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Relationships Between Word Decoding Speed, General Name-Retrieval Ability, and Reading Progress in First-Grade Children

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A discrete-trial reaction time methodology was employed in order to measure the speed with which skilled and less-skilled readers named colors, pictures, numbers, letters, and words. Words were the only stimulus type that the skilled readers named more rapidly. The equality of naming times for colors, pictures, and numbers suggests that a general name retrieval deficit, suggested by earlier studies of dyslexic children, does not appear to be characteristic of less-skilled nondyslexic children. Instead, the marked word decoding speed difference, in conjunction with the lack of a letter naming difference between the two groups, supports previous research that has suggested that phonological analysis skills may be important determinants of early reading acquisition.

Does a general ability to respond rapidly to symbolic stimuli differentiate skilled from less-skilled readers? Such a question is of current relevance due to several recent theoretical and empirical developments in the psychology of reading. It is the case that researchers of vastly different theoretical persuasions (e.g., LaBerge & Samuels, 1974; Smith & Holmes, 1971) all agree that words must be processed rapidly in order for fluent reading to occur. There is ample empirical evidence documenting the fact that skilled readers name words faster than less-skilled readers (e.g., Biemiller, 1977/1978; McCormick & Samuels, 1979; Perfetti & Hogaboam, 1975; Stanovich, 1980). However, the existence of a relationship between word naming speed and reading ability raises the question of whether the performance deficit displayed by less-skilled readers is due to a problem specific to word decoding or is, instead, due to a more general inability to rapidly process symbolic stimuli. The possible importance of the latter factor is suggested by the fact that in many information processing studies of reading that employ reaction time as a dependent measure, the main effect of reading ability is often much larger than the interaction contrast between reading ability and any reading-related factor that has been manipulated (see Barron, 1981). This suggests the possibility of the existence of a general speed factor that differentiates readers of differing fluency.

There is some evidence that a general rapid name retrieval ability differentiates normal readers from dyslexic children and children who show severe reading deficits. Denckla and Rudel (1976) found that dyslexic children named objects, colors, numbers, and letters slower than nondyslexic learning-disabled children, who in turn named the four stimulus sets slower than control children without dyslexia or learning disability. Spring and Capps (1974) found that dyslexic boys named digits, colors, and pictures slower than nondyslexic boys (see also Spring & Farmer, 1975) and that their time to name digits was particularly slowed. However, in contrast to these results, Seymour and Porpodas (1980) tested a small group of dyslexic subjects and found that although they had a severe deficit in word naming, they named pictures of objects as fast as nondyslexic subjects. Perhaps the only safe conclusion at this point is that although there have been indications of a general name retrieval deficit on the part of dyslexic children, discrepant results do exist and further empirical work appears to be necessary. Regarding the latter point, fu-

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ture research might be aided by the utilization of more controlled and accurate methodologies than have been employed in previous research. Specifically, both the Denckla and Rudel (1976) and Spring and Capps (1974) studies employed a continuous-list procedure, whereby subjects name a series of stimuli and their time to name the entire list is measured on a stopwatch. The times resulting from such a procedure are very likely to be in part determined by various sequential-response, scanning, and motor-production strategies that subjects may adopt. The discrete-trial procedure, in which the reaction time to a single stimulus is measured to millisecond accuracy, is a much cleaner methodology and was employed in the present study.

How well do the results indicating that name retrieval speed differentiates dyslexics from nondyslexics generalize to less-skilled readers not diagnosed as dyslexic? A study by Perfetti, Finger, and Hogaboam (1978) suggests that they do not. These investigators tested skilled and less-skilled third-grade readers who were all found in normal classrooms. They observed that although the less-skilled readers were markedly impaired in their ability to name words, these children named colors, digits, and pictures just as fast as the skilled readers. The results of Perfetti et al. (1978) suggest that the less-skilled nondyslexic reader is not deficient in rapid name retrieval, but instead has deficiencies in processes that are specific to word decoding (perhaps in processes responsible for phonological segmentation and recoding, see Golinkoff, 1978; Rozin & Gleitman, 1977). However, there is missing from the Perfetti et al. (1978) study a condition of much interest, namely, a condition in which the subjects respond to unrelated letters. This condition would allow for the assessment of the generality of the word naming deficit that was uncovered. Specifically, it would help to determine whether the ability to discriminate the components of words in isolation is related to the naming deficit, or whether the ability to decode the structure of words is the key difference. In the study to be reported, a letter condition was added to the conditions employed by Perfetti et al. (1978), in order to allow for such an inference. Also, the Perfetti et al. (1978) study utilized subjects (third-grade children) who were well beyond the initial stages of reading acquisition. In the present study, first-grade children were used as subjects in order to see if the highly diagnostic pattern of results observed by Perfetti et al. (1978) would be found for children in the crucial acquisition stages.

