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Sequential processing deficits in reading retardation

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SEQUENTIAL PROCESSING DEFICITS
IN READING RETARDATION

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Chapter I

Introduction

Authorities estimate that from twenty to forty per cent of the school population read at a level that is not in keeping with their mental capacity (Schiffman, 1962). Such estimates have aroused increasing interest in the nature and cause of reading retardation. Poor teaching methods, impaired vision and hearing, emotional disorders, lack of stimulating home environment, brain damage, and subnormal mentality have been found to be associated with reading difficulty. These factors bear an obvious causal relationship to reading retardation, and when correction of the underlying causative condition can be and has been achieved, reading improvement usually results.

In many instances, however, severe reading retardation occurs in the assumed absence of obvious or easily detectable associated deficits. Severe reading impairment occurring in children who appear to be normal in other respects has been referred to by a host of names, some of which are word-blindness, strephosymbolia, specific reading disability, specific language disability, dyslexia, developmental dyslexia, congenital dyslexia and specific dyslexia.

Some of the common reading characteristics of retarded readers are (a) failure to recognize letters of the alphabet, (b) failure to recognize words, (c) lack of word attack skills, (d) inability to consolidate isolated phonics into meaningful wholes, (e) difficulty maintaining a left-right direction, (f) choppy, word-by-word oral reading, (g) frequent letter and word reversals, (h) word guessing, and (i) omissions (Rabinovitch et al., 1954; Saunders, 1962).

Money (1962) states that "It is a simple matter to identify reading retardation, but far from simple to make the differential diagnosis of specific dyslexia [p. 15]." He indicates that only a small minority of children reading below grade level would be children with specific dyslexia. Rabinovitch (1962) also emphasized the need for differential diagnosis in reading retardation and went on to say that "criteria for differential diagnosis are still uncertain and the problem is complicated by much overlap [p. 75]." In an attempt at differential diagnosis, Rabinovitch et al. (1954) referred to retarded readers with known brain damage or suspected neurological deficits as a "primary" reading retardation group, and to those with normal potential for learning to read which had not been utilized because of exogeneous factors such as negativism or emotional blocking as a "secondary" reading retardation group. He indicated that most investigators would probably refer to the "primary" group as "dyslexics" (Rabinovitch, 1962). A significantly higher mean Performance than Verbal IQ in the primary group and a significantly smaller discrepancy in favor of Performance IQ in the secondary group was also reported by Rabinovitch et al. (1954).

Clinical studies have consistently indicated a higher rate of reading retardation among boys than among girls, with estimates usually exceeding 4 to 1. Rabinovitch et al. (1954) reported that there were no girls in the primary (dyslexic) group of retarded readers. Results of field studies, however, have indicated that this male preponderance is not so great. Eisenburg (1966) found the rate to be slightly more than twice as great for boys. Hermann (1959) wrote, ". . . a more thorough knowledge of word-blind families indicates quite clearly that although the girls are in the minority with regard to word-blindness, the distribution is not so unequal that they constitute only 25% [pp. 85-86]." Hallgren's (1950) extensive statistical analyses of data derived from hundreds of cases indicated that the sex distribution of specific dyslexia in the normal population does not differ appreciably from the normal sex distribution. Some authorities speculate that boys suffering from dyslexia are more often referred to clinics because society places greater emphasis on academic success of the male. Wagner (1970) stated that "Girls seem to be less affected by emotional reactions to failure than boys in the same way as the ratio of boys to girls is disproportionate (approximately 4:1)." If this is the case, it seems likely that male dyslexics would exhibit more severe behavior problems at home and at school, perhaps resulting in more frequent referrals to clinics by parents and teachers.

Doehring (1968) summarized many nonreading deficits found to be associated with specific reading disability, among which were: (a) mixed dominance (Orton, 1937), (b) left-right disorientation (Hermann, 1959), (c) disturbances of calculation abilities, finger localization, writing, and directional confusion, i.e. Gerstmann Syndrome (Kinsbourne & Warrington, 1966), (d) endocrine disorders (Smith & Carrigan, 1959), (e) immaturity of Gestalt functioning (de Hirsch, 1954), and (f) delayed maturation of perceptual abilities (Birch, 1962).

Such diversity of associated nonreading deficits led Doehring to question the appropriateness of the often used term "specific" in referring to children with reading disability. In an attempt to determine the degree of specificity of reading disability in retarded readers, he conducted a comprehensive survey of reading and nonreading abilities of retarded readers. A battery of 109 tests, selected to sample a wide variety of reading and nonreading abilities, was administered to a group of retarded readers and a group of normal readers who were matched on age, educational opportunity, and Performance IQ on the Wechsler-Bellevue.

Results of Doehring's study revealed that (a) disability of the retarded readers was not restricted to skills requiring reading or spelling. Retarded readers were significantly inferior to normal readers on 62 of the 103 measures analyzed. They were significantly superior to normal readers on five tests, the Wechsler-Bellevue Object Assembly subtest and four tests which involved somesthetic input. (b) Tests reqiring verbal and visual sequential processing were highly correlated with the lower reading factor for retarded readers, while tests of oral vocabulary were highly correlated with the higher reading factor for normal readers. (c) The two reading groups were as clearly differentiated by two spoken language abilities (vocabulary and rhyming) and two visual abilities (reversals discrimination and perceptual speed) as they were by the original criterion of oral reading retardation.

