APPENDIX TABLE B. SPEED (ITEMS NAMED PER SECOND) NORMS FOR RAN SUBTESTS AND COMPOSITES FOR GRADES 1, 3, 5 AND 8.

	Percentiles									
	1	2	5	10	25	50	75	90	95	99
Colors										
1	.556	.641	.714	.833	.980	1.136	1.250	1.190	1.316	1.515
3	.769	.893	.943	1.042	1.190	1.351	1.515	1.429	1.563	1.724
5	.926	1.020	1.111	1.250	1.389	1.563	1.786	1.724	1.852	2.174
8	1.220	1.282	1.351	1.515	1.724	1.923	2.174	2.000	2.273	2.500
Objects										
1	.266	.427	.485	.581	.685	.820	.943	.893	.980	1.136
3	.515	.610	.704	.806	.926	1.042	1.136	1.111	1.190	1.389
5	.685	.794	.847	.943	1.064	1.220	1.316	1.282	1.429	1.563
8	.862	.980	1.042	1.163	1.351	1.471	1.667	1.563	1.786	2.778
Numbers										
1	.714	.862	.926	1.190	1.429	1.563	1.852	1.667	1.923	2.273
3	1.087	1.190	1.316	1.563	1.852	2.083	2.381	2.273	2.632	2.778
5	1.282	1.515	1.613	1.923	2.273	2.500	2.941	2.778	3.125	3.846
8	1.389	1.786	1.923	2.174	2.500	2.941	3.333	3.125	3.333	4.167
Letters										
1	.485	.847	.943	1.163	1.429	1.667	1.852	1.724	2.000	2.381
3	1.136	1.282	1.389	1.563	1.852	2.174	2.381	2.273	2.632	2.941
5	1.389	1.613	1.724	1.923	2.273	2.632	2.941	2.778	3.125	3.333
8	1.220	1.724	2.083	2.273	2.632	2.941	3.333	3.333	3.571	3.846
COLOBJ (Mean)										
1	.379	.556	.588	.694	.794	.926	1.064	.980	1.111	1.250
3	.641	.758	.794	.909	1.042	1.163	1.282	1.250	1.316	1.429
5	.794	.926	1.000	1.064	1.220	1.351	1.471	1.429	1.563	1.724
8	1.020	1.136	1.220	1.316	1.515	1.667	1.852	1.786	1.923	2.174
NUMLET (Mean)										
1	.633	.862	.980	1.190	1.389	1.613	1.852	1.724	1.923	2.273
3	1.163	1.282	1.389	1.613	1.852	2.174	2.381	2.273	2.500	2.778
5	1.429	1.563	1.724	1.923	2.273	2.632	2.778	2.778	3.125	3.333
8	1.471	1.786	2.000	2.273	2.632	2.941	3.333	3.125	3.571	3.846

Notes: Values entered are the reciprocals of the entries in table I above, multiplied by 50 (the number of items named). They thus represent the speed expressed as items named per second.

The percentiles are reversed from table I, so that the left and right sides of the table remain the poor and good performing ends, respectively.

COLOBJ is the mean for colors and objects.

NUMLET is the mean for numbers and letters.

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Predicting the Future Achievement of Second Graders with Reading Disabilities: Contributions of Phonemic Awareness, Verbal Memory, Rapid Naming, and IQ

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Concurrent and prospective correlations among reading, spelling, phonemic awareness, verbal memory, rapid serial naming, and IQ were examined in a longitudinal sample that was studied at Grade 2 and Grade 8. Substantial temporal stability of individual differences in all of these skills was seen over the six-year period between assessments. The strongest predictors of future reading and spelling outcomes were different for normally achieving second graders than for those who had been designated as having reading disabilities. For the former, Grade 2 literacy scores were the best predictors of later achievement. For the children with reading disabilities, however, prediction of most future reading and spelling skills was substantially improved by the inclusion of the cognitive-linguistic measures, particularly rapid naming.

Individual differences in reading ability have consistently been shown to be very stable over time. On average, children who have difficulty learning to read in the early grades tend to remain relatively poor readers in the years that follow, and children who are very successful at the outset tend to remain at the top of the class. Hence, correlations between reading scores

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taken one to six years apart have been quite substantial (r = .63 to .86) in several large samples (e.g., Butler et al. 1985; Shaywitz et al. 1992). Similarly, it has typically been found that a majority of children who are judged to have reading disabilities (RD) at one age continue to meet the criteria for such a classification at later ages, and it is relatively uncommon for a child who is not considered to be RD in the early grades to later qualify for this designation (e.g., Badian 1988; Fergusson et al. 1996; Juel 1988; McGee, Williams, and Silva 1988; Satz et al. 1981).

