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ABSTRACT

Two longitudinal studies examined a "double deficit" hypothesis of reading disorders that contends that along with a core phonological deficit, slow speed of lexical access disrupts the efficient formation of orthographic representations and their quick retrieval. In the first study, 38 children from 6 classrooms in a predominantly white, middle class public school, were tested repeatedly from early in grade 2 to the end of grade 4. Subjects were divided into groups (good decoder-fast reader, good decoder-slow reader, poor decoder-fast reader, and poor decoders-slow readers) based on grade 4 scores. Multiple analysis of variance examined effects of two levels of nonword decoding and word latency with time of test a repeated measure. Main effects of both factors and of time were observed on many measures, and few interactions of the factors occurred. In the second study, 82 children from 3 public schools representing a range of different socioeconomic levels were tested in the spring of every year on a battery of reading and language measures from kindergarten to grade 4. Children were divided into groups similar to those in the first experiment. Analyses similar to those in the first study were conducted. Results of both studies indicate that the two deficits have independent, additive effects. Findings suggest that the processes resulting in rapid reading reflect in large part a cognitive skill independent of phonological decoding, and that a double deficit conceptualization of reading disability is critical for a more comprehensive account of reading disabled children. (Twelve tables of data are included.) (RS)

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A Double-Deficit hypothesis for developmental reading disorders

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Reading disabled children read many words and nonwords inaccurately, and those words they do know, they read slowly. A consensus has grown that a core deficit in phonological processing skill impairs the sounding out of nonwords and interferes with establishing complete orthographic representations accessible to memory. Within this view, Stanovich (1992) paints a plausible, representative picture of how early phonemic insensitivity is associated not only with poor word recognition but also with faulty reading strategies such as guessing a word based on a few cues, and less reading practice. These characteristics in turn impair orthographic skill.

The apparent seamlessness of this picture of phonologically - based deficits is complicated by several bodies of evidence concerning "Rapid Automatized Naming" and reading disability (Denckla & Rudel, 1976) (See Table 1):

1) the specificity of visual naming speed problems in dyslexic children when compared to average peers, garden-variety reading impaired, and other learning disabilites;

2) the robust predictability of later reading from naming speed even at prereading ages ;

3) the independence from phonological abilities and IQ of naming speeds 's contribution to reading;

4) the enduring naming speed problems of poor readers in languages with more regular orthographies, despite the less pronounced role of phonological problems in these readers;

5) the heritability of deficits in both phonological processes and rapid naming;

6) and finally, the moderating influence of naming speed on the effects of practice, even controlling for phonological skill.

To accommodate this evidence, we hypothesize that an additional core deficit must be considered. The double-deficit hypothesis contends that along with a core phonological deficit, slow speed of name retrieval indexes processes that disrupt the efficient formation of orthographic representations and their quick retrieval.

To examine this double-deficit proposal, we decided simply to look at the target reading skills we were trying to understand. For example, are there children with good nonword decoding skills who are slow to read even highly familiar, phonologically regular words? If nonword decoding and reading speed problems are different aspects of the same phonological deficit, there should be few such children, despite Maureen Lovett's (1987) early study of rate-disabled children and the identification of so-called "Phoenician" readers by Byrne et al. (1992). Similarly, there should be few poor decoders whose speed of reading familiar words is fast, so-called "Chinese" readers. However, if such children, anomalous for a single core deficit, can be found, we may be able to isolate a second core cognitive deficit independent of decoding skill and potentially associated with orthographic processing. Equally important, we may better understand the makeup of our most impaired readers.

To investigate these hypotheses, we analyzed the data from two longitudinal studies; my study looked at children from grades 2 to 4 (Bowers, 1993a; 1993b); Maryanne Wolf's study tracked children from Kindergarten to Grade 4 (Wolf, 1991). Moderately correlated Grade 4 measures of nonword decoding accuracy and easy word reading speed were used

to categorize children as high and low on these skills. MANOVA of the various reading and reading-related measures employed in the two studies over time explored the effects of these categories.

Study 1

Thirty-eight children from 6 classrooms in a predominantly white, middle-class public school were tested repeatedly from early in Grade 2 to the end of Grade 4. In grade 2, approximately half the group had been considered by their teachers to be poor readers. The rest of the sample were average readers in the same classrooms. (By grade 4, many of the initially poor readers were better readers.) During the fall of each year, several tests of reading accuracy, comprehension, and fluency, symbol naming speed, phonemic awareness, and vocabulary knowledge, were administered; each spring, an experimental assisted repeated reading intervention was conducted. (See Table 2.)

