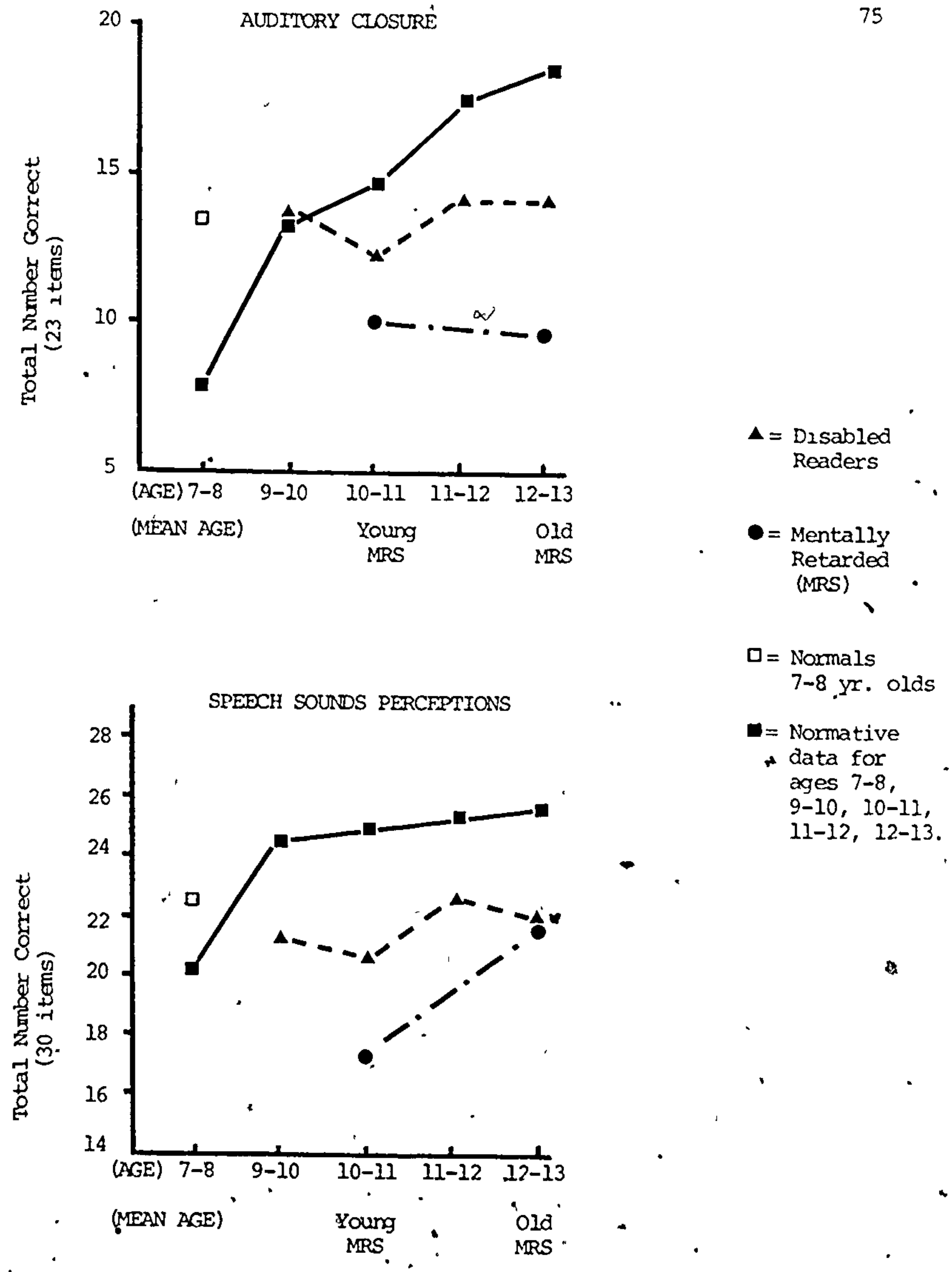

Figure 9. Mean performance scores for the normal (age 7-8), young mentally retarded (Mean age = 10.7), old mentally retarded (Mean age = 12.5) and reading disabled (ages 9, 10, 11, 12) children on Auditory Closure and Speech Sounds Perception. Normative means for ages 7-8, 9-10, 10-11, 11-12 and 12-13.