Individual examination of the test profiles of nine retarded readers revealed certain individual differences which were not apparent from the group analyses. Two of the retarded readers approached normality on verbal tasks, one approached normality on visual tasks, another approached normality on most tasks that did not require reading, and the remaining five retarded readers showed no clear pattern of deficits. Of particular relevance to the present study was the finding that all nine retarded readers were deficient on tasks requiring sequential processing. These findings led Doehring to hypothesize that, while some retarded readers may have verbal deficits and others may have visual deficits, all retarded readers share the same basic underlying deficit of sequential processing.

The essential role of sequential processing in reading was pointed out by de Hirsch (1955) when she wrote, "In order to read a little word like 'mat', a sequence of letters seen, a sequence in space has to be translated back into a sequence of sounds heard, a sequence in time [p. 237]." Orton (1937) reported that children with language disabilities have trouble with orderly recall of sequences, spatial sequences in the case of the dyslexic. Kinsbourne & Warrington (1962) found that a specific difficulty in relating the fingers to each other in correct spatial sequence existed in patients with finger agnosia. Finger agnosia is one symptom of the Gerstmann Syndrome, a syndrome which often occurs in conjunction with dyslexia.

This study is an attempt to carry out two of Doehring's (1968) recommendations for further research: (a) that more intensive analyses of sequential learning processes in retarded readers be conducted, and (b) that his study be partially replicated using a refined set of measures.

Doehring made the suggestion that a digit repetition task of the type used by Hebb (1961) would be appropriate for investigation of sequential processing deficits in retarded readers. Hebb's experiment was designed to investigate the nature of the trace in short-term memory. E read aloud a series of nine digits and Ss (college students) were instructed to repeat the series in the same order. Twenty-four series were presented, with the same series being repeated on every third trial without Ss having been informed of the repetition. The results of the study showed that cumulative learning of the repeated series did occur. Hebb concluded that a single repetition of a set of digits produces a structural trace which can be cumulative.

Hebb's procedure has been modified for the purpose of investigating sequential processing deficits in reading retardation. This type of procedure could also yield information regarding short term memory deficits of retarded readers, and this has also been investigated in the present study.

The use of group intelligence and reading tests differs from clinical studies in which individual tests are administered. The California Reading Test (CRT) measures reading vocabulary and reading comprehension, whereas most individual reading tests measure more specific and partial aspects of the reading process. Pearson correlation coefficients for the vocabulary and comprehension subtests of the CRT and some other standardized tests are: (a) CRT Vocabulary and Metropolitan Vocabulary (Test 2), .80, (b) CRT Comprehension and Metropolitan Reading (Test 1), .84, (c) CRT Vocabulary and Stanford Word Meaning Test (Test 2), .75, and (d) CRT Comprehension and Stanford Paragraph Meaning (Test 2), .77. A reliability coefficient of .95 is reported for the CRT (California Achievement Tests Manual, 1957).

The California Short-Form Test of Mental Maturity (CTMM) yields a Language and a Non-Language IQ derived from scores on four subtests: spatial relationships, logical reasoning, numerical reasoning, and verbal concepts. Correlation coefficients reported for the CTMM and individual intelligence tests are: (a) CTMM and Stanford-Binet, .88, (b) CTMM and Wechsler-Bellevue, .81, (c) CTMM and WISC, .81. The CTMM Manual states that ". . . the Short-Form correlates as well with the individually administered tests as it does with the other group tests, and sometimes even better [p. 7]."

Individual reading and intelligence tests are generally regarded to be more valid, but the impracticability of administration ruled out the possibility of their use in the present study. Nunnally (1959) points out, however, that group tests have been refined and have become increasingly precise.

Chapter II

Method

Subjects. The CTMM was administered to all seventh graders in a public junior high school during the first month of their seventh grade year. During the same month, the CRT was administered to those students who were enrolled in seventh grade remedial reading, developmental reading, and literature classes. Most students enrolled in remedial reading read two or more years below grade level. In developmental reading classes some were less severely retarded readers and some were normal readers. In general, seventh grade retarded readers were chronologically older than seventh grade normal readers, having repeated one or more grades in elementary school. For purposes of the present study, it was desirable to match a group of retarded readers with a group of normal readers on chronological age. In order to achieve this by obtaining some older normal readers, the CRT was also administered to an eighth grade enriched class. Mental ages for the eighth graders were computed from intelligence quotients they obtained on the CTMM which had been administered one year earlier when they were in the seventh grade.

Intelligence quotients, mental ages, chronological ages, and reading grade equivalent scores were available for 159 caucasian students. Those with Non-Language IQ's below 84, histories of severe illnesses, unusually low attendance records, abnormal psychiatric status, or vision and hearing defects were excluded from the study. From the remaining seventh graders, a group of 14 retarded readers was selected. A group of 14 normal readers, 10 seventh graders and 4 eighth graders, was selected to match the retarded readers on Non-Language IQ and chronological age. To control for the sex factor, seven girls and seven boys were included in each group. Non-Language IQ's are shown in Table 1 and chronological ages in Table 2.