Despite this rather strong degree of temporal stability, however, there remains considerable variability in reading achievement that is not accounted for simply by knowing a child's previous level of reading performance. In contrast to the overall trend, some children exhibit marked upward or downward shifts in achievement relative to their schoolmates. Some such changes, although predominantly small ones, are to be expected given that no test of achievement is entirely reliable (Fergusson et al. 1996). In addition, some classifications will inevitably change, given that dividing a continuous distribution of scores into two categories (RD or not) must occur at an arbitrarily selected cutoff point, and children whose scores are close to one side of the borderline on one occasion are likely to earn scores on the other side on another occasion (e.g., Shaywitz et al. 1992). Even so, it seems clear that real and meaningful shifts in reading ability can and do occur in some individual children. Some of these changes can result from differences in print exposure (e.g., Cunningham and Stanovich 1997). Little is known, however, about what strengths and weaknesses in reading-related cognitive and linguistic skills may also be associated with children's rates of progress in reading achievement over the long term.

In this study, the stability of individual differences in reading achievement was examined in a longitudinal sample in which reading skills were evaluated in the second and eighth grades (Scarborough 1989). In addition to determining how accurately the students' early achievement predicted their outcomes over the six-year interval, the analyses were designed to investigate the power of other kinds of measures to account for changes in reading status over time, particularly for children who had originally been designated as disabled readers. To that end, the set of predictors included not just reading and spelling scores, but also measures of more basic cognitive-linguistic skills—phonological awareness, verbal memory, rapid serial naming, and general verbal ability—that have been associated with reading ability differences in other samples (e.g., Ackerman and Dykman 1993; Cornwall 1992; Hansen and Bowey 1994; Stone and Brady 1995; Wagner, Torgesen, and Rashotte 1994).

Phonological awareness was of interest because of its well-established theoretical and empirical relationship to reading acquisition (e.g., Adams and Bruck 1995; Brady and Shankweiler 1991; Byrne and Fielding-Barnsley 1989; Ehri and Wilce 1980; Liberman et al. 1974; Perfetti et al. 1987). In this particular sample, as in many others, differences in phonological awareness at age five years were reliably associated with reading abilities in second grade (Scarborough 1989), and it was hypothesized that such differences would continue to play a role in maintaining individual differences in achievement.

Verbal memory is another ability that has sometimes, although not always, been found to be weak in many children with reading difficulties (e.g., Brady 1991; Stone and Brady 1995). Although verbal memory, like phonological awareness, requires phonological processing of spoken input, there is evidence that memory and awareness do not tap a unitary dimension of skill (e.g., McDougall et al. 1994). Because reading at older ages typically involves sentences and texts of considerable length, high achievement may increasingly depend on a child's ability to retain material in memory as it is being read so that syntactic and semantic analyses necessary to comprehension can be performed.

Rapid serial naming was examined because it has been hypothesized that such tasks tap another fundamental kind of processing that, if deficient, can impede reading acquisition (e.g., Bowers and Wolf 1993; Wolf 1997). There is a large and growing body of evidence to suggest that rapid naming is well correlated with reading abilities (e.g., Ackerman, Dykman, and Gardner 1990; Bowers and Swanson 1991; Wolf 1991). In particular, the speeded nature of this task may make it particularly well suited for predicting reading at older ages when fluency and automaticity are expected to be attained.

Finally, the correlation between reading skill and ***general intellectual ability*** (IQ) is known to increase in strength over the elementary school years (e.g., Stanovich, Cunningham, and Cramer 1984). Although preschool IQ scores in this sample were not an important predictor of second grade outcomes (Scarborough 1989), it was hypothesized that IQ might make a stronger contribution to individual differences, particularly in reading comprehension, at older ages.

METHOD

PARTICIPANTS

All of the children had participated, from the age of two years, in a longitudinal study that began in 1980 (Scarborough 1989, 1991). All were of normal IQ, were monolingual speakers of English, and resided in several dozen different municipalities in and around central New Jersey. They were from working class to upper-middle class families (strata I through IV) according to Hollingshead and Redlich's (1958) five-tiered classification of socioeconomic status on the basis of parental education and occupation.

The original sample of 88 children included an at-risk group of 38 children who had at least one parent or older sibling with a reading disability. In many instances, there were also dyslexic individuals outside the immediate family. There was no such incidence of reading disability in the families of the other 50 children. It is important to note that children from affected families were deliberately overrepresented in the sample. This was done with the expectation that a larger proportion of these preschoolers would later develop reading problems than would be expected in a population-representative sample of this size. (For details of the recruitment of the sample and the assessment of familial risk, see Scarborough 1989.)

During the summer following the completion of Grade 2 (1986 for some children, 1987 for the remainder), 78 (89 percent) of the original 88 children, then eight years old, were located. Of these, 66 could be directly tested (31 from the at-risk group, 35 not at risk). For 12 others (3 at risk, 9 not), information about reading achievement was obtained from parents and schools. The sample was divided into RD and NRD subgroups on the basis of their reading achievement as described in detail previously (Scarborough 1989). The RD group included 24 children (22 of whom had been initially designated as at risk) and the NRD group included 54 (of whom 12 had a family history of dyslexia).

Six years later, when they completed Grade 8, 68 (87 percent) of the Grade 2 sample were again located. Of these, 64 could be directly tested. Only parental reports could be obtained for the four adolescents who declined to participate (two RD and two NRD).