CHAPTER IV

DISCUSSION

The purpose of this study was to evaluate a similar sequence hypothesis and a deficit hypothesis as they are applied to research in mental retardation and reading disability. An attempt was made to compare mentally retarded children with normal children on a series of dependent measures, and to compare the same normal children with reading disabled children on the same dependent measures. Multivariate analyses of variance and pair-wise mean comparisons were carried out for each group.

In this chapter, the methodological limitations of this study will be discussed first. An evaluation of the findings in relation to the specific hypotheses will follow. Finally, the implications of this investigation will be examined, including suggestions for further research.

Methodological Limitations

Subject variables. A possible bias may have entered into the selection of subjects, in that, except for the normal readers, they had all been referred for a neuropsychological assessment. Specifically, mentally retarded children who are referred for neuropsychological assessments may be characteristically different from those familial retardates who are not referred. Another subject factor that may limit generalization of the findings is the limited number of subjects in the old mentally retarded group.

Criterion measures. The use of mental age as a measure of cognitive level also has limitations because we must first assume that intelligence tests tap basic cognitive processes and then that we can sum up these processes to make a statement about cognitive level. Considering these limitations, the WISC mental age is probably one of the best mental age measures available for assessing cognitive level.

In addition, the use of the WRAT reading grade level as a means of equating children on reading level is not entirely unproblematic. The WRAT reading subtest essentially requires the reader to pronounce increasingly more difficult words presented without the contextual cues in which reading usually takes place. We are assuming in the present study that this test makes accurate predictions about reading level. Support for the use of the WRAT stems from the fact that it is a widely used test with proven reliability and validity (Jastak & Jastak, 1965). Also, a reliable word-recognition test, even though limited in its ability to describe all of the dimensions of reading, is a viable and easily replicated procedure.

Design limitations. This study is also subject to the limitations imposed by a cross-sectional design. Making statements about age-related developmental skills would best be served within a longitudinal study. A longitudinal study from pre-school to late teens would certainly answer many questions about the universality of cognitive processes, the influence of environmental events and their interaction with internal events, etc.

Finally, it was beyond the scope of this study to consider the possibility of different subtypes in the reading disabled sample prior to selection. It seems likely that if different subtypes are included in the reading disabled sample there would be greater variability in that sample than might be obtained by more restrictive selection procedures (Fisk & Rourke, 1979; Satz & Morris, 1980).

Normal Children Compared to Retarded Children

Hypothesis 1: Motor tactile-perceptual. It was expected that performance on motor measures would increase as a function of chronological age. This prediction was supported for Strength of Grip. The old mentally retarded children scored significantly higher than both the normal children and the young mentally retarded children on this measure. However, no significant mean differences were found for Finger Tapping Speed and Maze Stylus Contacts, as had been predicted. Inspection of the data indicates that the old mentally retarded children performed better than the young mentally retarded children on all three tests, but these differences did not reach commonly accepted levels of statistical significance (Figures 3 and 4).

This finding seems to indicate that predictions for motor measures would have to take into account both gross and fine motor skills. Clausen's (1966) finding that Strength of Grip was related to chronological age was replicated. Contrary to expectations, fine and complex motor performances in the mentally retarded population were similar to the mean performances of the 7-8 year-old normals. This similarity in performance is in accord with Clausen's results, i.e., mentally retarded subjects (ages 8-10, 12-15, 20-24) did not differ from normal children (ages 8-10) on fine and complex motor tasks.