Intelligence and reading criteria were in accord with the recommendations of Rabinovitch et al. (1954). Non-Language IQ's rather than Language IQ's were used as the index of mental age, because scores on language tests are more seriously affected by the reading inadequacy itself. It can be inferred from this rationale that reading achievement and Language intelligence scores would be more highly correlated than reading achievement and Non-Language intelligence scores. The Pearson correlation coefficient for Language IQ and reading grade equivalent for the 28 _S_s in the present study was .85, whereas the same statistic for Non-Language IQ and reading grade equivalent was only .39.

Table 1

Non-Language IQ on the CTMM

Retarded Readers NLIQ	Retarded Readers Sex	Normal Readers NLIQ	Normal Readers Sex
123	M	131	F
121	M	120	F
121	M	118	F
115	F	116	M
109	F	113	M
106	F	111	M
105	M	109	F
102	M	108	M
102	F	107	F
100	M	100	M
97	F	95	M
93	F	91	M
88	F	90	F
86	M	86	F
Total 1468		Total 1495	
Mean 104.9		Mean 106.7	

Analysis of Variance

Source	df	MS	F
Between Groups	1	26.04	.17
Within Groups	26	155.23	

$F_{.95}(1, 26) = 4.23$

Table 2

Chronological Age

Retarded Readers Age in Months	Sex	Normal Readers Age in Months	Sex
175	M	176	F
175	M	169	M
174	F	163	M
170	F	163	F
168	F	161	M
167	F	155	F
165	M	155	F
164	F	152	M
157	F	152	M
156	M	151	F
156	F	151	M
155	M	149	M
147	M	148	F
147	M	144	F
Total 2276		Total 2189	
Mean 162.6		Mean 156.4	

Analysis of Variance

Source	df	MS	F
Between Groups	1	270.32	3.13
Within Groups	26	86.26	

$F_{.95}(1,26)=4.23$

These two correlation coefficients differ significantly at the .01 level of significance.

The criterion for reading retardation was reading achievement of two or more years below expected grade placement. Expected grade placement, based on Non-Language Mental Age was determined by referring to the Grade Placement and Age Norms of the California Achievement Tests. The expected reading grade placement was subtracted from the actual reading grade equivalent on the CRT to determine degree of reading retardation or acceleration. Students were considered to be normal readers if their reading grade equivalent on the CRT was no more than three months below their expected reading grade placement. Nine of the normal readers were accelerated, while five read slightly below expectancy. In Table 3, degree of retardation or acceleration is shown for each of the 28 Ss. The means of -3.8 for the retarded readers and +.6 for the normal readers did differ significantly at the .01 level of significance.

Although use of the broad term "reading retardation" is generally preferred for studies conducted in school settings, it is quite possible that the selected retarded readers in this study could be classified as dyslexics for the following reasons: (a) As shown in Table 4, the mean discrepancy between Language and Non-Language IQ for retarded readers was 22.21, a mean discrepancy slightly greater than that reported by Rabinovitch et al. (1954).

Table 3

Non-Language Mental Age (NLMA), Expected Reading Grade Placement (ERGP), Reading Grade Equivalent (RGE), and Degree of Retardation (DR-) or Acceleration (DA+)

Retarded Readers

NLMA	ERGP	RGE	DR(-) or DA(+)
187	10.0	4.0	-6.0
193	10.4	6.1	-4.3
184	9.8	6.2	-3.6
184	9.8	6.0	-3.8
179	9.4	5.9	-3.5
177	9.3	5.6	-3.7
180	9.5	3.9	-5.6
167	8.6	3.7	-4.5
162	8.2	3.7	-4.5
167	8.6	6.4	-2.2
165	8.4	4.4	-4.0
152	7.3	4.5	-2.8
148	7.0	4.5	-2.5
133	5.8	3.8	-2.0
		Mean	-3.8

Normal Readers

NLMA			DR(-) or DA(+)
197	10.6	10.3	- .3
187	10.0	9.7	- .3
179	10.0	10.3	+ .3
191	10.2	11.3	+1.1
195	10.5	10.9	+ .4
185	9.8	11.3	+1.5
172	9.0	10.4	+1.4
163	8.2	8.0	- .2
166	8.5	8.2	- .3
153	7.4	9.0	+1.6
145	6.7	6.8	- .1
155	7.6	7.3	- .3
134	5.8	8.2	+2.4
138	6.2	7.2	+1.0
		Mean	+ .6

Table 4

Discrepancies Between Language and Non-Language IQ on CTMM

Retarded Readers

LIQ	NLIQ	Disc.
100	123	23NL
89	121	32NL
105	121	16NL
86	115	29NL
79	109	30NL
79	106	27NL
64	105	41NL
69	102	33NL
94	102	8NL
99	100	1NL
70	97	27NL
60	93	33NL
74	88	14NL
89	86	3L
	Total	311NL
	Mean	22.21

Normal Readers

LIQ	NLIQ	Disc.
122	131	9NL
114	120	6NL
129	118	11L
129	116	13L
128	113	15L
131	111	20L
112	109	3L
101	108	7NL
103	107	4NL
115	100	15L
84	95	11NL
85	91	6NL
94	90	4L
79	86	7NL
	Total	31L
	Mean	2.21

(b) Retarded readers with diagnosed or suspected psychiatric abnormalities were excluded from the study. (c) Subjective judgments of the retarded readers' reading teachers indicated that most of the retarded readers exhibited some of the reading traits characteristically associated with dyslexia, e.g. frequent letter and word reversals, word guessing, inability to recognize simple words, difficulty maintaining left-right orientation.