The present analyses were based on the data for the 55 participants for whom test scores were available at both second and eighth grade. This sample includes 19 children from the RD subgroup (9 boys and 10 girls) and 36 from the NRD group (16 boys and 20 girls).

MEASURES

Reading. At both grades, the word identification, word attack, and passage comprehension subtests of the *Woodcock-Johnson Psychoeducational Battery* (1978) were administered. Rasch-scaled *W* scores for the three subtests, and a composite score computed by averaging them, were analyzed.

Spelling. Nonstandardized spelling-to-dictation measures were used. At Grade 2, the list included 30 words from Treiman (1984), half of which were regularly spelled and half of which were "exception" words. The list at Grade 8 included 50 words taken from the materials developed by Bruck (1993) and Waters, Bruck, and Malus-Abramowitz (1988). The percentage of words correctly spelled was computed at each grade.

Phonological Awareness. At each age, a phoneme deletion task was administered, on which the child was asked to say what is left after the first/last sound is removed from a spoken monosyllable. To insure that the test items were correctly perceived, the children repeated each item before carrying out the requested deletion operation. At Grade 2, the stimuli consisted of 24 words, such as m/ice, s/mall, hou/se, and pas/te. At Grade 8, there were 24 pseudowords adapted from Bruck (1992) including v/oot, f/lib, chu/t, and bas/t. The percentage of correct responses was scored.

Verbal Memory. At each age, the children were asked to imitate a series of 25 exceedingly rare, phonologically complex words that were effectively pseudowords (for example, *sesquepedalian, funambulist*, and *arteriosclerosis*). The percentage of correctly repeated items was scored at each age.[1]

Rapid serial naming. In this task, children were asked to say the names of all items in a large visual array as quickly as possible. At Grade 2, the 6 x 8 array contained pictures of 48 common objects. At Grade 8, the standard 5 x 10 Colors and Objects arrays from the Rapid Automatized Naming Test (Denckla and Rudel 1976) were used. The total number of seconds was measured for each array. Although some studies have found that naming of color or object arrays is less closely tied to

[1] Another measure of verbal memory, the WISC-R (1989) Digit Span subtest, was also obtained at Grade 2. These scores were correlated with the repetition (.41) and phoneme deletion (.33) tasks, but not with any other measures ($r < .25$). Digit Span, therefore, was not included as a predictor in the multivariate analyses.

reading skill than naming of digit or letter arrays (Wimmer 1993; Wolf 1991), others have not found a difference in the strength of the association (Denckla and Rudel 1976; Meyer et al. 1998; Snyder and Downey 1995). Object naming was chosen for this study out of concern that reading skill and naming speed for alphanumeric symbols might reciprocally influence each other. Particularly for second graders with reading disabilities, performance might be hindered by weaknesses in letter/number knowledge.

IQ. At Grade 2, the WISC-R was administered and Full-Scale IQ scores were computed. At Grade 8, following Sattler's (1992) guidelines, IQ was estimated from Information, Vocabulary, Arithmetic, Block Design, and Picture Arrangement subscores.

PROCEDURES

At both second and eighth grade, each child was individually examined by a member of the research team during a single session lasting approximately 2.5 hours. Testing took place in the family's home, in the presence of one or both parents. The examiner was kept "blind" to the risk status of the child and, at Grade 8, to the adolescent's previous reading status and educational history. All sessions were recorded so that scoring could later be independently reviewed by another researcher. In addition to the measures described above, a variety of other tests and questionnaires was given at each age, but these will not be discussed in this report.

RESULTS

PRELIMINARY ANALYSES

Arc sine transformations were applied to the proportional scores (spelling, phonological awareness, verbal memory) prior to parametric statistical analyses. No other adjustments, such as for distributional irregularities (severe skewness, outliers, multimodality), were needed to meet the assumptions of the planned statistical tests. In addition, correlations of sex and socioeconomic status (SES) with the literacy outcome measures were examined to determine whether these demographic factors needed to be covaried in subsequent prediction analyses. At neither age were any of these correlations found to be significant ($r < .22$).

To obtain a composite measure of overall reading and spelling achievement at each age, the three Woodcock-Johnson subscores and the spelling score were entered into a principal components analysis. The single factor that was extracted from each analysis accounted for 70 percent of the variance in these measures at Grade 2 and 60 percent at Grade 8.

A summary of the sample's performance on all measures at Grade 2 and Grade 8 is provided in table I.

CONCURRENT RELATIONSHIPS AMONG THE READING AND COGNITIVE MEASURES

Pearson correlations among the eight measures at each grade are shown in table II. Because a large number of significance tests were conducted, a conservative significance level of .01, two-tailed, was adopted in analyzing these relationships. Because IQ and phonemic awareness were each found to be correlated (r = .29-.33, $p < .05$) with SES at both second and eighth grade, partial correlations controlling for SES were also computed. These were virtually identical to the coefficients shown in table II, and, therefore, are not reported here.

With one exception, there were moderately strong correlations among all of the reading and spelling measures at both

TABLE I.
SUMMARY OF PERFORMANCE BY THE SAMPLE ON ALL MEASURES AT GRADE 2 AND GRADE 8.