It may be that fine and complex motor activities are influenced by factors such as attention and motivation, which could affect success on these tasks. An alternative explanation might be that performance on fine and complex motor skills may also be interpreted within the similar sequence hypothesis, i.e., performance on these skills is a function of cognitive level, and equal-mental-age subjects would not be expected to demonstrate significant mean performance differences when compared to equal-mental-age normals.

No significant mean differences were found on Tactile Finger Recognition. Inspection of the data (Figure 4) indicates that the performance means of old and young mentally retarded children were not significantly different from those of the normal children. Performance levels on Tactile Finger Recognition for subjects in this study may also be a function of equation on mental age, and thus fit within the framework of the similar sequence hypothesis.

Hypothesis 2: Non-verbal cognitive. It was expected that normal children, young mentally retarded children, and old mentally retarded children, equated on mental age, would not be significantly differentiated on non-verbal measures. No significant mean differences were found on pair-wise comparisons between the three groups on Block Design, Object Assembly, Tactual Performance Test-Memory Component, and Tactual Performance Test-Total Time (see Figures 5 and 6). In addition, inspection of the data indicates that the mean performance levels for the young and old mentally retarded children were below their age established norms. These results clearly support Zigler's

(1969) similar sequence hypothesis.

Hypothesis 3: Verbal cognitive. It was expected that there would be no mean performance differences on verbal tasks for normal, young mentally retarded, and old mentally retarded children. The mean performance scores for the old and young mentally retarded children on the Sentence Memory test, the Peabody Picture Vocabulary test, the WISC Vocabulary subtest, and the Auditory Closure test, were not significantly different from the performance means of the normal children who were equated on mental age. The only significant mean differences evident were between the young mentally retarded children and the normal children on the Verbal Fluency and the Speech Sounds Perception tests.

The performance differences on the latter two tests, evident only in the young mentally retarded children, may be due to experiential factors, e.g., decreased attentional ability and motivation at a younger age. The finding that the mentally retarded children are equivalent to equal-mental-age normal children by age 12 suggests that even though the young mentally retarded children are behind in these two tests, they would be expected to catch up to their mental-age counterparts. This inference is limited, of course, because of the nature of the cross-sectional design.

Also, the mean scores for the retarded children were well below the norms established for their chronological age. The results clearly offer considerable support for the similar sequence hypothesis. In addition, conflicting evidence is provided in regard to Milgram's (1971, 1973) finding that similar performance on verbal measures is only evident when children were matched on mental age with normal 6-year-olds. In this study, the only significantly different verbal performance means occurred between the normals and young retarded children on the Auditory Closure and Speech Sounds Perception Tests. No other significantly different performance means were apparent.

In summary, it appears that there is considerable support for the validity of the similar sequences hypothesis as a means of explaining cognitive abilities in mild mental retardation. In the population under study, a deficit hypothesis was not a useful interpretive tool.

Normal Readers Compared to Disabled Readers

Hypothesis 1: Motor tactile-perceptual. It was expected that performance on motor measures would increase in a linear fashion as a function of chronological age. Although not all age groups were significantly different from each other (see Appendix C), inspection of the means for Strength of Grip, Finger Tapping Speed and Maze Stylus Contacts indicates a linear relationship as a function of chronological age, which provides support for Hypothesis 1 (Figures 3 and 4). In fact, when the graphs for the disabled readers are compared to the means plotted for the normative data, they are almost identical. This finding neither supports nor contradicts the similar sequence hypothesis or the deficit hypothesis. However, it does indicate that neither gross nor fine motor abilities seem to be influenced by the processes underlying reading disability or vice versa.

The scores on Tactile Finger Recognition do not demonstrate this same increase as a function of chronological age (Figure 4). The disabled readers' performance means are not significantly different from those of the normal readers (ages 7-8) on this variable. Also, the performance means for the disabled readers are below the means plotted for the normative sample. It can be seen from an inspection of the normative data that a ceiling effect for this test appears to be reached between the ages of 11 and 13 years. However, the reading disabled, at these same ages, continue to make more errors than would be expected for their chronological age. This finding conflicts with that of Fletcher, Taylor, Morris and Satz (1981c) who found that poor readers caught up on a similar task by the end of Grade 2. These results are more in accord with Reed's (1968) finding that ten-year-old poor readers performed poorly on right handed Tactile Finger Recognition, and with Fisk and Rourke's (1979) finding that errors on Tactile Finger Recognition were characteristic of two subtypes of disabled readers.

