Do the Effects of Computer-Assisted Practice Differ for Children with Reading Disabilities With and Without IQ–Achievement Discrepancy?

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Abstract

This study was designed to assess whether the effects of computer-assisted practice on visual word recognition differed for children with reading disabilities (RD) with or without aptitude–achievement discrepancy. A sample of 73 Spanish children with low reading performance was selected using the discrepancy method, based on a standard score comparison (i.e., the difference between IQ and achievement standard scores). The sample was classified into three groups: (1) a group of 14 children with dyslexia (age *M* = 103.85 months; *SD* = 8.45) who received computer-based reading practice; (2) a group of 31 "garden-variety" (GV) poor readers (age *M* = 107.06 months; *SD* = 6.75) who received the same type of instruction; and (3) a group of 28 children with low reading performance (age *M* = 103.33 months; *SD* = 9.04) who did not receive computer-assisted practice. Children were pre- and posttested in word recognition, reading comprehension, phonological awareness, and visual and phonological tasks. The results indicated that both computer-assisted intervention groups showed improved word recognition compared to the control group. Nevertheless, children with dyslexia had more difficulties than GV poor readers during computer-based word reading under conditions that required extensive phonological computation, because their performance was more affected by low-frequency words and long words. In conclusion, we did not find empirical evidence in favor of the IQ–achievement discrepancy definition of reading disability, because IQ did not differentially predict treatment outcomes.

A review of the literature on reading disabilities (RD) indicates that there are cognitive differences between "garden-variety" poor readers and children with dyslexia outside of the word recognition module (i.e., because these children differ in intelligence), but there is no indication that the nature of processing within the word recognition module differs at all for poor readers with and without IQ–achievement discrepancy. In fact, a number of studies have found no evidence that children with dyslexia and garden-variety poor readers are different in reading, mathematics, or spelling skills or in other basic cognitive processes (e.g., Jiménez & García, 1999; Jiménez & Rodrigo, 1994; Rodrigo & Jiménez, 2000; Share, McGee, & Silva, 1989; Siegel, 1988, 1989, 1990, 1992; Stanovich, 1989; Stanovich & Siegel, 1994). Nevertheless, "indirect validation of the idea of differentiating poor readers on the basis of IQ-discrepancies would derive from data showing that high- and low-IQ poor readers are differentially sensitive to specific educational interventions" (Stanovich, 1994, p. 22).

Most research on the validity of IQ–achievement discrepancy in the definition of learning disabilities (LD) has focused on the differences in cognitive profiles among poor readers. However, little attention has been paid to whether poor readers with high IQ scores are somehow more remediable than poor readers with low IQ scores. Several studies have suggested that the effect of remedial education was mediated by the influence of IQ (Rutter & Yule, 1975; Wise, Ring, & Olson, 1999). For instance, Rutter and Yule (1975) found differential growth curves for individuals with dyslexia and garden-variety poor readers. The garden-variety poor readers displayed greater growth in reading but less growth in arithmetic ability than the participants with dyslexia. Wise et al. (1999) analyzed the effects of computer-aided remediation for RD including the training of phonological awareness with and without explicit attention to articulation. Individual differences in response to treatment were related to the

VOLUME 36, NUMBER 1, JANUARY/FEBRUARY 2003, PAGES 34–47

participants' initial levels of phonological awareness, naming speed, IQ, and grade.