	Grade 2			Grade 8		
Measure	*M*	*SD*	range	*M*	*SD*	range
Word Identification	492.7	13.8	471–523	534.2	12.6	507–572
Word Attack	498.3	13.5	454–519	511.3	9.9	491–533
Passage Comprehension	492.8	12.1	466–514	524.6	8.8	505–542
Reading Cluster	494.6	11.3	467–514	523.3	8.1	505–544
Spelling (% correct)	65.1	16.0	24–98	79.0	10.1	48–96
Phoneme Deletion (% correct)	77.1	13.1	29–100	88.9	10.9	42–100
Verbal Memory (% correct)	74.6	14.3	43–100	82.3	11.2	56–100
Rapid Serial naming (seconds)	56.5	14.2	33–99	34.0	5.8	25–53
Full-Scale IQ	117.4	11.0	90–143	113.1	10.9	87–140

Note: n = 55

grades, with somewhat larger effects at Grade 2 (median $r = .62$) than at Grade 8 (median $r = .525$). Of particular note is that word attack and passage comprehension scores were unrelated at the older age, indicating a dissociation between these aspects of reading skill over time.

The cognitive-linguistic variables, on the other hand, were only weakly related to each other on both occasions. Consistent with the findings of previous studies, each was correlated with at least one measure of reading and/or spelling at Grade 2 and, except for rapid serial naming, at Grade 8. These findings suggest that phonemic awareness, verbal memory, rapid naming, and IQ each tap somewhat different reading-related skills.

TEMPORAL STABILITY OF INDIVIDUAL DIFFERENCES IN COGNITIVE-LINGUISTIC ABILITIES

Even though different instruments were used at the two ages, considerable stability over a six-year interval was seen for the four cognitive-linguistic measures. The correlation between Grade 2 and Grade 8 scores were .49 for phoneme deletion, .66 for verbal memory, .51 for rapid serial naming, and .68 for IQ (all $p < .01$). This suggests that each measure tapped a dimension of individual differences that remained quite stable during the school years, even though its relationships with various reading skills were somewhat different at the two grades as shown in table II.

TABLE II.
CONCURRENT CORRELATIONS AMONG MEASURES AT GRADE 2 (BELOW THE DIAGONAL) AND GRADE 8 (ABOVE THE DIAGONAL).

	Reading and Spelling				Other Skills			
	1.	2.	3.	4.	5.	6.	7.	8.
Reading and Spelling								
1. Word Identification	—	.53**	.52**	.64**	.28	.41*	−.27	.38*
2. Word Attack	.66**	—	.06	.54**	.47**	.22	−.13	.17
3. Passage Comprehension	.58**	.41*	—	.43*	.11	.36*	−.01	.50**
4. Spelling	.70**	.70**	.48**	—	.40*	.38*	−.12	.54**
Other Skills								
5. Phoneme Deletion	.42*	.40*	.35*	.45**	—	.02	−.02	.22
6. Verbal Memory	.39*	.39*	.18	.47**	.18	—	−.19	.24
7. Rapid Serial Naming	−.30	−.15	−.18	−.39*	−.19	−.25	—	−.14
8. Full-scale IQ	.48**	.25	.46**	.27	.31	.28	−.24	—

*$p < .01$, two-tailed **$p < .001$

Note: $n = 55$.

TABLE III.
CORRELATIONS OF GRADE 2 SCORES WITH GRADE 8 SCORES ON READING AND SPELLING MEASURES.

	At Grade 8				
At Grade 2	Word Identific'n	Word Attack	Passage Compreh'n	Spelling	Read/Spell Composite
Word Identification	.67**	.48**	.46**	.53**	.70**
Word Attack	.58**	.60**	.13	.46**	.59**
Passage Comprehension	.51**	.19	.41*	.51**	.54**
Spelling	.64**	.48**	.29	.63**	.68**
Read/Spell Composite	.72**	.53**	.38*	.63**	.75**

*$p < .01$, two-tailed **$p < .001$

Note: $n = 55$.

TEMPORAL STABILITY OF INDIVIDUAL DIFFERENCES IN READING AND SPELLING ABILITIES

Correlations between second and eighth grade reading and spelling scores are shown in table III. Along the diagonal, it can be seen that each measure showed significant stability of individual differences over the six-year interval between assessments, with the composite measure having the strongest correlation and the passage comprehension subtest having the weakest. Passage comprehension in Grade 8 was also predicted moderately well by Grade 2 word identification scores and by the composite measure, but not by earlier performance on word attack or spelling. Conversely, Grade 8 word attack scores were not predicted by second grade comprehension abilities. Word identification and spelling, however, were quite well predicted by each of the second grade measures, as was the eighth grade composite.

Classification of the participants as RD or NRD on the basis of their second grade reading abilities also showed the degree of stability that had been seen in previous research. In Grade 2, a cutoff of −1.5 *SD* below the mean reading cluster score for the not-at-risk sample, which was equivalent to a delay of one year or more in achievement, had been used to assign children to the two subgroups (Scarborough 1989). Figure 1 shows the bivariate distribution of reading cluster scores of the RD and NRD children at the two grades. In the graph, the second grade cutoff point is marked by a vertical dotted line. The points for the RD sample fall to the left of the line and those of the NRD fall to its right.

