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ABSTRACT

A study investigated how knowledge of a word's meaning, phonology, and orthography influences who will become a poor reader and who will develop adequate skill. Subjects (38 students from a small Ontario, Canada, city) were selected in grade 2 for their poor reading ability and followed until they reached grade 4. Conditions were devised in which latency for naming single digits or letters presented on a computer screen were compared to naming latency for a target digit or letter when it was embedded in an array of symbols which were either relevant or irrelevant to the subsequent item to be named. Nine of the 38 subjects remained poor readers in grade 4. Findings suggest that no one difficulty will lead to the status of a poor reader; instead, early strength in semantic, orthographic, or phonological processes may help to develop reading despite other deficits. (Eight tables and two figures of data are included.) (RS)

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Paper presented to The Society for Research on Child Development
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Implications for reading skills of developing abilities to automatize name retrieval under varied conditions

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Knowledge of a word's meaning, of its phonology and its orthography are all vital ingredients in reading. To use Ehri's (Ehri & Wilce, 1983) term, these three aspects of a word are "unitized" in skilled readers, retrieved together quickly and easily. Indeed, the major issue I'd like to address today is how such knowledge influences who will become a poor reader and who will develop adequate skill. However, understanding orthographic and unitization processes in reading has lagged behind the study of phonology and semantics. To remedy this imbalance, I propose that simple measures of digit or letter name retrieval speed may provide not only an index of unitization skill, but also might plausibly be a contributor to orthographic skill. First let me sketch why I think naming speed might be so important.

Poor readers not only learn to identify fewer words, they recognize quite slowly the names of the few words they do know. Measures of accuracy and speed are correlated, but what is the common process linking them? The relationship between speed and accuracy isn't restricted to words. Blachman (1984) notes that the speed of color naming in kindergarten is correlated with how many letter names a child learns that year. In Grade 1, those children who automatize better the letter names can also learn more words. She concludes that "ability to automatize a recently learned set of verbal labels is related to ability to learn a new set of labels". Slow retrieval of letter names and sounds may have continuing effects or at least correlates. As Adams (1990) concludes, even skillful readers "visually process virtually every individual letter of every word they read" (p.409). Could it be that slow speed of registering the letters in a word, in combining the visual encoding and name retrieval functions, continues to impede both learning new words and retrieving their names quickly?

Many researchers have demonstrated that poor and good readers are differentiated by their speed of naming lists of numbers or letters (eg., Denckla & Rudel, 1976; Spring & Capps, 1974; Spring & Davis, 1988; Wolf, Bally & Morris, 1986). Table 1 shows the continuous list format used in the present study, one of several formats which show naming speed-reading relationships. But just what processes underlie these correlations has been difficult to demonstrate. Investigators have questioned whether instead of name retrieval per se, the relationship reflects an ability to manage the multiple item format, to control attentional processes when reading a list, or to engage in more effective parallel processing of adjacent items. Lynn Swanson's dissertation, conducted in my lab, proposed that "decomposing" the continuous list task might reveal what elements of it accounted for correlations with reading tasks over time. Single-item name retrieval, name retrieval when no "rest" or recovery time occurs between items, and retrieval when items are embedded in an array of yet-to-be-named items are all aspects of the continuous-list task that can be studied under discrete-trial conditions.

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For the present study, we devised conditions in which latency for naming single digits or letters presented on a computer screen were compared to naming latency for a target digit or letter when it was embedded in an array of symbols which were either relevant or irrelevant to the subsequent item to-be-named. Table 2 shows examples of these conditions. You see that in the relevant condition, the #5 to the right of the clearly defined target, #1, appears as the next target, that is, #5 is the target in the display shown on line 2; in the irrelevant condition, the #4 to the right of the target on line 1, does not become the next target on line 2. Each condition occurred with two inter-stimulus intervals: with a short ISI, the next display occurred immediately upon naming the present target; in the long ISI, the next display occurred 1.25 seconds after naming the present target. We studied two cohorts of children from a small Ontario city who were selected in Grade 2 for their poor vs. average reading ability and followed them until they reached Grade 4. I have reported elsewhere (Bowers & Swanson, 1991) that poor readers in Grade 2 had deficits in latency of retrieval of discretely-presented digits and letters under all the above conditions and that in addition, Grade 2 poor readers were especially disadvantaged under brief ISI conditions. These children were retested during the next two years on the several conditions of naming digits and letters as well as on various phonological awareness and reading measures. Of the 38 children assessed in the third year of the study, more than half had been considered poor readers in grade 2; however, many of them had improved in reading over the two year period, so that only 9 of the 38 were in the bottom quartile of Woodcock Reading Mastery (Woodcock, 1973) Word Identification scores for Grade 4 in the third year of the study. Today I'd like to focus on the profile of naming speed and other measures which characterize those children who remain poor readers in Grade 4, compared to the characteristics of the children who became or remained better readers.