Method

Subjects

The subjects were 22 first-grade children (10 females and 12 males) recruited from a classroom in a predominantly middle-class elementary school. Two additional children were in the subject pool but failed to complete all of the experimental tasks. The children were tested during early June. At that time the teacher was asked to rank order the 22 children on the basis of their reading ability. The top 11 readers constituted the skilled group and the bottom 11 constituted the less-skilled group. All of the children were administered Reading Subtest Level I of the Wide Range Achievement Test (WRAT), the Reading subtest (sections A and B, Primary Level 1) of the Stanford Achievement Test, and a short paragraph that was read orally and was timed by the experimenter. The mean WRAT score of the skilled readers was 51.9, and the mean score of the less-skilled readers was 40.3, a difference that was highly significant, $t(20) = 5.60$, $p < .001$. According to the Stanford scores, the mean reading ability of the skilled readers was at the 3.1 grade level and the mean reading ability of the less-skilled readers was at the 1.6 grade level, $t(20) = 4.09$, $p < .001$. Skilled readers read the paragraph in a mean time of 61.6 seconds, whereas the mean reading time of the less-skilled readers was 114.8 seconds, $t(20) = 4.99$, $p < .001$. Not surprisingly, a check on the actual progress the children had made through beginning reading materials also confirmed the teacher's ratings. There was little overlap between the two groups. For example, no less-skilled reader attained a Stanford score as high as a skilled reader, only one less-skilled attained a WRAT score as high as a skilled reader, and only three less-skilled readers had paragraph reading times as fast as a skilled reader.

Stimuli and Apparatus

The stimuli were the numbers 1 through 10, line drawings of objects (fork, hat, kite, bike, house, tiger, saw), 10 letters (*i*, *b*, *t*, *a*, *v*, *m*, *f*, *n*, *c*, *y*), 20 strings of Xs that were colored either red, yellow, blue, or green, and 20 words (*think*, *head*, *you*, *went*, *did*, *where*, *and*, *three*, *all*, *had*, *gone*, *play*, *again*, *two*, *goes*, *come*, *open*, *done*, *great*, *going*). These stimuli constituted what will hereafter be called the number, picture, letter, color, and word conditions, respectively. All of the number, letter, and word stimuli were typed in News Gothic font, except the Xs in the color condition, which were typed in IBM Courier 72. The stimuli were photographed and mounted on 35mm white on black slides. Slides in the color condition were colored either red, yellow, blue, or green with acetate films. The slides were projected onto a white screen by a Kodak Carousel 760H projector. Subjects sat approximately 90 cm from the screen, and a five-letter word subtended a horizontal visual angle of approximately three degrees. Stimulus onset was controlled by a Vincent Associates Uniblitz Shutter that was positioned over the lens of the projector. When the experimenter pushed a control button, the shutter was electronically opened, and the projected image of the stimulus item appeared. Simultaneously, a Lafayette Instruments electronic clock (Model 54419-A, accurate to the millisecond) was started by the same push of the control button. When the subject verbally responded, a voice-activated relay stopped the clock and closed the shutter. The microphone that led to the voice-activated relay was held by the subject.