Children were divided into nonword decoding groups and word latency groups on the basis of Grade 4 scores on the Word Attack subtest above and below the 35th percentile and on latency to correctly recognize easy Grade 2 regular words on which almost all Grade 4 children had reached ceiling accuracy performance. (See Table 3.) There were 15 good decoder - fast readers (no deficit group), 8 good decoder - slow readers (rate-deficit only group), 7 poor decoder - fast readers (phonological-deficit only group), and 8 poor decoder - slow readers (double-deficit group). Consistent with the selection criteria, the two good decoder groups did not differ significantly on word attack percentile scores in Grade 4 (M=66 and 58), but did in word reading speed (M=611 and 911 ms respectively). Similarly, the two fast reader groups did not differ on reading speed (M=611 and 634 ms), but did differ on word attack skills (M=66 and 26 percentiles).The children with No-Deficit and Double-Deficit differed from one another on all measures in the study, during all three years, and the latter group were clearly the worst readers. However, there were 15 children with dissimilar skills in phonemic decoding and lexical access speed.

MANOVA examined effects of two levels of nonword decoding and word latency with time of test a repeated measure. Main effects of both factors and of time were observed on many measures, and few interactions of these factors occurred. (See Table 4.) Several variables revealed a main effect for one factor and a trend toward an effect of the other factor. The nonword decoding factor was significantly associated with Word Identification, Comprehension, Vocabulary knowledge, difficulty of passage, and Auditory Analysis scores, while the word latency factor was significantly associated with number of correct exception words, especially those of low frequency, reading comprehension, story speed and errors, and Digit Naming Speed.

Consistent with the absence of interactions, comparisons of No-deficit and Rate-deficit only groups, who are equated on good nonword decoding, found that while similar to each other on word identification, vocabulary knowledge and auditory analysis skill, the groups differed on several indices of reading skill not directly tied to speed: reading comprehension and knowledge of exception words and less frequent words, and on errors reading text of similar difficulty levels, the latter a finding replicating Lovett's finding for her rate disabled group. They also differed on speed of story reading even controlling for errors, and on Digit naming speed. (See Table 5.)

Similarly, children matched on poor decoding skill but differing in speed of very familiar words, the phonological-deficit only and double-deficit groups, did not differ significantly on Word Identification percentile scores across the three years ($F(1,13)=1.55$, n.s.). (See Table 6.) However, double-deficit children were less accurate than phonological-deficit only children on acuracy of moderately frequent words and were significantly poorer on the untimed reading comprehension measures across Grades 3 and

4 ($F(1,13)=5.02$, $p<.05$), despite not differing in Vocabulary knowledge across time ($F(1,13)=.09$, n.s). While at no time did their Auditory Analysis scores differ, their naming speed always differed, as did their speed of reading stories.

"Single deficit" groups

What about the single-deficit groups? To the extent that they resemble one another, it is suggestive that effects of phonemic decoding and lexical speed are additive for the skill in question. And the results of Study 1 suggest this is the case. Rate-deficit and phonological-deficit groups differed only on digit naming speed across time ($F(1,13)=9.53$, $p<.01$). (See Table 7.) They do not differ on Word Identification across the three years ($F(1,13)=.86$, n.s.), on regular or exception word accuracy, or on Reading Comprehension in Grades 3 and 4 ($F(1,13)=.51$, n.s). Vocabulary skill shows non-significant differences ($F(1,13)=3.09$, $p=.1$) favoring the rate-deficit group. None of the story-reading variables, including speed, differentiated the groups. Similarly, groups did not differ significantly on Auditory Analysis Test performance ($F(1,13)=1.94$, n.s.). Thus, the skills represented by decoding and speed of lexical access can compensate for one another on some reading measures. In the absence of the compensatory skill, as in the double-deficit group, all reading indices are quite poor.

Study 2

Eighty-two children from three public schools representing a range of different SES levels were tested in the spring of every year on a battery of reading and language measures from Kindergarten to Grade 4. The battery included standardized tests of oral reading and reading comprehension, and nonstandardized tests measuring accuracy and speed of regular and exception words, concrete and abstract words, function words, and nonsense words. Language measures included tests of expressive and receptive vocabulary and six continuous-list rapid naming measures (RAN and RAS).(See Table 8.)