Table 3 describes the reading, continuous list naming speed, and vocabulary skills in Grade 4 of children categorized as poor, moderately poor and average readers based on their Grade 4 Woodcock Word Identification skills. Seven of the nine moderately poor readers had been in the poor reader group in Grade 2; six of the average readers had also been considered poor then.

The poor reader group differ from the moderately poor group on all the reading skills, including, strikingly, speed of correct identification of words. Poor readers differ as well on continuous-list digit naming speed. However, both groups have average ability on the WISC-R Vocabulary subtest (Wechsler, 1974). Moderately poor readers differ from average readers not only on word identification skill but also on Word Attack (Woodcock, 1973), Passage Comprehension (Woodcock, 1990), and Vocabulary skill. While they differ on their speed on identifying harder regular words (selected from the words of moderage frequency of Lovett, Ransby & Barron, 1988), they do not differ on speed of easier regular and exception words (selected from Olson et. al., 1985). Nor do they differ on Digit Naming Speed.

How do the 9 poor readers differ on speed of naming discretely presented digits and letters from the moderately poor readers and the better readers in Grade 4? Fig. 1 graphs the latencies of responses. MANOVA of these three groups' naming latencies (transformed to logs) under the various conditions indicated a significant main effect of reader group ($F = 3.54, p < .05$). There were no interactions attributable to poor vs. good reader groups; both groups named single items faster than those in either relevant or irrelevant multiple arrays. Regardless of group, letters were named slower than numbers and ISI did not affect naming latencies. Poor and good readers differed quite consistently from each other on all conditions; moderately poor readers are very similar to good readers, differing significantly on no measure. Since letter naming and digit naming latency are highly correlated and follow similar patterns for good and poor readers, it is likely that the phenomena is not apt to be a side-effect of reading experience per se.

How did these same children look on these measures when they were assessed in Grades 2 and 3? Let us focus on just the speed of naming digits, since these stimuli are the most automatized for all children. These graphs (Fig. 2) show the pattern of scores on discrete digit naming across grades 2, 3 and 4 for the children who were poor, moderately poor, and average readers in Grade 4. In all grades, the poor and good readers differ from one another on overall digit latency, (p<.1, p<.05 and p<.05 respectively) and no interactions of condition or ISI with reader group occur. Moderately poor readers do not differ from either group significantly, although their scores are clearly closer to the better readers. All reader groups increase over time in their speed of response, although the graph suggests that the poor readers are a bit more erratic in their progress. In short, symbol name retrieval under all conditions seems impaired in just the poorest readers.

The finding that relevant information to the right of the target was no more helpful to good than poor readers across all grades is consistent with the argument that good readers' fast word recognition is not due to better parallel processing of even unfamiliar patterns (as these number sequences are) but that instead, fast speed of individual letter identification helps to build up learned associations between letters, an argument made by Adams (1990). Thus letter naming speed may tap a process important to building up orthographic knowledge. Spring and Davis (1988) also suggest that continuous list digit naming speed taps the automatic character identification common to both direct lexical access and speech recoding routes to word recognition. It may be that the direct effect of this common automatic process is learning orthographic patterns.

The simple continuous-list measure of naming speed remains an excellent measure of basic name retrieval speed, correlating r=.74 with average latency to name digits on discrete trials in Grade 4. Both variables correlate highly with speed of reading easy words throughout the full range of reading ability, supporting naming speed as a measure of unitization. However, as the graphs illustrated, naming latency is related to word identification accuracy only in the lower ranges of word recognition. When intact classrooms are studied rather than reader group extremes, there may well be too few children at the low end of the distribution to find strong relationships between reading accuracy and latency of name retrieval.