Table 1
Mean Reaction Time (in msec) for Each Naming Condition and Mean Number of Errors in the Word Condition as a Function of Reader Skill

	Skilled		Less-skilled	
Condition	*M*	*SD*	*M*	*SD*
Color	821	236	766	111
Picture	869	238	835	166
Number	660	118	653	125
Letter	775	212	774	170
Word reaction time	1008	277	1351	394
Word errors	3.3	2.8	9.7	2.0

Procedure

Most of the testing took place during a single session held in early June. Each subject was individually tested, and a session lasted approximately 25 minutes. During this session, the number, picture, letter, and word conditions were completed. Subjects were told which category of stimuli would appear, and that they would be seeing a series of individual stimuli. Their task was to name the stimulus as fast as possible. The order of conditions was number, picture, letter, and word for each subject. In addition, the order of stimuli within each condition was the same for each subject. Practice trials preceded the presentation of the experimental stimuli in each condition. The color condition was completed in late April during a testing session that was part of another investigation.[1]

Results

Trials on which the subject incorrectly named the stimulus, trials on which the response time was greater than 3,000 msec, and trials on which the response time was more than 2.5 standard deviations above the mean for that condition were scored as subject errors and dropped from the reaction time analysis. In the word condition, words that the subject did not know were also scored as subject errors and dropped from the reaction time analysis. Subject errors in all of the conditions except the word condition were relatively rare. Across all subjects, the total number of errors on the color, picture, number, and letter conditions were 11, 2, 2, and 10 out of a total of 440, 154, 220, and 220 responses, respectively. Less-skilled readers produced 7, 1, 2, and 6 of these errors, across the conditions. The split-half reliabilities of the color, picture, number, letter, and word tasks were .65, .62, .75, .73, and .74, respectively. The mean reaction time in each of the naming conditions was calculated for each subject. The mean of these means, in addition to the mean number of subject errors in the word condition, are displayed in Table 1 as a function of reader skill. Less-skilled readers named colors, pictures, numbers, and letters just as fast as the skilled readers. There were no significant differences between the groups in any of these conditions (all $|t|$s < 1). However, there were marked differences between the groups in the word naming task. Less-skilled readers made many more errors on word trials than skilled readers, $t(20) = 6.28$, $p < .001$. Furthermore, even when all errors, unknown words, and unusually long trials were eliminated, there was a difference between the two groups in how fast they named words. That is, the skilled readers named words approximately 340 msec faster than the less-skilled readers, $t(20) = 2.36$, p

[1]Although not the focus of the present study, a measure of contextual facilitation was also derived for each subject by having them read a coherent paragraph and a random word list in a manner similar to Biemiller (1977/1978). Neither the difference nor the ratio between paragraph and random word reading times differentiated the skilled from the less-skilled readers, and these measures will not be considered further. The order of tasks was the same for each subject so as not to obscure the correlational analyses. Differential fatigue across the two ability groups should not be a problem because the tasks preceding the word naming task were just those at which the less-skilled readers were most proficient. Furthermore, none of the children displayed any behavioral or verbal indication of fatigue.

Table 2
Intercorrelations for Measures of Reading Ability, Naming Latencies, and Word Errors

Variable	1	2	3	4	5	6	7	8	9
1. WRAT		.67**	−.79**	.27	.16	.06	.07	−.52*	−.88**
2. Stanford			−.61**	.44*	.18	−.02	.17	−.46*	−.73**
3. Paragraph reading time				−.30	−.11	−.12	−.12	.70**	.78**
4. Color					.66**	.59**	.76**	.04	−.33
5. Picture						.74**	.84**	.31	−.23
6. Number							.76**	.38	−.13
7. Letter								.26	−.15
8. Word reaction time									.47*
9. Word errors									

Note. WRAT = Wide Range Achievement Test.
* $p < .05$. ** $p < .01$.

< .05, even after all words unknown to the less-skilled readers (or on which they produced unusually long responses) were eliminated. Thus, skilled readers not only know more words than less-skilled readers, but they more quickly decode words that are known to both groups.

Results based on correlation analyses were highly convergent with the pattern of results obtained when the subjects were divided into skilled and less-skilled reader groups. Table 2 displays a correlation matrix where the three measures of reading ability (WRAT scores, Stanford scores, and paragraph reading time) were correlated with the latencies on the naming tasks (color, picture, number, letter, and word), and number of errors on the word task. Several patterns are immediately apparent. The three measures of reading ability correlated among themselves. Color, picture, number, and letter naming time were intercorrelated, but were not related to word naming time, word error rate, or the measures of reading ability. Word naming time and word error rate each were significantly correlated with all three measures of reading ability.