However, other studies have provided strong evidence that IQ is not predictive of treatment outcomes. Share et al. (1989) used the IQ stratification procedure used by Siegel (1988) to compare different IQ groups on rate of growth in reading, but they did not find consistent differences among the various groups. Later, Vellutino, Scanlon, and Lyon (2000) designed a study to evaluate the utility of early, intensive intervention to help diagnose specific reading disabilities. They studied children who were initially selected from a large kindergarten sample. In the middle of their first-grade year, subsamples of poor readers and typically reading controls were selected from the population of children who had not been lost through attrition. To assess growth in reading over time, word subtests were given to children in the poor and typical reader groups at least annually through the fourth grade. Children were grouped as follows: very limited growth (VLG), limited growth (LG), good growth (GG), and very good growth (VGG). All of the children in the VGG group and approximately half of the children in the GG group received only 1 semester of remediation. All children in the LG and VLG groups received 2 semesters of remediation. The major finding was that no appreciable differences were found among the various groups on any of the IQ measures. According to these findings, IQ did not differentially predict response to remedial intervention, because IQ scores did not differentiate between poor readers who were found to be readily remediated and poor readers who were difficult to remediate. Similar results were obtained by Kershner (1990). The purpose of Kershner's experiment was to test whether IQ and self-concept in students with LD were significant predictors of changes in academic performance over 2 years of small-group remedial instruction and tutoring. The children's intellectual skills had no effect on their ability to profit from remedial teaching. The only influence that IQ had on learning was indirect, through its covariance with self-concept. Kershner concluded that high-IQ children with LD were no more successful than low-IQ children with LD in improving their academic performance over 2 school years of intensive remedial efforts. Finally, Hurford et al. (1994) trained children at risk for reading disabilities and children at risk for becoming garden-variety poor readers. They found that both trained groups benefited from the training; therefore, they concluded that it is possible to identify children at risk for reading difficulties and to significantly improve their phonological processing and reading abilities independently of their IQ scores.

In sum, the studies reviewed here have reported contradictory results. On the one hand, some studies have shown that IQ has predictive value for treatment outcomes (e.g., Rutter & Yule, 1975; Wise et al., 1999). On the other hand, other studies have reported that general aptitude measures do not affect treatment outcomes in students with LD (e.g., Hurford et al., 1994; Kershner, 1990; Vellutino et al., 2000). Thus, there is no clear evidence whether children with LD and high IQ are more remediable than children with LD and low IQ.

A relevant question in this context is related to the definition of reading performance. This variable can be measured based on either word recognition or reading comprehension. Kavale (1989), reviewing studies about the long-term effect of instruction on LD, concluded that IQ explained the improvement in reading comprehension but not in word reading and spelling. In fact, several studies found empirical evidence that reading comprehension is influenced by memory and Verbal IQ (Bowers, Steffy, & Tate, 1988). More recently, Swanson (1999) conducted a meta-analysis of instructional research with samples of children and adolescents with LD in the domains of word recognition and reading comprehension. One of the objectives in Swanson's study was to test the assumption that general aptitude measures influence treatment outcomes. Swanson found that cutoff scores qualified treatment effects in word recognition studies, and variations in IQ–reading discrepancy scores qualified treatment effects in reading comprehension studies. That is, studies using cutoff score criteria yielded higher effect sizes than studies not using cutoff score criteria for word recognition studies. However, the effect sizes for reading comprehension measures were moderated by high and low IQ scores, because those studies that reported differences between mean IQs and mean reading scores yielded low effect sizes when IQ scores were in the high-average range compared to other conditions. That is, studies of individuals with low-average IQ scores with at least a 15-point IQ–reading discrepancy yielded higher effect sizes than studies of persons with an IQ–reading discrepancy but IQs above 90.

As suggested by Swanson (1999), "there have been conceptual shifts regarding what underlies reading problems in children with LD, which in turn has raised questions about the best instructional intervention for remediating such problems" (p. 504). Now, there is consensus that many cases of RD are caused by difficulties in visual word recognition. The majority of recent research has suggested that word identification problems are basically phonological route problems (e.g., Olson, Kliegl, Davidson, & Foltz, 1985; Perfetti, 1985; Rack, Snowling, & Olson, 1992; Siegel & Ryan, 1988; Stanovich, 1988; Van Den Bos & Spelberg, 1994; Wagner & Torgesen, 1987). Many studies carried out in languages with an opaque orthography using the reading level (RL) match design have found empirical evidence in favor of a deficit in phonological processing, because individuals with dyslexia have more difficulty in reading nonwords than typical readers matched in age or in RL match design (Olson, Wise, Conners, Rack, & Fulker, 1989; Stanovich & Siegel, 1994). Furthermore, the degree of phonological reading deficit is not related to the degree of discrepancy between reading and IQ (for a review, see Stanovich & Siegel, 1994). Moreover, some empirical evidence does exist in languages with a transparent orthography (e.g., Spanish) that individuals with RD do show the same severe difficulties in the use of the phonological route as they do in the English language (e.g., Jiménez, 1997; Jiménez & Hernández-Valle, 2000). Therefore, some suggestions from research in languages with an opaque orthography can be extrapolated to other languages. For example, as suggested by Siegel (1992), for diagnosing reading disabilities, the most appropriate measure appears to be simply a pseudoword reading test, as a critical measure of phonological processing. With regard to the best instructional intervention for remediating RD, Swanson (1999) also tested whether certain models of instruction (e.g., direct instruction, strategy instruction) have broad effects across word recognition and reading comprehension measures. He found that effect sizes were higher for word recognition when studies included direct instruction. Furthermore, an increasing number of researchers have used computers in experiments on the remediation of RD (e.g., Jones, Torgesen, & Sexton, 1987; Olofsson, 1992; Olson & Wise, 1992; Torgesen & Barker, 1995; Van Daal & Reitsma, 1993; Van der Leij, 1994). It has been demonstrated that reading on the computer with speech feedback significantly improved poor readers' phonological decoding and word recognition. Moreover, studies of computer-aided remediation for children with RD have demonstrated that their word recognition skill improved when different forms of orthographic units were manipulated (Olson & Wise, 1992).