As noted earlier, slow naming speed is just one correlate of disabled reading. The literature has amply demonstrated that poor readers lack explicit knowledge of phonemes, and are poor at tasks such as sound deletion. Again, our data confirm this pattern. In Grade 4, children's scores on an adaptation of Rosner & Simon's Auditory Analysis Test (Rosner & Simon, 1971), a sound deletion measure, correlate with word reading accuracy r=.56. Yet another well-known correlate of reading is vocabulary skill, or knowledge of word meanings. I suggest that naming speed, auditory analysis skill, and vocabulary knowledge can be considered measures, respectively, of the orthographic, phonological and semantic processes needed for reading. Table 4 presents the simple correlations of these 3 "predictor" skills with each other and with two types of reading measures, those tapping reading accuracy and those assessing word recognition speed. Reading accuracy is tapped by the word identification and word attack subtests from the Woodcock Reading Mastery Test of 1973 and the Passage Comprehension subtest from the recent revision of this test. Latency to correct identification of easy and moderately difficult regular words represent the word speed measures. All reading scores are significantly intercorrelated.

What are the respective roles of naming speed, phonological awareness and knowledge of word meanings in Grade 4 for reading in Grade 4? Multiple Regression analyses (Table 5) show that vocabulary, Auditory Analysis (i.e., AAT) and digit naming speed (i.e., DNS) contribute variance independent of one another (see Step 3) as well as overlapping variance (Steps 1 and 2) to measures of reading accuracy, while only naming speed contributes to word speed. Contributions are additive, so that a high degree of predictability of reading problems occurs with knowledge of all three skills. Multiple Correlations hover close to .7. But just how these independent skills jointly determine reading problems over time is not so clear.

Let us turn then to the longitudinal data to shed light on this question. What measures taken in Grade 2 will reveal which of the children will be poor readers in Grade 4? As Table 6 indicates, when these poor readers were in Grade 2, they were very slow namers and could delete very few phonemes correctly. Table 7 shows the correlation between Grade 2 predictor skills and reading in Grade 4. Notice that the predictors are not highly intercorrelated; auditory analysis and digit naming speed are correlated r=.35 and vocabulary is unrelated to these measures. Each of these predictors are themselves reliable across the two year period. Multiple Regression analyses (See Table 8) indicated that Grade 2 WISC-R Vocabulary, auditory analysis skills (AAT) and digit naming speed (DNS) predicted overlapping variance (Steps 1 and 2) as well as independent variance (Steps 3 and 4) to reading two years later. Moreover, the interaction of auditory analysis and digit naming speed predicts significant variance in easy and more difficult word speed. Thus, if a child has a fast digit naming speed in Grade 2, his word speed in grade 4 will be fast, regardless of his skill at auditory analysis. But if he is a slow digit namer, his later word speed is helped by good auditory analysis skills. Altogether, these three variables predict a substantial amount of variance in later reading.

What does this pattern mean in practice for individual children? Most of the 9 children whom we considered poor readers in Grade 4 were, when in Grade 2, well able to delete the initial consonant in a word such as "task", as shown by other data we gathered. However, all were unable to reliably delete last consonants, such as the /n/ in tone or the first consonant of a blend such as /b/ in block, as shown by their all having low scores on our Auditory Analysis measure. However, 12 other children who were better readers in Grade 4 also have comparably low Grade 2 Auditory Analysis scores. The children with poor phonological skill in Grade 2 who nevertheless become adequate readers differ significantly from those who stay poor readers, in their naming speed and their Vocabulary in Grade 2. Thus if auditory analysis is low, it appears a child can compensate for that deficit to some extent by a good vocabulary or by faster speed of symbol retrieval. Not all slow namers in Grade 2 became poor readers of course; those who did not become poor readers had higher Vocabulary scores. Although the Vocabulary, Auditory Analysis and Digit Naming Speed scores in Grade 2 are not strongly inter-correlated, those children who happen to have lower scores all around, with no "protective" skills, are quite disadvantaged later on.