Educational opportunity and sociocultural environment were judged to be essentially the same for both groups, as all _S_s had attended the same or similar elementary schools. The junior high school from which _S_s were selected and the elementary schools which they had previously attended are located in a low socioeconomic area.

Procedure. Four of the tasks involved are modifications of Hebb's (1961) procedure. In the four tasks described below, different sensory modalities are involved: (a) Task I: Auditory stimuli and auditory responses, (b) Task II: Visual stimuli and visual responses, (c) Task III: Visual stimuli and visual-kinesthetic responses, and (d) Task IV: Auditory stimuli and auditory-visual responses.

Task I. Digits. On each of ten trials _E_ read aloud in random order a series of five digits (1, 3, 5, 7, 9) at the rate of one per second. _S_s were instructed to listen carefully and repeat the series in the same order. The same series of digits was presented on trials 1, 4, 7, and 10.

Presentations were identical for all Ss. On each trial, the number of digits repeated in the correct serial position was recorded. The number of perfect repetitions of an entire series of five digits was also recorded for each S.

Task II. Shapes. On each of ten trials S viewed a card containing a random sequence of five geometric shapes (star, circle, cross, triangle, quarter moon) for five seconds. He was then asked to arrange five smaller cards, one of the shapes being on each card, in the order in which they appeared on the larger card. As in Task I, the same series of shapes was presented on trials 1, 4, 7, and 10, and the sequence on each trial was identical for all Ss. Scoring procedures were the same as in Task I.

Task III. Blocks. Five blue wooden blocks were placed 1" apart on a table between S and E. E tapped each of the five blocks in random order at the rate of one per second. S was instructed to watch carefully and repeat the sequence of taps in the same order. Number of trials, position of repeated series, and scoring procedures were the same as in Tasks I and II.

Task IV. Sounds. Ten trials of five familiar sounds (dog, horse, clock, doorbell, saw) were taped in random order. Each sound lasted three seconds, with one second between sounds. S was given five pictures on cards, one picture to be associated with each sound. To be sure that each S could identify the sounds, a pre-experimental trial was conducted in which S was asked to point to the picture associated with each sound as he heard it. All Ss were able to correctly identify all five sounds on the pre-experimental trial. Each S was then given ten trials. At the end of each trial he was asked to arrange the associated pictures in the order in which he had heard the sounds. Position of repeated series and scoring procedures were the same as in the previous tasks.

Appendix A shows the sequences of stimuli presented on each of the ten trials for the four tasks. Order of presentation of the four tasks was counterbalanced by randomization.

Five weeks after original testing, all Ss were retested on the four sequential processing tasks with the order of presentation for each S being the same as on original testing. Composite scores from the non-repeated trials of the four tasks were used to compute a test-retest reliability coefficient. The sequential processing tasks appear to have face and content validity, as all four tasks do involve reproduction of a series of stimuli in a particular sequence.

The four tests which Doehring (1968) found to clearly differentiate retarded and normal readers were: (a) Minnesota Aphasia: Rhyming (b) Wechsler-Bellevue: Vocabulary, (c) Thurstone Reversals, and (d) Visual Perceptual Speed: Single Form. In the present study, the Vocabulary subtest of the WISC was substituted for the Vocabulary subtest of the Wechsler-Bellevue, and the four tests were administered. Scores from these four tests were combined with scores from the four sequential processing tasks and a multiple correlation coefficient was computed to determine which measures best differentiate retarded readers and normal readers.

Chapter III

Results

Sequential Processing Tasks. Four scores were recorded for each S on each of the four sequential processing tasks: (a) number of responses in correct serial position on non-repeated trials (trials 1, 2, 3, 5, 6, 8, and 9), (b) number of perfect repetitions of a series of five on non-repeated trials, (c) number of responses in correct serial position on repeated trials (trials 4, 7, and 10), and (d) number of perfect repetitions of a series of five on repeated trials. The data were analyzed by four 2 x 4 analyses of variance, one analysis for each of the dependent variables. ANOV summary tables for the four analyses are shown in Tables 5, 6, 7, and 8. Means for the retarded readers and normal readers did differ significantly at the .05 level of significance for all four dependent variables.

Differences between the ordered means for the four sequential processing tasks are shown in Tables 9, 10, 11, and 12. Means for the digits, sounds, and blocks tasks were significantly greater than the mean for the shapes task, and the mean for the digits task was signifi-

Table 5

Analysis of Variance: Number of Responses in Correct Serial Position on Non-Repeated Trials

Source	df	MS	F
Reading Group (A)	1	185.15	4.62*
Task (B)	3	187.07	11.08*
A X B	3	13.78	.82

*$p < .05$

$F_{.95}(1,26) = 4.23$
$F_{.95}(3,78) = 2.73$

Table 6

Analysis of Variance: Perfect Repetitions on Non-Repeated Trials

Source	df	MS	F
Reading Group (A)	1	21.44	4.67*
Task (B)	3	23.51	11.04*
A X B	3	1.41	.66