Hypothesis 2: Non-verbal cognitive. It was expected that the disabled readers would perform on non-verbal tasks in a manner appropriate to their chronological age. There were significant mean differences related to chronological age on Block Design, Object Assembly and Tactual Performance Test-Total Time (Figures 5 and 6). Even though not all means were significantly different from each other (Appendix C), it can be seen readily that the relationship was basically linear and tended to increase as a function of chronological age. Again, the curves for the disabled readers are remarkably similar to the curves graphed for the normative data.

Thus, the results on the non-verbal tests are not in accord with the hypothesis offered by Fletcher and Satz (1980b) and Fletcher et al. (1981a) which predicts that no cognitive performance differences will be found when older disabled and younger normal children are compared, after being matched for reading level. The findings consistent with Rourke's (1976b, 1981a) view that developmental skills ordinarily thought to be subserved primarily by the right cerebral hemisphere will be age-appropriate in disabled readers.

The scores on Tactual Performance Test-Memory Component did not significantly differentiate between the normal readers and any of the disabled reading groups. Inspection of the data (see Figure 6) indicates that the curve for the reading disabled closely resembles that of the normative data. It seems that the lack of differentiation may be a function of the test itself, i.e., the range of scores for the normative data for ages 7 to 13 is 4.00 to 4.75. In view of this apparent limitation, no differential support for either theory is offered.

Hypothesis 3: Verbal cognitive. It was expected that disabled readers would perform in a variable fashion on verbal subtests, i.e., not according to the normal developmental levels indicated for these tests. In this section, significant and non-significant differences for the verbal subtests will be discussed, followed by a rationale for the different findings and a concluding summary.

There were no significant mean differences between normal readers (ages 7-8) and disabled readers at 9, 10, 11, and 12 years of age on the Verbal Fluency, Auditory Closure and Speech Sounds Perception tests (Figures 7 to 9). In addition, the only significant difference on the Sentence Memory Test was between reading disabled nine-year-olds and twelve-year-olds. This latter finding may be an anomaly due to sampling and statistical variability, or it may indicate a gradual improvement from ages 9 to 12 that reflects a developmental skill which resembles Rourke's (1976b) Type 4 paradigm (see Figure 2).

Significant mean differences were observed for both Vocabulary and Peabody Picture Vocabulary Test Raw Scores (Figures 7 and 8). On both of these tests the reading disabled performed in a manner appropriate to their chronological age. Inspection of the data reveals levels of performance that are almost identical to the graphed normative data.

The findings that there were no mean differences on the Verbal Fluency, Auditory Closure, and Speech Sounds Perception tests between the reading disabled and the normal readers equated on reading level, offers some support for the similar sequence hypothesis (Fletcher & Satz, 1980b; Fletcher, Satz & Morris, 1981a). The performance of the reading disabled on the Sentence Memory test may also support the similar sequence hypothesis (Figure 7). This graph represents a Type 4 developmental progression (see Figure 2) in which performance consistently lags below the normative mean, albeit with improvement as chronological age increases. At one point in the development of the similar sequence hypothesis, predictions were made that the disabled readers would eventually catch up on this skill. However, this is no longer an inherent component of the hypothesis, and thus the disabled readers' performance might be viewed as consistent with both a similar sequence hypothesis and a deficit hypothesis.

It can be seen that the performance means for the disabled readers on the Auditory Closure, Speech Sounds Perception and Verbal Fluency tests fall below the mean performance scores expected for developmental gains associated with chronological age as plotted for the normative sample (Figures 8 and 9). Furthermore, it does seem that this relationship of performance and chronological age might be best represented by Rourke's (1976b) Type 5 paradigm (see Figure 2).