Multiple regression analyses were performed for each of the ability measures in order to investigate further the trends in the pattern of correlations among the variables. The results of these analyses are displayed in Table 3. The variables were entered into the regression equation in the fixed order of picture, number, letter, word reaction time, and word errors. The theoretical rationale for this ordering was that variables tapping a general speed factor (picture, number, and letter naming time) were given priority in the analysis so that when word reaction time was entered as the fourth variable it would indicate how much variance was accounted for by word decoding speed independent of general speed factors. The number of errors, a variable that probably reflects knowledge of words, was entered last in order to determine whether word knowledge, independent of decoding and general speed

Table 3
Summary of Multiple Regression for Each of the Three Reading Ability Measures

	WRAT		Stanford		Paragraph time	
Variable entered	R	Increase in R^2	R	Increase in R^2	R	Increase in R^2
Picture	.16		.18		.11	
Number	.19	.01	.29	.05	.12	.00
Letter	.22	.01	.32	.02	.13	.00
Word reaction time	.65	.37**	.59	.25*	.82	.66**
Word errors	.89	.38**	.78	.25**	.90	.14**

Note. WRAT = Wide Range Achievement Test.
* $p < .05$. ** $p < .01$.

factors, contributes to reading variance. The three general speed variables were entered in the order picture, number, and letter to reflect the increasing similarity of these stimuli to words.

As is clear from Table 3, the three multiple regression analyses on the reading measures displayed highly consistent patterns. The three measures of general speed accounted for little variance. None of the regressions were significant when only the three general speed measures were entered (all *p*s $> .25$). However, when word naming time was entered there was a highly significant increase in variance accounted for. The number of word errors also caused a significant increase in the variance explained.

Discussion

The fact that skilled and less-skilled readers displayed large differences on word naming time and errors confirms, and extends to a lower age range, earlier research showing word level factors to have strong relationships with reading skill (Biemiller, 1977/1978; McCormick & Samuels, 1979; Perfetti et al. 1978; Perfetti & Hogaboam, 1975; Stanovich, 1980). The present study is particularly indicative of this relationship, since very large differences were obtained with groups of skilled and less-skilled readers who were formed on the basis of a median split of a classroom, rather than having been chosen from the extremes of reading skill. Thus, neither the mean differences nor the correlations are inflated due to the use of extreme groups. The 340 msec difference in word naming time is particularly indicative of a decoding speed deficit in the less-skilled readers given the way that the mean reaction times for the two groups were determined. The method actually served to decrease naming speed differences between the groups because only words that a given child clearly knew were included in the analysis. Trials on which subjects named the wrong word were eliminated, as were trials on which the subject did not know the word. In addition, unusually long reaction times were eliminated from the naming time analysis by the procedure of not including times longer than 3,000 msec or more than 2.5 standard deviations above the mean. Not surprisingly, a disproportionate number of these times were produced by the less-skilled readers. As a result of all these procedures, the mean naming times of the skilled readers were based on a larger set of words than those of the less-skilled readers. More importantly, the skilled readers were naming some of the more difficult words that the less-skilled readers did not know. Thus, the skilled readers showed a 340 msec reaction time advantage even though they were naming words that were, as a whole, more difficult than those on which the reaction times of the less-skilled readers were based.

The number of errors made on words displayed a strong relationship with reading ability in all of the analyses. Not only was this variable highly correlated with all three measures of reading ability, but the multiple regression analyses indicated that this variable made an independent contribution to predicting reading variance after decoding and general speed variables were factored out. This suggests that word knowledge, in addition to decoding speed, is an important determinant of reading skill.