An implication of the current study is that no one difficulty will "doom" a child to poor reader status; instead, early strength in semantic, orthographic or phonological processes may help to develop reading despite other deficits. For example, if a child with adequate ability to recognize symbols quickly but poor phonological knowledge sees and pronounces meaningful written words often enough, perhaps a "good enough" phonological representation of words will be developed. Similarly, a slow namer with adequate phonological awareness may laboriously sound out a written word, using its phonology to reach its semantic representation, and do it often enough that eventually a better visual representation is acquired. Children with a weakness in only one of the knowledge bases for reading may be slower to unitize word retrieval. but with adequate experience with reading, may develop it through somewhat circuitous routes. Our assessments of their strengths and weaknesses may be of help in guiding them there. The most difficult cases remain those children who lack strength in either phonology or orthography, especially when oral language expertise is not well developed. Devising their routes to semantic representations of written material is a challenge for us all.

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4	1	3	2	5	8	4	2
1	5	3	8	1	4	3	5
8	2	4	8	3	1	5	2
1	3	5	2	8	4	3	8
2	5	1	4	2	4	1	3
8	5	3	1	8	2	5	4

TABLE 2

DISCRETE TRIAL CONDITIONS

SINGLE	RELEVANT	IRRELEVANT
3	4 1 5 3 2	5 2 4 1 8
	↑	↑
8	1 5 3 2 8	4 3 5 8 2
	↑	↑
2	5 3 2 8 4	8 1 4 3 2
	↑	↑

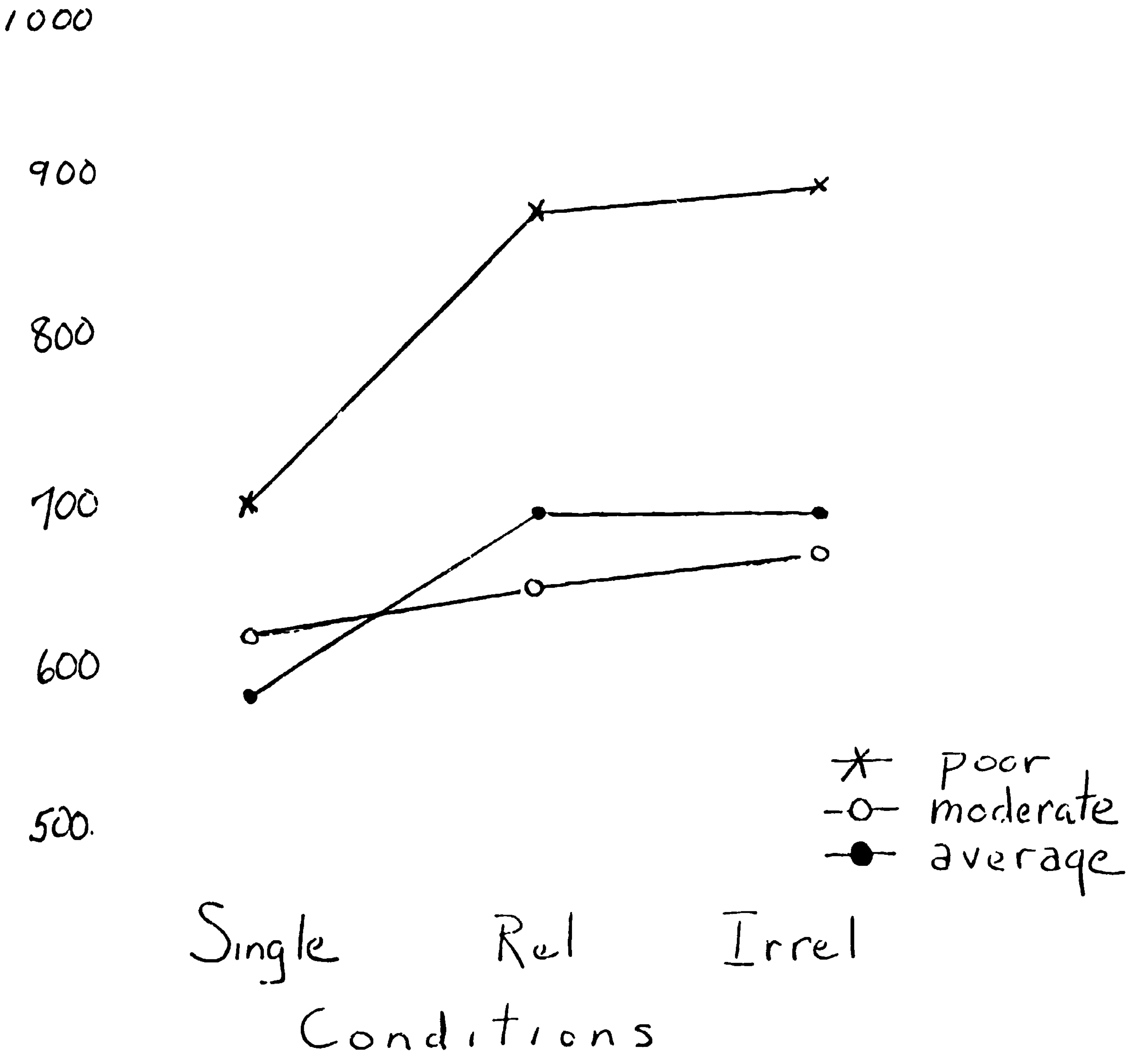

Fig. 1 Latencies in msec across ISI

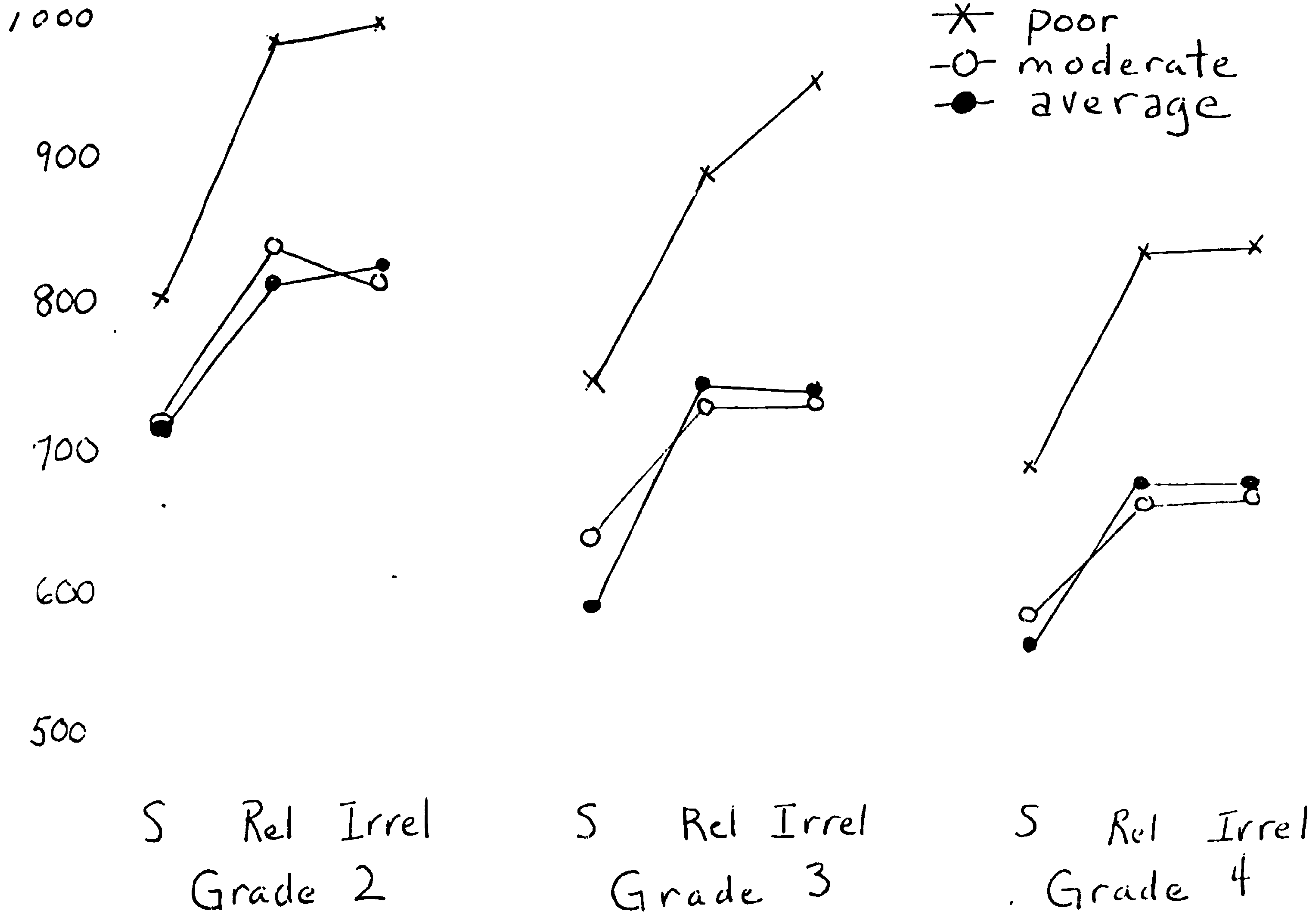

Fig. 2. Latencies in msec. for digit naming across 151

TABLE 3

GRADE 4 WORD IDENTIFICATION ACCURACY GROUPS: MEAN SCORES

	< 25th %ile (N=9)	26th to 35th %ile (N=9)	> 35th %ile (N=20)
Word Ident %ile	16.1	32.7	60.6
Word Attack %ile	22.2	36.1	64.0
Pas. Comp-R %ile	8.8	18.7	42.8
Latency in msec. for:			
- reg. easy words	1084	718	688
- exc. easy words	1136	728	714
- reg. hard words	1474	1084	796
Digit Naming Speed in:			
- items/sec.	1.75	2.25	2.21
WISC-R Vocabulary	10.2	10.1	12.8

TABLE 4

CORRELATIONS OF GRADE 4 PREDICTOR SKILLS WITH READING

	PREDICTOR SKILLS			READING ACCURACY			READING SPEED	
	Vocab.	DNS	AAT	Word Ident.	Word Attack	Pas. Comp.-R	Latency for Words Harder	Easier
							(signs reversed)	
WISC-R Vocab.	X	.08	.32*	.42**	.38**	.37*	.23	.09
Digit Naming Speed		X	.24	.45**	.41**	.33*	.59***	.65***
Auditory Analysis Test			X	.56***	.63***	.50***	.28*	.30*

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

TABLE 5

MULTIPLE REGRESSION PREDICTING GRADE 4 READING PER CENT OF VARIANCE ACCOUNTED FOR AT EACH STEP

	READING ACCURACY			READING SPEED	
STEP	WORD IDENT	WORD ATTACK	COMP-R	HARDER WORDS	EASIER WORDS
1 VOCAB	17**	14*	14*	------	------