Age appropriate gains were evident on the Vocabulary and the Peabody Picture Vocabulary Test Raw Scores. These findings contradict expectations advanced by proponents of both hypotheses. Fletcher and Satz (1980b) predict that no cognitive performance differences will be found when normal and disabled readers are equated on reading level. Rourke (1981b) although not supporting the prediction of equal cognitive performances at equivalent reading levels, does predict that the disabled readers' performance on verbal measures will not parallel those of the normal readers.

Rationale. A possible rationale for the disparate findings that exist on the verbal tests may be sought by further breaking down the "verbal cognitive" category. The WISC Vocabulary and the Peabody Picture Vocabulary Tests both require, primarily, receptive and expressive language. Success on these tests is most likely influenced by length of schooling, general life experience with the spoken word, and the visual cues provided by the Peabody Picture Vocabulary Test. The remaining verbal subtests, Auditory Closure, Verbal Fluency, Speech Sounds Perception, and Sentence Memory, require, for the most part, auditory processing skills.

Thus, it would seem that the disabled readers in this study did not have difficulty with vocabulary tests that required them to define words, or to match pictures to a verbal definition. However, the remaining tests require auditory processing skills within a novel framework. Success on the Auditory Closure and Speech Sounds Perception tests, in particular, would seem to require well developed phonemic hearing ability. Success on the Verbal Fluency test depends on expressive vocabulary and the selection of words for expression on the basis of phonetic cues. It may be that a successful performance on this test reflects a past history of good phonemic hearing, so that the child can rapidly generate words that begin with any particular sound.

On the Sentence Memory Test, the disabled readers manifested some improvement with age, but they still performed below the levels expected for their chronological age. For the subjects in this study, this lower-than-normal performance pattern may reflect their ability to recognize familiar words and grammatical constructions in the sentences presented for recall, in combination with poor phonemic hearing ability. A possible explanation for the dissociation between the disabled readers' performance on these two groups of tests may be that a sample of subjects was selected that primarily included a subtype of reading disabled child with auditory processing difficulties.

Fisk and Rourke (1979) established three reliable subtypes of learning disabled children, one of which they termed an auditory-verbal subtype (representing the particular difficulties for that type). They suggested that subjects within this subtype "...have outstanding difficulties on auditory-verbal tasks that have rather novel task demands (e.g., choosing the graphic representations of nonsense words; blending into words syllables that are uttered in a staccato-like fashion by the examiner)." Satz and Morris (1980), also reported a subtype that was selectively impaired on only the Verbal Fluency test. Perhaps the selection of children at a WRAT reading grade level of two resulted in this particular subtype being heavily represented.

<u>Conclusion</u>. A brief concluding statement is offered here to

summarize this section on the comparison between normal and disabled readers. Essentially, the motor measures were included to provide a comprehensive review of developmental skills rather than as a means of evaluating directly the two hypotheses. The performances of the disabled readers on motor measures reflected developmental age gains, as predicted. Their performance on Tactile Finger Recognition was in accord with expectations derived from a deficit hypothesis.

When the performance results for the cognitive abilities, both verbal and non-verbal, are considered, support for the similar sequence hypothesis wanes. It was evident that, on non-verbal cognitive tests, the disabled readers performed in an age-appropriate manner, as they do on the WISC Vocabulary and Peabody Picture Vocabulary tests. In particular, the age appropriate performance of the disabled readers on the WISC Vocabulary (a test closely related to reading proficiency) provides contradictory evidence for a hypothesis that explicitly predicts that disabled readers will perform in a similar fashion to normal readers when equated for reading level. On the verbal tests with a heavy auditory processing component the performance of the disabled reader is not age-appropriate. In summary, although performances on isolated variables may appear to reflect development along a similar sequence continuum, when all the variables are considered, the performance patterns appear to be more in accord with a deficit hypothesis.