*$p < .05$

$F_{.95}(1,26) = 4.23$
$F_{.95}(3,78) = 2.73$

Table 7

Analysis of Variance: Number of Responses in Correct Serial Position on Repeated Trials

Source	df	MS	F
Reading Group (A)	1	57.15	8.15*
Task (B)	3	36.93	4.84*
A X B	3	9.93	1.30

*$p < .05$

$F_{.95}(1,26) = 4.23$
$F_{.95}(3,78) = 2.73$

Table 8

Analysis of Variance: Perfect Repetitions on Repeated Trials

Source	df	MS	F
Reading Group (A)	1	7.00	8.14*
Task (B)	3	4.77	5.07*
A X B	3	1.17	1.24

*$p < .05$

$F_{.95}(1,26)=4.23$
$F_{.95}(3,78)=2.73$

Table 9

Differences Between Ordered Means: Number of Responses in Correct Serial Position on Non-Repeated Trials

	Shapes Task II	Blocks Task III	Sounds Task IV	Digits Task I
Task II		2.46*	4.39*	6.00*
Task III			1.93	3.54*
Task IV				1.61

*$p < .05$

Table 10

Differences Between Ordered Means:
Perfect Repetitions on Non-Repeated Trials

	Shapes Task II	Blocks Task III	Sounds Task IV	Digits Task I
Task II		.96*	1.57*	2.14*
Task III			.61	1.18*
Task IV				.57

*$p < .05$

Table 11

Differences Between Ordered Means: Number of Responses in Correct Serial Position on Repeated Trials

	Shapes Task II	Blocks Task III	Sounds Task IV	Digits Task I
Task II		.68	1.96*	2.50*
Task III			1.28	1.82*
Task IV				.54

*$p < .05$

Table 12

Differences Between Ordered Means:
Perfect Repetitions on Repeated Trials

	Shapes Task II	Blocks Task III	Sounds Task IV	Digits Task I
Task II		.15	.61*	.90*
Task III			.46	.75*
Task IV				.29

*$p < .05$

cantly greater than the mean for the blocks task on the two measures from the non-repeated trials. On the two measures from the repeated trials, means were significantly greater on digits and sounds than on shapes, and significantly greater on digits than on blocks. Means for the blocks and shapes tasks did not differ significantly as they had on non-repeated trials. Reading status and type of task did not interact significantly.

Summary tables for the rhyming, vocabulary, reversals, and perceptual speed tests taken from Doehring's (1968) study are shown in Tables 13, 14, 15, and 16. Means for the retarded readers and normal readers did differ significantly on the rhyming and vocabulary tests, but did not differ significantly on the reversals and perceptual speed tests.

Mean number of responses in correct serial position on non-repeated trials was used as the score for each S on each of the four sequential processing tasks. These four scores were combined with scores from the four tests taken from Doehring's study and a multiple correlation coefficient was computed, with retarded reading and normal reading being treated as dichotomies. The multiple correlation coefficient of .702 is significant at the .05 level; with such a small number of Ss, however, shrinkage is appreciable, and the corrected multiple correlation coefficient of .562 is not significant. Table 17 shows contributions of the eight

Table 13

Analysis of Variance: Rhyming

Source	df	MS	F
Between Groups	1	170.04	10.71*
Within Groups	26	15.87	

*$p < .05$ $F_{.95}(1,26)=4.23$

Table 14

Analysis of Variance: Vocabulary

Source	df	MS	F
Between Groups	1	416.57	8.23*
Within Groups	26	50.61	

*$p < .05$ $F_{.95}(1,26)=4.23$

Table 15

Analysis of Variance: Reversals

Source	df	MS	F
Between Groups	1	234.32	3.26
Within Groups	26	71.79	

$F_{.95}(1,26)=4.23$

Table 16

Analysis of Variance: Perceptual Speed

Source	df	MS	F
Between Groups	1	72.32	2.41
Within Groups	26	30.01	

$F_{.95}(1,26)=4.23$

variables to the multiple correlation coefficient. Regression weights for the eight tests are shown in Table 18.

A multiple correlation coefficient using degree of retardation or acceleration as the criterion was also computed. The multiple correlation coefficient of .736 was significant at the .05 level, but the corrected multiple correlation coefficient of .617 failed to reach significance. Intercorrelations of the eight tests are shown in Table 19.

Cumulative Learning. Cumulative learning of the repeated series presented on trials 1, 4, 7, and 10 was investigated by performing a 2 x 4 groups by trials analysis of variance for each of the four tasks. Summary tables for the four analyses are shown in Tables 20, 21, 22, and 23. Means for the retarded readers and the normal readers did not differ significantly on any of the four tasks, and the only task on which cumulative learning occurred was the sounds task (see Table 24). Graphs showing number of responses in correct serial position on the ten trials are shown in Figure 1.

From composite scores on the four sequential processing tasks, a test-retest Pearson reliability coefficient of .368 was obtained. This coefficient failed to reach the .374 critical value required for significance at the .05 significance level.