No differences in color, picture, or number naming speed were found between the two groups. Thus, the findings of Perfetti et al. (1978), who worked with third graders, were replicated using a first-grade sample. The present results are thus in conflict with the studies of Denckla and Rudel (1976) and Spring and Capps (1974) who did find differences between dyslexic and nondyslexic children in naming these stimulus types. The two most likely explanations for this discrepancy involve the procedures and subject populations used in the relevant studies. Both the Denckla and Rudel (1976) and the Spring and Capps (1974) studies employed a continuous-list procedure, whereas the Perfetti et al. (1978) study and the present experiment employed the more precise discrete-trial procedure. Another important difference between the present study and those of Denckla and Rudel (1976) and Spring and Capps (1974) is the type of reader tested. The present study employed the less-skilled readers in a normal classroom, whereas the other two studies tested dyslexic children with severe reading disabilities. Thus, if the general speed difference uncovered by Denckla and Rudel (1976) is real (i.e., if it holds up under a replication using a discrete-trial procedure), then the present results indicate that this deficit in rapid name retrieval does not account for differences in reading skill among children in the normal range of reading ability. This would be an indication that processing deficits uncovered in studies employing dyslexic subjects do not necessarily generalize as explanations for individual differences across the entire range of reading skill. Such a conclusion would suggest caution in applying findings from groups with extreme deficits to children who, although somewhat behind their peers, are functioning adequately in a normal classroom. Irrespective of these more general conclusions, the present results indicate that a general name retrieval speed is not a factor that discriminates between skilled and less-skilled readers in the range investigated. Instead, factors that are specific to word decoding appear to be a major determinant of reading skill differences.

An examination of letter naming speed allows for the further specification of what factors at the word level are related to reading skill. If, for example, difficulty in dealing with the visual components of words is a problem for less-skilled readers, then there should be reader skill differences in letter naming speed. If however, the crucial deficit in word naming speed is due to difficulties in phonological recoding or other higher-level segmentation processes, rather than feature extraction from letter units, then there should not necessarily be reader skill differences in letter naming speed. The results were in fact clearcut. The two groups named letters with equal facility, indicating that the key deficit is not an inability to deal with the visual components of words but instead involves letter sound translation and/or the decoding of multiple letter units (see also Katz & Wicklund, 1971, 1972). This conclusion is supportive of those researchers who have argued that phonological processing abilities may be more crucial than visual processing skills in determining early reading success (Golinkoff, 1978; Rozin & Gleitman, 1977; Vellutino, 1977).

The present results are apparently in conflict with the findings of Biemiller (1977/1978), Speer and Lamb (1976), and Staller and Sekuler (1975), who did observe reader skill differences in letter naming speed. However, all of these studies employed a continuous-list procedure, as opposed to the discrete-trial procedure employed in the present experiment. Thus, the pattern of results is correlated with experimental paradigm. In fact, Staller and Sekuler (1975) themselves suggested that the continuous-list procedure may produce differences in naming time that are due to differences in processes other than those involved in single letter naming. They observed that skilled readers named normal letters faster than less-skilled readers but that the two groups did not differ on the time to name a list of mirror-image letters. Staller and Sekuler (1975) argued that it was possible that differences in peripheral processing mechanisms could account for the pattern of results. In the continuous list procedure, the letters to the right of the letter that the subject is naming are in peripheral vision. If skilled readers are able to extract more information from the periphery, then they will display superior performance even if the two groups do not differ in their ability to name individual stimuli. Staller and Sekuler (1975) speculated that the mirror-image condition may have interfered with peripheral processing, thus rendering ineffective the processing mechanism that was the cause of the skilled readers' advantage. Regardless of the status of these specific theoretical arguments, they illustrate the more general point that many different processes (other than name retrieval) can contribute to performance differences when a continuous-list procedure is employed. When the speed of retrieving the name of a single stimulus is the variable of interest, then the discrete-trial procedure is preferred. Thus, the present study indicates that when the controls of this methodology are employed, letter naming speed does not differentiate skilled from less-skilled first graders.

Less-skilled first-grade readers do not appear to be characterized by a general deficit in their ability to rapidly retrieve the names of stimuli. Rather, they appear to be deficient in their word knowledge and their ability to rapidly decode words that are known. The latter deficit appears not to be due to a problem in dealing with the visual components of words, since there were no reader skill differences in letter naming. Processes of phonological segmentation and recoding appear to be more likely candidates for the processes that result in the observed individual differences in word naming speed. Although these processes were not directly isolated in the present study, the results are certainly consistent with other empirical investigations and theoretical speculations about the role of phonological processes as determinants of reading skill differences (e.g., Golinkoff, 1978; Vellutino, 1977). The results, however, are also not inconsistent with the hypothesis that differences in dealing with the serial order of letter sequences in part determines the ease of reading acquisition (see Mason, 1980; Singer, 1979).