Comparisons of the Normal Children to the Disabled Readers and to the Mentally Retarded Children

This final contrast entailed a comparison of the normal children to the disabled readers, and to the mentally retarded children. To do this, a summary matrix was devised to indicate the tests on which the two "abnormal" groups differed significantly from the normal group. Also, the performance patterns of the disabled readers and the mentally retarded children were contrasted with those performance means graphed for the normative sample. The rationale for comparing the two populations is derived from Fletcher and Satz's (1980b) and Fletcher, Satz and Morris' (1981a) adoption of the essential aspects of Zigler's (1969) theory, i.e., that both the learning disabled and mentally retarded child are developing along the same invariant cognitive continuum as do normal children.

In the present study we have attempted to equate normal children with mentally retarded children on mental age and normal readers with disabled readers on reading level as a means of testing the viability of the similar sequence hypothesis. It was expected that non-significant performance means would represent cognitive similarities between the normal and experimental groups, thus supporting the similar sequence hypothesis. On the other hand, significant performance mean differences were expected to indicate cognitive dissimilarities, thus supporting a deficit hypothesis.

Summary matrix. A summary matrix was designed to present the performance means drawn from the pair-wise comparisons between the normal, mentally retarded, and reading disabled children (Table 12). The "S" signifies a similar and non-significant mean comparison on the variable under study. A "D" signifies a dissimilar or significantly different performance mean for the variable under study. All means presented are in comparison to the normal children. If the similar sequence hypothesis is applicable to both populations, then the performance patterns on the dependent measures (except the motor measures) for both the mentally retarded children and the disabled readers is expected to be similar.

TABLE 12

A SUMMARY MATRIX COMPARING PERFORMANCE MEANS FOR THE NORMAL CHILDREN (NORMALS), YOUNG MENTALLY RETARDED, AND OLD MENTALLY RETARDED CHILDREN (MRS), AND THE DISABLED READERS (RDS) ON ALL DEPENDENT MEASURES. 'S' SIGNIFIES A SIMILAR OR NON-SIGNIFICANT PERFORMANCE, AND 'D' SIGNIFIES A DISSIMILAR OR SIGNIFICANT MEAN PERFORMANCE[1]

	Categories															
	Motor tactile-perceptual				Non-verbal cognitive				Verbal cognitive							
Variables	GRIPM	FTAPM	MAZCM	TFR	BLKDES	OBJASS	TPTMEM	TPTTT	SENMEM	PPVTRS	VOCAB	VFLU	AUDCLO	SSPER		
Groups																
Normals vs Young MRS	S	S	S	S	S	S	S	S	S	S	S	S	D	D		
Normals vs Old MRS	D	S	S	S	S	S	S	S	S	S	S	S	S	S		
Normals vs RDS																
Age 9-10	S	S	S	S	S	S	S	D	S	D	D	S	S	S		
Age 10-11	S	S	S	S	D	D	S	D	S	D	D	S	S	S		
Age 11-12	D	S	D	S	D	D	S	D	S	D	D	S	S	S		
Age 12-13	D	D	D	S	D	D	S	D	S	D	D	S	S	S		

[1]Abbreviations are defined in the Method section under "Dependent Measures."

Inspection of the matrix indicates that the comparison between the normal and mentally retarded children, equated on mental age, is remarkable because of the number of similar (non-significant) performance means. On the other hand, the comparison between the normal readers and disabled readers, equated for reading level, has many significant, as well as non-significant differences, indicating a dissimilar performance between the two groups. Another interesting observation occurs when we note the sequence of "S's" and "D's" in the columns comparing the normal and disabled readers. At no point when a "D", or dissimilar performance, occurs does an "S", or similar performance, occur at a later age. This was not the case for the comparison between the normal and mentally retarded children, i.e., on the Verbal Fluency and Speech Sounds Perception tests, the "D's" found at a young age are followed by "S's" at a later age.