Table 17

Contributions of Eight Tests to the Multiple Correlation Coefficient
(Rhyming=Rh, Digits=D, Vocabulary=V, Reversals=Rev, Sounds=Sd, Perceptual Speed=PS, Blocks=B, Shapes=Sh)

Tests	R	cR
Rhyming	.540*	
Rh + D	.617*	.597*
Rh + D + V	.663*	.628*
Rh + D + V + Rev	.682*	.631*
Rh + D + V + Rev + Sd	.696*	.628*
Rh + D + V + Rev + Sd + PS	.699*	.610
Rh + D + V + Rev + Sd + PS + B	.701*	.588
Rh + D + V + Rev + Sd + PS + B + Sh	.702*	.562

*$p < .05$

Table 18

Regression Weights of Eight Tests

Test	Regression Weight
Rhyming	.04
Digits (Task I)	.24
Vocabulary	.01
Reversals	-.01
Sounds (Task IV)	-.16
Perceptual Speed	.006
Blocks (Task III)	.04
Shapes (Task II)	-.03

Table 19

Intercorrelations of Eight Tests

Tests	1	2	3	4	5	6*	7	8
1		.05	.58	.25	.18	-.11	.18	.13
2			.20	.62	.33	-.10	.23	.10
3				.14	.17	-.16	.19	.33
4					.43	-.27	.40	.35
5						-.10	.32	.43
6*							-.17	-.33
7								.50
8								

Test 1: Digits
Test 2: Shapes
Test 3: Blocks
Test 4: Sounds
Test 5: Perceptual Speed
Test 6: Reversals*
Test 7: Rhyming
Test 8: Vocabulary

*Scores on the Reversals test were based on number of errors, while scores on the other seven tests were based on number of correct responses; thus the Reversals test is negatively correlated with the other seven tests.

Table 20

Analysis of Variance: Cumulative Learning on Digits (Task I)

Source	df	MS	F
Reading Group (A)	1	4.72	2.18
Trial (B)	3	.10	.28
A X B	3	.53	1.47

$F_{.95}(1,26)=4.23$
$F_{.95}(3,78)=2.73$

Table 21

Analysis of Variance: Cumulative Learning on Shapes (Task II)

Source	df	MS	F
Reading Group (A)	1	10.32	2.26
Trial (B)	3	2.96	1.68
A X B	3	2.20	1.25

$F_{.95}(1,26)=4.23$
$F_{.95}(3,78)=2.73$

Table 22

Analysis of Variance: Cumulative Learning on Blocks (Task III)

Source	df	MS	F
Reading Group (A)	1	10.94	3.66
Trial (B)	3	1.18	.81
A X B	3	.75	.52

$F_{.95}(1,26)=4.23$
$F_{.95}(3,78)=2.73$

Table 23

Analysis of Variance: Cumulative Learning on Sounds (Task IV)

Source	df	MS	F
Reading Group (A)	1	.04	.02
Trial (B)	3	2.97	2.75*
A X B	3	.06	.06

*$p < .05$

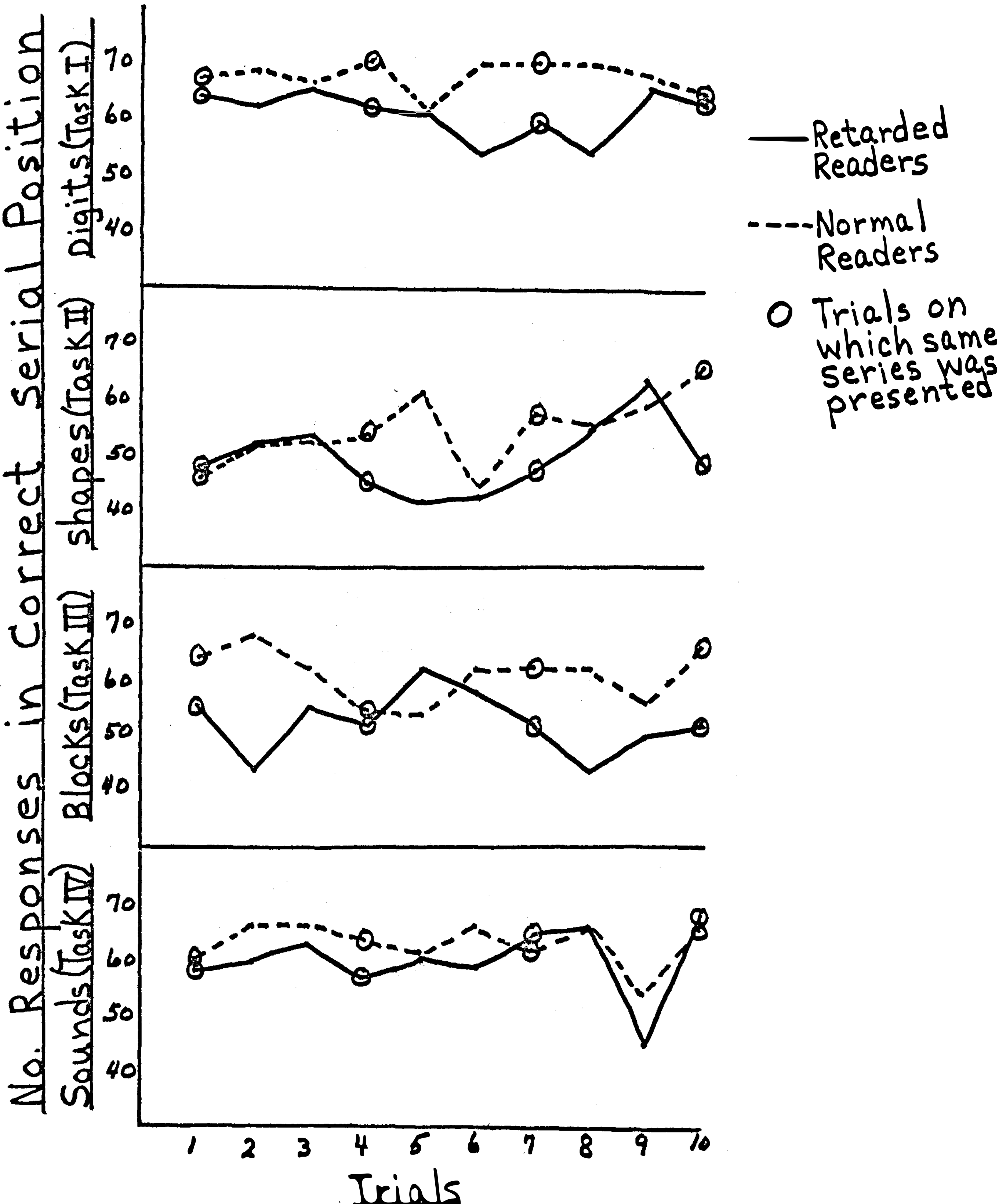
$F_{.95}(1,26) = 4.23$
$F_{.95}(3,78) = 2.73$