Children were divided into subgroups similar to Study 1 on the basis of their Grade 4 accuracy of nonword decoding and speed of reading concrete, regular words. (SeeTable 9.) Four subgroups were defined: 53 non-deficit average readers (at or above the mean on both measures); 8 rate-deficit only readers (one standard deviation below the mean on speed measure only); 14 phonological-deficit only readers (one standard deviation or more below on nonword decoding only); and 7 double-deficit readers (one standard deviation or more below on both rate and decoding measures). Consistent with our criteria, the two able decoding groups did not differ significantly on nonword decoding (M=6.20 and 6.5, NS) but did differ on word reading speed (M=8.9 s and 24.6 s, $p<.001$). The two able reading rate groups did not differ on reading speed (M=8.9 s and 11.8 s; NS) but did differ on nonword accuracy (M=6.3 and 3.4, $p < .001$). Non-deficit average readers differed significantly from double-deficit readers on all measures of the battery except function word accuracy and receptive vocabulary. The double-deficit subgroup comprised the worst readers in the study on every measure of reading.

Like Study 1, the no-deficit and rate-deficit groups were similar on accuracy for regular and function words and vocabulary, but differed significantly on accuracy for exception words, speed for all reading measures, reading comprehension, oral reading, and all RAN and RAS measures of continuous naming speed. (See Table 10.) The phonological-deficit group and the Double-deficit group began in Grade 1 similarly impaired in word recognition, comprehension, and oral reading, with significant differences in all reading speed measures and naming speed tasks (the double-deficit group was significantly slower). (See Table 11.) Across time the differences between these groups widened in word recognition for exception words, reading comprehension, oral reading, with the double-deficit group becoming progressively more impaired than all other subgroups. The extent of the differences between the phonological-deficit only subgroup and the double-

deficit subgroup (who have, by definition, phonological plus rate deficits) underscores the critical need to go beyond our single-deficit explanations for the developmental dyslexias.

The one area of contrast between Study 1 and Study 2 is found in the comparison of the single-deficit groups. (See Table 12.) Like Study 1, the subgroups differed significantly on most rapid naming measures. Unlike Study 1, the rate-deficit only subgroup in Study 2 were consistently (Gr 1 to 4) more impaired on speed of all reading tasks, reading comprehension and ultimately (by Gr 4) on oral reading. Although the results only approached significance, accuracy for exception words was also lower. Despite ample access to decoding strategies, these rate-deficit children appear less able to achieve automatic access to words via lexical routes and perhaps as a consequence do not understand what they read well. Yet this group is often excluded from our samples because of their relatively good decoding skill.

Conclusions

Researchers may have mistakenly concluded that phonological decoding and speed of lexical access for familiar words are part of the same core phonological deficit because the worst readers have weaknesses in both areas. To some extent, strength in one area can compensate for weakness in another, yet single-deficit children are handicapped as readers. The present results indicate that the two deficits have independent, additive effects. Our knowledge of reading disability will suffer by continuing to view linguistic processing speed as only a byproduct of phonological skill. When children have a slower than normal reading or naming speed, even good phonological decoding does not make them good readers. Most importantly, the combination of poor phonemic sensitivity and phonological decoding and slow naming and reading speed appears to characterize our very worst readers (i.e., dyslexic children).

Finally, what do our results tell us about the nature of this "second" core deficit? Differences in naming speed for digits, words and text, as well as reading comprehension, might reflect simply differences in speed of access to orthographic codes. However, the fact that slow readers also showed accuracy differences for specific types of words, especially exception words, is consistent with a further hypothesis that slow naming speed reflects processes that hamper the induction of orthographic patterns upon exposure to print. The larger pattern of results suggests that the processes resulting in rapid reading reflect in large part a cognitive skill independent of phonological decoding, and that a double deficit conceptualization of reading disability is critical for a more comprehensive account of reading disabled children.

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Table 1.

Evidence concerning a second deficit indexed by tests of rapid naming.

1. Specificity of visual naming speed deficits

2. Predictive capacity (Kindergarten and later)

3. Independent contribution to word recognition

4. Naming speed problems more enduring than phonological deficits in more regular languages

5. Heritability of both phonological and naming speed deficits.

6. Moderating influence of naming speed on effects of practice

Table 2.

Measures for Study 1

1. **Word Identification, Word Attack, and Passage Comprehension**

2. **Latency to correct reading of isolated words** presented on computer:
   a) High frequency regular and exception words in Grade 4
   b) Moderate frequency regular and exception words in Grade 4

3. **Speed of naming single digits** on a continuous list, measured in items per second

4. **Auditory Analysis Test** (Rosner & Simon, 1971): deletion of the first or second consonant of a consonant blend, or of the last consonant

5. **Oral Vocabulary** knowledge (WISC-R) in Grades 2 and 4

6. **Story reading measures**: Children read 100 word passages at a level of difficulty appropriate for each child. Analyzed are:
   a) Story difficulty level
   b) Number of errors
   c) Words read per minute for first reading of one story

Table 3.