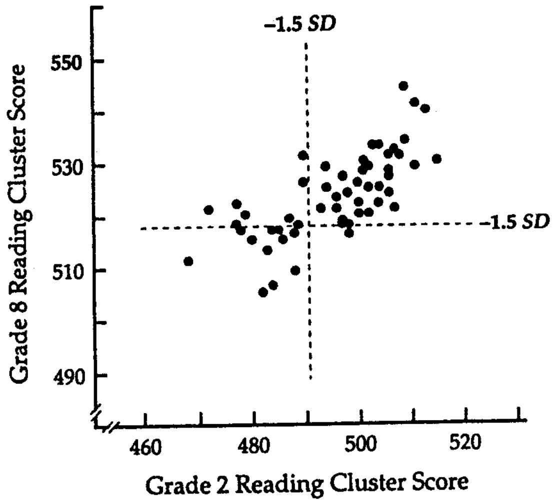

Figure 1. *Bivariate distribution of Grade 2 and Grade 8 Reading Cluster Scores (n = 55).*

At Grade 8, the cutoff point analogous to the second grade criterion is shown by the horizontal dotted line in the figure. The 11 cases with scores in the lower left quadrant and the 35 in the upper right quadrant are the children whose classifications remained the same at the two grades. The eight points in the upper left quadrant represent children whose reading improved enough to avoid (though often just barely) meeting the RD criterion in eighth grade, and the one child who fell in the lower right quadrant was not a disabled reader in second grade but did fall slightly below the cutoff six years later. In sum, 58 percent of the children who were originally assigned to the RD group, and 97 percent of those in the NRD group, had stable classifications over six years. It must be emphasized, however, that of the children whose classifications changed, all but two remained "borderline" cases (within a few points of the cutoff) in eighth grade, and the two who showed more impressive gains had been the highest achievers within the RD group in second grade.

CAN MORE ACCURATE PREDICTIONS BE MADE BY TAKING OTHER FACTORS INTO ACCOUNT?

In a series of multiple regression analyses, the prediction of eighth grade reading was next examined in relation to the four cognitive-linguistic measures at Grade 2. For each outcome

measure, the four new predictors were entered as a group, and the resulting multiple correlation was compared to the simple across-age prediction of that outcome measure by itself. Except for passage comprehension, it turned out that the Grade 8 scores were predicted as well or better by the corresponding Grade 2 score than by the combination of phoneme deletion, verbal memory, rapid serial naming, and IQ scores (.67 versus .61 for word identification; .60 versus .42 for word attack; .63 versus .58 for spelling; and .75 versus .66 for the composite variable). For passage comprehension, which was earlier noted to be the least temporally stable of the reading measures ($r = .41$), the multiple correlation based on other variables was higher, but only slightly ($R = .49$). In a subsequent hierarchical multiple regression analysis, when Grade 2 comprehension was entered first, the addition of the set of cognitive-linguistic measures at the second step did not result in a significant increase in the proportion of variance accounted for. Results similar to these were also obtained for the other reading and spelling outcome measures. It was clear from these analyses that knowing a second grader's phonemic awareness, verbal memory, rapid serial naming, and IQ scores did not yield a more accurate prognosis than simply knowing about the child's reading ability.

The foregoing analyses failed to take into account, however, an interesting feature of the data that can be seen in figure 1. Visual examination of the scatterplot suggested that the relationship between Grade 2 and Grade 8 reading cluster scores was not linear but was flatter along the lower portion of the Grade 2 distribution and steeper for the higher portion. In other words, it looked as though the prediction of eighth grade scores from second grade scores was much stronger within the NRD group than within the RD group. This observation was confirmed statistically[2], and across-age correlations for reading cluster scores were found to be very weak within the RD group ($r = .18$) but quite strong within the NRD group ($r = .64$), even though the ranges of scores at both ages were equivalent for the two subsamples. It would seem then that this difference in the size of the correlations is not simply an artifact of range restrictions. Given this indication that the predictability of future reading might be quite different for disabled readers than for other students, the series of multiple regression

[2] The addition of a quadratic term at the second step of a hierarchical multiple regression predicting Grade 8 from Grade 2 reading cluster scores resulted in a significant increase in R^2 from .51 to .56, $F(2,53) = 6.046$, $p = .017$.

analyses described above was repeated, this time separately for the two groups. The results are summarized in table IV.

For the larger NRD group, the results pretty much mirrored those for the entire sample, as one would expect. The multiple correlations based on the four cognitive-linguistic predictors were not much larger, if at all, than the simple across-age correlations of each reading measure with itself. Moreover, in subsequent hierarchical regressions, it was found that including the four additional predictors did not significantly increase the proportion of variance accounted for, beyond that predicted by the second grade measure of the dependent variable itself. In sum, the best predictors of future reading and spelling skills of the normally-achieving subsample were those skills themselves at the younger age.