Table 24

Differences Between Ordered Means:
Cumulative Learning on Sounds (Task IV)

Repeated	Trial 4	Trial 1	Trial 7	Trial 10
Trial 4		.18	.43	.75*
Trial 1			.25	.57
Trial 7				.32

*$p < .05$



No. Responses in Correct Serial Position
Digits (Task I)
Shapes (Task II)
Blocks (Task III)
Sounds (Task IV)
70
60
50
40
1 2 3 4 5 6 7 8 9 10
Trials
Retarded Readers
Normal Readers
Trials on which same series was presented

Fig. 1

Chapter IV

Discussion

Sequential Processing. Results of this study indicate that retarded readers are deficient on tasks involving sequential processing, both auditory and visual. They were also deficient on the two verbal auditory tests which Doehring (1968) used, i.e. rhyming and vocabulary. They were not deficient on the two visual tests which did not involve sequential processing, i.e. reversals and perceptual speed. This latter finding should not be interpreted to mean that retarded readers are not deficient on other visual tasks, and an explanation for this is provided in the Doehring study. Doehring's multiple correlation procedure, a multiple stepwise regression analysis, indicated the degree to which retarded readers and normal readers were differentiated by specific combinations of measures, and he pointed out that "a number of nonreading tests which were highly discriminative as individual measures were not selected at all because of the high correlation of their power to discriminate reading status with that of previously selected measures [p. 103]." Among those highly discriminative as individual measures which were not selected by this procedure were two visual memory tasks. The reversals and perceptual speed tests used in the present study were less discriminative as individual measures in Doehring's study than were the two visual memory tests. Doehring's hypothesis that retarded readers have verbal and/or visual deficits, accompanied by an underlying basic sequential processing deficit, is strongly supported by the present findings.

Even though control was exerted on Non-Language IQ, age, sex, race, and socio-economic level, results of the correlational part of this study must be interpreted cautiously, as the number of Ss is small and the number of tests administered relatively large. Nevertheless, the results are consistent with Doehring's findings. The four tests taken from the Doehring study and used in this study contributed to the discrimination of retarded and normal readers in the same relative order as they did in the Doehring study. Rhyming differentiated the groups best, vocabulary and reversals contributed a considerable amount to the multiple correlation coefficient, and perceptual speed contributed least.

While rhyming was the measure which best differentiated the two reading groups, one of the sequential processing measures, digits, provided the greatest increase of discrimination. It is likely that the rhyming test itself involves a basic ability to handle sequences, as the subject is required to emit a series of spoken words that sound similar to a given word. Again, this indicates that while retarded readers may be deficient on verbal and/or visual tasks not requiring sequential processing, they are even more deficient on tasks requiring sequential processing.

The low reliability coefficient obtained for the sequential processing tasks may be attributed to several factors. Thorndike and Hagen (1955) state that age, grade, socio-economic, and ability ranges of the group tested are factors which must be considered in comparing reliability coefficients. Higher reliability coefficients may be expected when groups are heterogeneous in respect to those factors. Because of the nature of the present study, the groups were selected to be homogeneous in regard to age, grade, socio-economic level, and ability. Reliability of a test also depends on the length of the test, with reliability usually increasing as length of the test increases. Short tests involved in the present study, coupled with homogeneity of groups tested, could well account for the low reliability coefficient obtained.

Guilford (1956) points out that unreliable measures reduce the power of tests of significance. Yet, in spite of another power-reducing limitation, small N, statistical tests used in the present study revealed significant differences between retarded readers and normal readers on the four sequential processing tasks. This finding attests to the reliability of the tasks. It is likely that test-retest administration of these four tasks to large heterogeneous groups would result in increasing the reliability coefficient considerably.