	Nonword Decoding	
	High	**Low**
Latency for words	above 35th percentile	below 35th percentile
Fast (below 750 ms)	n = 15 Decoding: 66%ile Latency: 611 ms	n = 7 Decoding: 26%ile Latency: 634 ms
Slow (above 750 ms)	n = 8 Decoding: 58%ile Latency: 911 ms	n = 8 Decoding: 20%ile Latency: 1136 ms

Table 4.

Nonword accuracy factor	Easy word latency factor
Word Identification	# correct exception words, and less frequent words
Reading Comp, untimed	Reading Comp, untimed
Vocabulary	Story errors
Difficulty Level of story	Story speed
Auditory Analysis Test	Digit Naming Speed

Table 5.
Comparison over time of **No-deficit** (n = 15) and **Rate-deficit** (n = 8) groups on other measures.

Similarities	**Differences** (Rate deficit only are less skilled)
- Word Identification percentile	- Reading Comprehension - untimed
- WISC-R Vocabulary	- # correct exception words
- Auditory Analysis Test	- # correct less frequent words
	- # of errors reading stories at same level of difficulty
	- Speed of story controlling errors
	- Digit naming speed

Table 6.
Comparison over time of **Phonological-deficit** (n = 7) and **Double-deficit** groups (n = 8) on other measures.

Similarities	**Differences** (Double deficit less skilled)
- Word Identification %iles	- # correct less frequent words
- # correct frequent words	- Reading Comprehension - untimed
- Story difficulty and errors	- Speed of reading stories
- WISC-R Vocabulary	
- Auditory Analysis Test	- Digit Naming Speed

Table 7.
Comparison over time of the single-deficit groups: **Phonological-deficit** only (n = 7) and **Rate-deficit** only (n = 8), on other measures.

Similarities	**Differences** (Rate-deficit less skilled)
- Word Identification percentile	- Digit Naming speed
- Reading Comprehension - untimed	
- # correct regular and exception words, high and moderate frequency	
- Story reading difficulty, errors, and speed	
- Auditory Analysis Test	

Table 8.

Measures for Study 2

1. **Gray Oral Reading**

2. **Gates-MacGinitie Reading Comprehension**

3. **Word recognition accuracy and speed for**

   a) regular words, concrete and abstract
   b) exception words, concrete and abstract
   c) function words

4. **Nonword accuracy and speed**

5. **Vocabulary**

   a) Expressive: Boston Naming Test
   b) Receptive: PPVT

6. **Continuous rapid naming measures:** RAN and RAS

Table 9

Nonword Decoding

Speed of concrete regular words	**High** (Average and higher)	**Low** (Below 1 SD)
Fast (Average and faster)	n = 53 nonwords = 6.3 Speed = 9 s	n = 14 nonwords = 3.4 Speed = 12 s
Slow (Slower than 1 SD)	n=8 nonwords = 6.5 Speed = 25 s	n = 7 nonwords = 2.0 Speed = 38 s

Table 10.
Comparison over time of **No-deficit** (average) (n = 53) and **Rate-deficit** only (n = 8) subgroups on other measures.

Similarities	**Differences** (rate-deficit only are less skilled)
- Accuracy for regular words	- Accuracy for exception words
- Accuracy for function words	- Speed on all reading tests
- Expressive vocabulary	- Reading comprehension - untimed
- Receptive vocabulary	- Oral reading
	- RAN and RAS rapid naming tests

Table 11.
Comparison of Grade 4 **Phonological-deficit** (n = 14) and **Double-deficit** (n = 7) subgroups on other measures.

Similarities	**Differences** (Double-deficit children less skilled)
- Accuracy of regular words	- Speed on all reading measures
- Accuracy of function words	- Later accuracy of exception words
- Early reading comprehension	- Later reading comprehension
- Early oral reading	- Later oral reading
- Receptive vocabulary	- RAN and RAS rapid naming tests

Table 12.
Comparison of the single-deficit groups: **Phonological-deficit** only (n = 14) and **Rate-deficit** only (n = 8) on other measures.

Similarities	**Differences** (Rate-deficit only less skilled)
- Accuracy of regular words	- Speed of all reading tasks
- Accuracy of function words	- Most RAN and RAS rapid naming
- Early oral reading	- Later oral reading
- Expressive vocabulary	- Reading Comprehension
- Receptive vocabulary	- Tendency for accuracy of exception words