Comparison of the Mean Performance Patterns of the Mentally Retarded Children and the Disabled Readers

When the mean performances of the mentally retarded children and disabled children are viewed in comparison to the normative data, it can be seen that their performance patterns are not similar (see Figures 3 to 9). Although the data for the mentally retarded population is limited because they are represented only at two mean age levels, it can be seen that their performance means generally can be represented by Rourke's (1976b) Type 4 paradigm (see Figure 2), i.e., consistently lower levels of performance when compared to chronologically matched normals.

However,, the disabled readers show a differential pattern throughout, sometimes consistent with the normative data and at other times well below age-appropriate norms (see Figures 3 to 9). Thus, we may conclude that the disabled readers do not appear to be developing along the same invariant cognitive continuum as do either normal or mentally retarded children.

Summary and Conclusions

The purpose of this study was to evaluate the similar sequence and deficit hypotheses in two fields of research, mental retardation and reading disabilities. These two "abnormal" groups were evaluated in the same study because the essential components of the similar sequence hypothesis, i.e., rate, level, and sequence of cognitive development, are applied to both populations. Furthermore, the similar sequence hypothesis, as applied to reading disability research, was adapted from Zigler's (1969) model as applied to mental retardation research.

The data offer considerable support for the similar sequence hypothesis as a means of predicting performance for the mildly mentally retarded. The prediction that familially retarded children, equated on cognitive level with normal children, would perform in a similar manner was supported across a wide range of dependent measures. From these similar performances, according to Zigler, one may assume that cognitive processes in the mentally retarded children are similar to those in normal children, albeit developing at a slower rate and with presumably limited attainable levels.

The findings from the present study considerably strengthen the similar sequence hypothesis as it applies to mild mental retardation. However, conclusive support would require a longitudinal study comparing cognitive abilities for children matched both on mental age and chronological age. In addition, more valuable information may be gained if measures were included which would assess cognitive processing styles.

The usefulness of the similar sequence hypothesis as it pertains to disabled readers has been seriously questioned. Overall, the variable performance of the disabled readers does not support the "reading level component" of the similar sequence hypothesis which predicts that children equated on reading level will perform in a similar manner on cognitive tasks. In addition, the comparison of the performance patterns of disabled readers to those of the mentally retarded manifested different patterns of responses. The performance patterns of the disabled readers are not in accord with predictions derived from the similar sequence hypothesis.

A viable conclusion seems to be that the similar sequence hypothesis is too broad and non-specific to serve as a means of organizing data relating to reading disabilities. The variable rates and levels of performance for the disabled readers on the different dependent measures in the present study are in accord with Rourke's (1981b) contention that "...a 'normal' pattern of development would be the exception rather than the rule..." for disabled readers.

Further research efforts might be best directed away from "global" hypotheses and towards understanding the specific ways of processing print that underlie different subtypes of disabled readers. Furthermore, "subtype" research offers possibilities for intervention based on an increased knowledge of differential abilities underlying each subtype of reading disability.

Implications

1) The support for the similar sequence hypothesis suggests that an approach to the treatment and education of the familially mentally retarded child would benefit from the use of techniques based on the knowledge of normal cognitive development.

2) The lack of support for the similar sequence hypothesis as a means of interpreting developmental abilities in the reading disabled has implications for treatment. If one considers disabled readers to be processing print in the same manner as normal younger readers, as do proponents of the similar sequence hypothesis, an argument may be made for treating disabled readers in a manner appropriate for normal but younger readers. However, the variable and uneven performances of the disabled readers, as supported in the present study and in previous studies analyzing learning disability subtypes, suggests that the underlying mechanisms contributing to the differential performance exhibited by disabled readers must be considered prior to remedial action.