For the RD group, the picture was dramatically different. First, the across-age correlations for the reading measures were much lower than the multiple correlations of Grade 8 reading with the four cognitive-linguistic factors (.43 versus .76 for the composite; .31 versus .75 for word identification; .51 versus .76 for word attack; .01 versus .38 for passage comprehension; and .61 versus .81 for spelling). It is not surprising, therefore, that when subsequent multiple regression analyses included the second grade reading measure at the first step, substantial additional proportions of variance were accounted for by including the cognitive-linguistic predictors, above and beyond the prediction of reading by itself (except for passage comprehension). The increase in R^2 was .42 (p = .038) for the reading/spelling composite, .46 (p = .039) for word identification, .31 (p = .11) for word attack, and .29 (p = .068) for spelling. These findings suggest that the accuracy of prognoses for children who have already developed a reading disability can be substantially improved by taking into account not just how poor the child's reading achievement is, but also some additional information about cognitive and linguistic abilities.

Which skills were most closely related to the eighth grade outcomes of the children who were designated as RD in second grade? Of the four cognitive-linguistic abilities that were analyzed in this study, rapid serial naming speed emerged as the most consistently useful predictor for the RD subsample, making a unique contribution to the prediction of their composite, word identification, word attack, and spelling scores, according to the beta weights from the regression analyses (table IV). It bears noting here that these relationships between rapid naming and later reading do not appear to have been inflated by

any undue influence of extreme scores (outliers) as can occur in analyses of small samples. When Spearman rank order correlations (which are far less prone to such distortion) were computed, Grade 2 rapid naming speed remained well correlated with the Grade 8 composite (r_s = –.60), word identification (–.64), word attack (–.35), and spelling (–.58) measures. These coefficients are in close agreement with the Pearson correlations listed in table IV.

In contrast, phoneme awareness and verbal memory differences within the RD group at Grade 2 were only weakly related, if at all, to how much progress in reading these children made over the following six years, although phonemic awareness did make a contribution to the prediction of future spelling. Finally, along with rapid naming, IQ also contributed to the prediction

TABLE IV. PREDICTION OF GRADE 8 READING SKILLS FROM GRADE 2 PHONEME DELETION, VERBAL MEMORY, RAPID SERIAL NAMING AND IQ SCORES: RD VERSUS NRD SUBSAMPLES.

Grade 8 Outcome Measure	Grade 2 Predictor(s)	RD Group (n = 19) r	β	R	NRD Group (n = 36) r	β	R
Read/Spell Composite	Phoneme Deletion	.28	.35		.35*	.27	
	Verbal Memory	.26	–.05		.43**	.36*	
	Rapid Naming	–.61**	–.78**		–.33*	–.19	
	IQ	–.06	–.43		.40**	.25	
	All four			.76**			.64**
	Read/Spell Composite alone	.43*			.72***		
Word Identif'n	Phoneme Deletion	.24	.31		.20	.13	
	Verbal Memory	.25	–.06		.46**	.40*	
	Rapid Naming	–.62**	–.78**		–.26	–.16	
	IQ	–.03	–.39		.32*	.19	
	All four			.75**			.56*
	Word Ident'n alone	.31			.48*		
Word Attack	Phoneme Deletion	.06	.17		.17	.15	
	Verbal Memory	.26	.09		.25	.25	
	Rapid Naming	–.39*	–.62**		–.09	–.01	
	IQ	–.42*	–.71**		.13	.06	
	All four			.76**			.32
	Word Attack alone	.51*			.34*		

(Continues)

TABLE IV. PREDICTION OF GRADE 8 READING SKILLS FROM GRADE 2 PHONEME DELETION, VERBAL MEMORY, RAPID SERIAL NAMING AND IQ SCORES: RD VERSUS NRD SUBSAMPLES. *(cont.)*

Grade 8 Outcome Measure	Grade 2 Predictor(s)	RD Group (n = 19) r	β	R	NRD Group (n = 36) r	β	R
Passage Compreh.	Phoneme Deletion	.11	.05		.24	.16	
	Verbal Memory	–.05	–.11		.28*	.20	
	Rapid Naming	–.07	.04		–.21	–.11	
	IQ	.36	–.39		.39**	.30	
	All four			.38			.49
	Passage Compreh. alone	.01			.44*		
Spelling	Phoneme Deletion	.38	.45*		.33*	.26	
	Verbal Memory	.26	.09		.20	.14	
	Rapid Naming	–.64**	–.81**		–.26	–.17	
	IQ	.01	–.39*		.28	.18	
	All four			.81**			.45
	Spelling alone	.61**			.50**		

*$p < .05$, two-tailed **$p < .01$

of word attack and spelling outcomes, but surprisingly, this represented an *inverse* relationship with outcomes. In other words, it was the reading disabled children with slower naming speeds and *higher* IQs who were least able to read pseudowords and spell accurately in eighth grade.