2 AAT	20**	28***	16**	------	------
2 DNS	23***	20**	13*	37***	43***
3 AAT	11**	18**	10*	------	------
3 DNS	14**	9*	------	33***	36***
3 VOCAB	10*	6*	------	------	------
R	.71	.72	.60	.65	.67

* $p < .05$

** $p < .01$

*** $p < .001$

TABLE 6

GRADE 2 SCORES OF GRADE 4 READING GROUPS

	< 25th %ile (N = 9)	26th to 35th %ile (N = 9)	> 35th %ile (N = 20)
WISC-R VOCAB.	9.2(3.0)	10.1(3.1)	12.3(3.2)
DIGIT NAMING SPEED	1.26 (.27)	1.58(.30)	1.61(.42)
AUDITORY ANALYSIS TEST	2.2 (1.8)	7.0(5.6)	8.8(6.8)

TABLE 7

CORRELATIONS OF GRADE 2 PREDICTOR SKILLS WITH READING SCORES IN GRADE 4

	Predictor Skills			Reading Accuracy			Reading Speed	
							Latency for words:	
	Vocab	DNS	AAT	Word Ident	Word Attack	Pas Comp	Harder	Easier
							(signs reversed)	
Vocab	X	.02	.05	.42**	.32*	.50**	.23	-.02
DNS		X	.35*	.40**	.37*	.41**	.58***	.57
AAT			X	.47**	.58***	.33*	.36*	.33*

TABLE 8

MULTIPLE REGRESSIONS PREDICTING GRADE 4 READING FROM GRADE 2 MEASURES: PER CENT OF VARIANCE ACCOUNTED FOR AT EACH STEP

	READING ACCURACY			READING SPEED	
STEP	WORD IDENT	WORD ATTACK	COMP-R	HARDER WORDS	EASIER WORDS
1 VOCAB	18**	10*	25**	------	------
2 DNS	16**	13*	16**	33***	33***
2 AAT	20**	32***	9*	12*	11*
3 DNS	7*	------	10*	23***	24***
3 AAT	11*	22***	------	------	------
3 DNS X AAT	------	------	------	11**	7*
4 VOCAB	16**	8*	22***	------	------
R	.71	.70	.70	.72	.65

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