APPENDIX A

NORMATIVE MEANS FOR CHILDREN AGES 7-8, 9-10, 10-11, 11-12 AND 12-13 YEARS[1]

	AGE				
Variable	7-8	9-10	10-11	11-12	12-13
GRIPM	10.42	13.90	16.05	18.28	20.47
FTAPM	25.48	30.49	33.70	36.98	38.38
MAZCM	54.16	36.50	29.04	24.44	22.00
TFR	2.25	1.00	.40	.25	.25
OBJASS	16.00	19.50	21.50	23.00	24.00
BLKDES	7.00	13.00	18.00	23.00	27.00
TPTMEM	4.00	4.30	4.40	4.60	4.75
TPTTT	13.66	9.56	8.10	6.71	5.91
SENMEM	12.75	14.80	15.60	16.70	17.78
PPVTRS	63.31	73.39	78.86	83.42	87.65
VOCAB	21.50	28.50	33.00	36.50	39.50
VFLU	7.26	9.21	10.00	11.00	11.30
AUDCLO	7.80	13.40	14.60	17.45	18.44
SSPER	20.04	24.57	24.88	25.33	25.40

[1]Abbreviations are defined in the Method section under "Dependent Measures."

APPENDIX B

Grip Strength

	N	Y	O
N			X
Y			X
O			

Finger Tapping

	N	Y	O
N			
Y		N/S	
O			

Maze Stylus Contacts

	N	Y	O
N			
Y		N/S	
O			

Tactile Finger Recognition

	N	Y	O
N			
Y		N/S	
O			

Block Design

	N	Y	O
N			
Y		N/S	
O			

Object Assembly

	N	Y	O
N			
Y		N/S	
O			

Tactual Performance Memory

	N	Y	O
N			
Y		N/S	
O			

Test Total Time

	N	Y	O
N			
Y		N/S	
O			

Sentence Memory

	N	Y	O
N			
Y		N/S	
O			

Vocabulary

	N	Y	O
N			
Y		N/S	
O			

Peabody Raw Score

	N	Y	O
N			
Y		N/S	
O			

Verbal Fluency

	N	Y	O
N		X	
Y			
O			

Auditory Closure

	N	Y	O
N			
Y		N/S	
O			

Speech Sounds Perception

	N	Y	O
N		X	
Y			
O			

Mean pair-wise comparisons for the normal children (N), young mentally retarded children (Y) and old mentally retarded children (O) on all dependent measures using Scheffé's maximum F test (Ferguson, 1959). (x = sig. at .05 level).

APPENDIX C

Grip Strength

	8	9	10	11	12
8				xx	xx
9				xx	xx
10				xx	xx
11					
12					

Finger Tapping

	8	9	10	11	12
8					x
9					x
10					x
11					
12					

Maze Stylus Contacts

	8	9	10	11	12
8				x	xx
9				x	xx
10					xx
11					
12					

Tactile Finger Recognition

	8	9	10	11	12
8					
9					
10			N/S		
11					
12					

Significance Level xx = .01 x = .05 N/S = Nonsignificant

Block Design

	8	9	10	11	12
8			x	xx	xx
9				x	xx
10				x	xx
11					
12					

Object Assembly

	8	9	10	11	12
8			xx	xx	xx
9				xx	xx
10				x	xx
11					
12					

TPTMEM

	8	9	10	11	12
8					
9					
10			N/S		
11					
12					

TPTTT

	8	9	10	11	12
8		xx	xx	xx	xx
9					x
10					
11					
12					

Sentence Memory

	8	9	10	11	12
8					
9					x
10					
11					
12					

Vocabulary

	8	9	10	11	12
8		xx	xx	xx	xx
9				xx	xx
10					x
11					
12					

Peabody Raw Score

	8	9	10	11	12
8		xx	xx	xx	xx
9				xx	xx
10				x	x
11					
12					

Verbal Fluency

	8	9	10	11	12
8					
9					
10		N/S			
11					
12					

Auditory Closure

	8	9	10	11	12
8					
9					
10			N/S		
11					
12					

Speech Sounds Perception

	8	9	10	11	12
8					
9					
10			N/S		
11					
12					

Neuman-Keul's pair-wise comparisons for normal and disabled readers on all dependent measures (Winer, 1962). (x = sig. at .05 level) (xx = sig. at .01 level).

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