Cumulative Learning. Lack of evidence for cumulative learning of the repeated series (except in the sounds task) must also be interpreted cautiously. For purposes of the present study, Hebb's (1961) procedure was modified by decreasing the number of trials from 24 to 10 and decreasing the length of the series of stimuli presented from 9 to 5. It seems likely that this resulting procedure would be a less sensitive measure of cumulative learning. Future research should take this into consideration.

A finding of particular relevance to reading retardation was that retarded readers and normal readers did not differ significantly in amount of cumulative learning on any of the four tasks. A deficit in associative learning on the part of retarded readers has been generally accepted by some investigators (Schiffman, 1962; Rabinovitch, 1962). This indicates that further research is warranted, and it is recommended that full cognizance be taken of the accumulated knowledge derived from studies in the laboratories of learning psychologists.

Sex Ratio. Some students who met the criteria for reading retardation outlined in the present study were not included as Ss because of lack of testing time. It was interesting to note, however, that of the 48 students who met the criteria for reading retardation, 29 were girls (60%) and 19 were boys (40%). A further unusual finding was that 25 (86%) of the retarded reader girls had significantly higher CTMM Non-Language than Language IQ's (at least 15 points discrepancy), whereas this was true for only 13 (68%) of the retarded reader boys. Comparisons with the clinical study by Rabinovitch et al. (1954) in which he reported that there were no girls in the dyslexic group are difficult to make because group tests are involved in one case and individual tests in the other. It would seem unlikely, however, that this difference alone could account for such contrast in findings because (a) Rabinovitch's definition of reading retardation was adopted for this study, (b) reports indicate that the CRT is highly correlated with the Metropolitan Reading Test, one of the reading tests used by Rabinovitch, and (c) the CTMM is reported to be highly correlated with the Wechsler Intelligence Scales which were used by Rabinovitch.

Clinical studies and school studies of reading retardation have often yielded conflicting results. One possible explanation for this lies in the already mentioned fact that less precise diagnostic tools are usually employed in school studies, with individual tests being used in the clinical situation and group tests in the school situation. Differences in definitions of reading retardation offer another explanation. Defining reading retardation as reading ability of two years below grade level, rather than two years below expected reading grade level as determined by Non-Language IQ, would obviously result in a different sample of retarded readers. Results of this study indicate that, when Rabinovitch's definition of reading retardation is used, retarded readers selected from a school population and retarded readers in a clinical situation show important similarities. Retarded readers exhibited most of the same deficits in this school study as they had in Doehring's clinical study, with the same measures best differentiating retarded readers and normal readers in both studies. While the percentage of female retarded readers in this school setting differs from most clinical reports, it is more in line with other field studies. As Newbrough and Kelly (1962) pointed out, the integration of knowledge from these two complementary approaches should result in a more complete understanding of reading disability.

Chapter V

Summary and Conclusions

Doehring (1968) hypothesized that a basic sequential processing deficit underlies specific reading disability. To investigate sequential processing deficits in reading retardation, four tasks involving the reproduction of stimuli in a particular sequence were administered to a group of retarded readers and a group of normal readers matched on age, sex, race, educational opportunity, socio-cultural environment, and Non-Language IQ on the CTMM. The normal readers were significantly superior to the retarded readers on the four sequential processing tasks and on two other tests, vocabulary and rhyming. The two groups did not differ significantly on reversals discrimination, perceptual speed, or cumulative learning. These results clearly support the hypothesis that retarded readers are basically deficient in ability to process sequences.

Procedures and results of clinical studies were compared with those of the present junior high school study. Similarities and differences of retarded readers in clinical settings and retarded readers participating as Ss in this study were delineated and discussed.

APPENDIX A

Order of Presentation of Stimuli

Order of Presentation of Stimuli

	Task I Digits	Task II Shapes	Task III Blocks	Task IV Sounds
Trial 1*	5,1,9,3,7*	star, triangle, cross, moon, circle*	5,2,1,4,3*	dog, horse, doorbell, saw, clock*
Trial 2	5,7,1,3,9	cross, moon, circle, triangle, star	1,5,2,3,4	doorbell, dog, clock, saw, horse
Trial 3	3,5,1,7,9	cross, triangle, star, moon, circle	3,5,1,2,4	clock, doorbell, dog, saw, horse
Trial 4*	5,1,9,3,7*	star, triangle, cross, moon, circle*	5,2,1,4,3*	dog, horse, doorbell, saw, clock*
Trial 5	1,9,5,7,3	star, circle, triangle, moon, cross	3,2,4,1,5	horse, saw, dog, doorbell, clock
Trial 6	9,3,5,7,1	moon, circle, star, cross, triangle	5,1,4,3,2	doorbell, clock, dog, saw, horse
Trial 7*	5,1,9,3,7*	star, triangle, cross, moon, circle*	5,2,1,4,3*	dog, horse, doorbell, saw, clock*
Trial 8	3,1,7,5,9	cross, star, triangle, circle, moon	1,5,2,4,3	doorbell, saw, dog, horse, clock
Trial 9	5,3,1,9,7	circle, moon, cross, triangle, star	3,5,2,1,4	horse, doorbell, clock, dog, saw
Trial 10*	5,1,9,3,7*	star, triangle, cross, moon, circle*	5,2,1,4,3*	dog, horse, doorbell, saw, clock*

*Repeated series of stimuli

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