References

Barron, R. W. Development of visual word recognition: A review. In T. G. Waller & G. E. MacKinnon (Eds.), *Reading research: Advances in theory and practice* (Vol. 3). New York: Academic Press, 1981.

Biemiller, A. Relationships between oral reading rates for letters, words, and simple text in the development of reading achievement. *Reading Research Quarterly*, 1977/1978, *13*, 223–253.

Denckla, M. B., & Rudel, R. G. Rapid automatized naming (R.A.N.): Dyslexia differentiated from other learning disabilities. *Neuropsychologia*, 1976, *14*, 471–478.

Golinkoff, R. M. Phonemic awareness skills and reading achievement. In F. Murray & S. Pikulski (Eds.), *The acquisition of reading*. Baltimore, Md.: University Park Press, 1978.

Katz, L., & Wicklund, D. A. Word scanning rate for good and poor readers. *Journal of Educational Psychology*, 1971, 62, 138–140.

Katz, L., & Wicklund, D. A. Letter scanning rate for good and poor readers in grades two and six. *Journal of Educational Psychology*, 1972, *63*, 363–367.

LaBerge, D., & Samuels, S. J. Toward a theory of automatic information processing in reading. *Cognitive Psychology*, 1974, *6*, 293–323.

Mason, M. Reading ability and the encoding of item and location information. *Journal of Experimental Psychology: Human Perception and Performance*, 1980, 6, 89–98.

McCormick, C., & Samuels, S. J. Word recognition by second graders: The unit of perception and interrelationships among accuracy, latency, and comprehension. *Journal of Reading Behavior*, 1979, *11*, 107–118.

Perfetti, C. A., Finger, E., & Hogaboam, T. Sources of vocalization latency differences between skilled and less skilled young readers. *Journal of Educational Psychology*, 1978, *70*, 730–739.

Perfetti, C. A., & Hogaboam, T. Relationship between single word decoding and reading comprehension skill. *Journal of Educational Psychology*, 1975, *67*, 461–469.

Rozin, P., & Gleitman, L. R. The structure and acquisition of reading II: The reading process and the acquisition of the alphabetic principle. In A. Reber, & D. Scarborough (Eds.), *Toward a psychology of reading*. Hillsdale, N.J.: Erlbaum, 1977.

Seymour, P. H. K., & Porpodas, C. D. Lexical and non-lexical processing in developmental dyslexia. In U. Frith (Ed.), *Cognitive processes in spelling*. London: Academic Press, 1980.

Singer, M. H. Comment on "Alternative conceptualizations of dyslexia: Evidence in support of a verbal-deficit hypothesis." *Harvard Educational Review*, 1979, *49*, 125–128.

Smith, F., & Holmes, D. L. The independence of letter, word, and meaning identification in reading. *Reading Research Quarterly*, 1971, *6*, 394–415.

Speer, O. B., & Lamb, G. S. First grade reading ability and fluency in naming verbal symbols. *The Reading Teacher*, 1976, *29*, 572–576.

Spring, C., & Capps, C. Encoding speed, rehearsal and probed recall of dyslexic boys. *Journal of Educational Psychology*, 1974, *66*, 780–786.

Spring, C., & Farmer, R. Perceptual span of poor readers. *Journal of Reading Behavior*, 1975, *7*, 297–305.

Staller, J., & Sekuler, R. Children read normal and reversed letters: A simple test of reading skill. *Quarterly Journal of Experimental Psychology*, 1975, 27, 539–550.

Stanovich, K. E. Toward an interactive-compensatory model of individual differences in the development of reading fluency. *Reading Research Quarterly*, 1980, *16*, 32–71.

Vellutino, F. R. Alternative conceptualizations of dyslexia: Evidence in support of verbal-deficit hypothesis. *Harvard Educational Review*, 1977, *47*, 334–354.

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