DISCUSSION

Considerable temporal stability of individual differences in reading achievement over a six-year period was found in this longitudinal sample. Few of the children who had been designated as reading disabled in second grade became more than low-average readers in adolescence, and of the rest, only one met the criterion for RD in eighth, but not second, grade. In both respects, these results are consistent with those from previous research with larger and more population-representative samples (e.g., Badian, 1988; Butler et al. 1985; Fergusson et al. 1996; Juel 1988; McGee et al. 1988; Satz et al. 1981; Shaywitz et al. 1992).

The main goal of the analyses, however, was to examine reading outcomes, not just in relation to previously measured

reading skills, but also in relation to some more basic cognitive and linguistic abilities that have consistently been shown to correlate with, and prospectively predict, reading skills at younger ages: phonemic awareness, verbal memory, rapid serial naming speed, and IQ (e.g., Ackerman and Dykman 1993; Cornwall 1992; Hansen and Bowey 1994; Wagner, Torgesen, and Rashotte 1994). Correlational analyses of these measures yielded results that were quite consistent with previous findings in several respects. First, as expected, these four skills were indeed associated with reading abilities in the sample at both second and eighth grade. Second, individual differences in these abilities were found to have considerable temporal stability, consistent with previous evidence for moderate to high across-age correlations during the elementary school years for IQ (e.g.,Bloom 1964) and for phonemic awareness, verbal memory, and rapid serial naming (e.g., Wagner et al. 1997). Third, the intercorrelations among these four skills were quite low at both grades. Similar dissociations between these skills have been obtained in other samples (e.g., Bowers 1995; Bowers and Swanson 1991; Wimmer 1993). On the other hand, it is not uncommon for correlations to be observed among them (e.g., Cornwall 1992; Hansen and Bowey 1994; Wagner, Torgesen, and Rashotte 1994). To some extent, such results may be task specific; for example, correlations between phonemic awareness and memory measures tend to occur when memory-laden "oddity" tasks are used to assess phonemic awareness (Kyle and Oakhill 1998). In addition, the age and diversity of participants and/or the distribution of reading abilities in a sample may affect the strength of these kinds of associations. In any event, even when these measures are related to some extent, they usually account for some unique (as well as common) variance in reading in multivariate analyses, suggesting that they tap somewhat different reading-related abilities (e.g., Bowers 1993; Bowers, Steffy, and Tate 1988; McBride-Chang and Manis 1996; McDougall et al. 1994; Torgesen et al. 1997). The present findings are consistent with that conclusion.

It was hypothesized that, singly or in combination, these four stable and largely independent measures might serve as good predictors of future achievement in their own right, and might increase the accuracy of prognoses when used in conjunction with measures of reading and spelling. For predicting outcomes along the whole range of reading ability, however, it turned out that little was gained by taking into account children's cognitive and linguistic abilities in addition to their early reading and spelling scores. Even for reading comprehension, which was the least temporally stable aspect of reading ability, very little improvement in prediction accuracy was obtained by using the wider set of predictor measures. Similar results were obtained when only the NRD group was analyzed on its own. Apparently, by the end of the second grade, differences among children in phonemic awareness, verbal memory, rapid naming speed, and IQ have already made their contributions to determining individual differences in reading skill for normally achieving students whose subsequent degrees of success rest primarily on prior literacy skills themselves, and perhaps on other factors that were not examined here such as print exposure (Cunningham and Stanovich 1997).

From an educational perspective, however, making predictions about the future reading achievement of successful students is rarely a concern. Of greater interest is the prognosis for young schoolchildren who have fallen behind in learning to read. For these children, the present findings suggest that the severity of their reading disabilities may be less informative in predicting future improvement than their strengths and weaknesses in other areas. Somewhat surprising is that neither phonemic awareness nor verbal memory abilities in second grade were particularly useful for prognosis, although the former did make a modest contribution to the prediction of spelling outcomes. In contrast, differences in IQ, and especially in rapid serial naming speed at the younger age, provided the most information about future achievement in the RD subsample.

For the two literacy tasks that make the heaviest demand on knowledge of phoneme-grapheme correspondences, namely word attack (reading pseudowords) and spelling, more negative outcomes in eighth grade were found for the reading disabled children with higher IQ scores. This unexpected result suggests that the brighter children with reading disabilities may have been at a disadvantage over the long term in developing their decoding/encoding skills, perhaps because their greater general aptitude allowed them to be more successful at using visual memory, contextual cues, and astute guessing when reading unfamiliar words in text. To my knowledge, however, this finding has not been noted previously, and it would be very unwise to place much weight on it until additional evidence for a such a relationship becomes available, if ever.

The finding of greatest interest and potential practical utility was that rapid serial naming speed was a consistently strong

prognostic indicator for the children with RD, making a substantial contribution to the prediction of all aspects of their eighth grade reading and spelling skills except comprehension. Rapid naming was the only measure in this study that tapped children's speed of processing, and this may account for its success as a predictor of adolescent outcomes (e.g., Kail and Hall 1994). It has been widely observed that during the elementary school years, reading curricula typically make increasing demands for fluency and speed in reading and writing beyond the primary grades. If two children have mastered decoding to an equivalent extent, the one who can do so more rapidly will be at an advantage. This child will be able to accomplish more reading in a given amount of time, increasing print exposure and gaining practice that improves accuracy and fluency even more. How well the children with reading disabilities did on the Grade 8 reading tests presumably reflected such differences in prior learning experiences, even though the outcome measures were not themselves speeded tasks. Of course, naming speed could also reflect constitutional, as well as experiential, ability differences among children with reading disabilities.

Ordinarily, a great deal of caution would be called for in drawing conclusions from multivariate analyses conducted in a sample as small as this one. In this instance, however, the results gain credence because there is converging evidence from several sources regarding the particularly strong role of rapid serial naming speed in predicting the future progress of children with reading disabilities. First, similar results to those reported here recently have been reported by Meyer, Wood, Hart, and Felton (1998) for two different longitudinal samples, each evaluated at Grades 3, 5, and 8. In their first study, prediction of later outcomes from third grade measures was compared for 15 poor readers (bottom 10 percent) versus their classmates. For the poor readers only, rapid serial naming was highly correlated with future word identification ($r = .64–.68$) but not with future comprehension. Phonemic awareness and IQ were not effective predictors. Similarly, in a larger sample of 64 impaired readers, word identification (but again not comprehension) at the later grades was predicted by rapid naming but not by phonemic awareness or IQ, even when the analyses controlled for Grade 3 differences in word reading ability which, as in the present study, were not very strong correlates of later reading scores within the RD sample ($r = .24$). This independent replication of the current findings certainly adds a great deal to their credibility.

Two other studies provide converging evidence for the special importance of rapid naming speed in predicting the future achievement of children with reading disabilities. Korhonen (1991) used cluster analyses to identify subgroups among third graders with learning disabilities. One subgroup was characterized by slow naming speed, and when follow-up evaluations of the sample were made in sixth grade, it was found that this naming subgroup had shown the least progress in reading achievement, whereas more of the children with other cognitive profiles had improved over the three intervening years. In an intervention study, Lovett (1995) examined individual differences in naming speed as a predictor of response to remedial efforts. Based on pre-treatment diagnostic testing of children with severe reading disabilities (aged 7 to 13 years), three subgroups were identified according to whether their deficits were in phonological awareness only, in naming speed only, or in both domains. Compared to children in a control condition, all three subgroups made significant gains in word reading abilities following 35 hours of treatment (involving *phonological awareness and blending* or *word identification strategy training*). However, the phonological awareness deficit group made much more progress than the other two groups which did not differ. That is, both remedial programs were less effective at improving the word recognition skills of the children with rapid serial naming deficits, even though they had higher IQ and comprehension scores than the other groups.

Despite the convergence of findings from these various studies that differences among poor readers in their rapid naming skills are predictive of future gains in reading achievement, this prognostic relationship has not always been observed. Torgesen et al. (1997) conducted predictive analyses, from second to fourth and from third to fifth grade, in a subsample of 43 poor readers (bottom 20 percent) from a longitudinal study of 215 children who were followed from Kindergarten to Grade 5. With IQ controlled, rapid naming speed predicted reading, but phonemic awareness was an even stronger predictor. Notably, in the Torgesen et al. sample, the temporal stability of reading scores over the two-year interval was much higher ($r = .66$ from Grade 2 to Grade 4, and .85 from Grade 3 to Grade 5 for word identification) than in other samples of poor readers. This may explain why rapid naming made no unique contribution to prediction above and beyond that made by the prior reading score. The authors report, furthermore, that their sample was exceptionally heterogeneous with regard to SES and ethnicity; they suggest

that the greater homogeneity in other samples may account fohe weaker temporal stability and larger effects of cognitive dierences. Moreover, Torgesen et al. noted that very few of the por readers showed significant improvement in reading ability rer time (relative to norms), and suggested that cognitive differeces among them perhaps did not affect rates of progress as much in other samples because effective instruction had not been receied. In other words, the special prognostic value of rapid naming ay only apply under circumstances in which future reading abili is not so heavily determined by previous achievement.

Taken together, the findings suggest that when children ith reading disabilities show differential rates of progress in reacng achievement over the elementary school years, those with sloer naming abilities tend to show the least improvement. Rapiderial naming tasks may thus prove to be a useful means of idtifying children who may need additional assistance, above id beyond the kinds of interventions that are effective for poor rders with unimpaired naming speeds. At present, however,he basis for the close association between rapid naming speed id future reading abilities is not entirely clear. Inefficient retrievof lexical information, slow articulation of speech, difficulty in ustaining attention, poorly established phonological represeations of names, and other weaknesses in poorer readers hve been mentioned by various researchers as possibly underlyng the observed relationship (Ackerman and Dykman 1993; Bovrs and Swanson 1991; Kail and Hall 1994; Wagner and Torgen 1987; Wolf 1991). Little research has been conducted, howeveto evaluate the relative merits of these possibilities. Until this qustion is clarified, it is difficult to know precisely what kinof training would be most effective for children whose reading isabilities are accompanied by slow naming speed.

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