The aim of our study was to analyze whether the effects of computer-assisted practice differ between children with RD with and without an IQ–achievement discrepancy. If we were to find that IQ can differentially predict treatment outcomes, then our findings would offer empirical evidence in favor of the IQ–achievement discrepancy definition of RD.

Method

Participants

The initial sample was selected according to the teachers' opinions about which children had specific difficulties in reading, but did not have a history of school failure, and those who had difficulties in all subjects. However, we studied only those children with poor reading performance according to the results obtained from the administration of the *Bateria de Evaluación de los Procesos Lectores de los Niños de Educación Primaria* (PROLEC) Pseudoword subtest (Cuetos, Rodríguez, & Ruano, 1996). Children with reading difficulties were defined as those who had a percentile score of < 25 on the Pseudoword subtest. A sample of 73 Spanish children was obtained. The children came from urban areas and from average socioeconomic backgrounds and attended several state schools, and their age range was between 7 years 1 month and 10 years 6 months (M = 104.83 months; SD = 8.03). Using the standard score discrepancy method, the children with reading difficulties were classified into two groups based on the presence or absence of a difference between their IQ test scores and their standard scores on the Pseudoword subtest of the PROLEC. Children were classified as having dyslexia if their Pseudoword standard score was more than 15 points lower than their IQ score (n = 14) and if their IQ test score was > 80. Children were considered garden-variety poor readers if their Pseudoword standard score was less than 15 points lower than their IQ score (n = 31) and if their IQ test score was > 80. The overall sample was classified into three different groups:

1. An experimental group of 14 children with dyslexia (8 boys, 6 girls; age M = 103.85; SD = 8.45) who received computer-based reading practice;
2. An experimental group of 31 garden-variety poor readers (17 boys, 14 girls; age M = 107.06; SD = 6.75) who received the same type of computer-based practice; and
3. A control group of 28 children with RD (20 boys, 8 girls; age M = 103.33; SD = 9.04) who did not receive computer-assisted practice.

There were no significant differences in the distribution of the participants across groups as a function of gender, $\chi^2 = 1.86$, $p = .39$, nor were there differences between groups in age, $F = 1.67$, $p = .20$. Moreover, the results showed that there were differences between groups in IQ, $F(2,69) = 4.85$, $p < .01$. The dyslexia group's mean IQ was higher in comparison to that of garden-variety poor readers, $t = 12.3$, $p < .03$, and that of the control group, $t = 15.2$, $p < .009$. There were no differences in IQ between garden-variety poor readers and the control group, $t = 1.27$, $p = .21$. Children who had sensory deficits, acquired neurological deficits, or other problems traditionally used as exclusionary criteria for LD were excluded.

Materials

IQ and Reading Tests. The *Culture Fair Intelligence Test*, a measure of *g*, scale I (Cattell & Cattell, 1950/1989), includes eight subtests, of which we only administered the short forms, which include the Substitution, Labyrinth, Identification, and Similarities subtests. The test allows us to get a measurement of the *g* factor.

As a standardized reading skills test, we used the PROLEC (Cuetos et al., 1996). This test includes different reading subtests, of which we administered only the following subtests: Word Reading; Pseudoword Reading, and Text Comprehension. The Word and Pseudoword Reading subtests required correct identification of real words and pseudowords. Both subtests are based on the accuracy of the responses. The Text Comprehension subtest includes a short story and questions that are asked of the children after reading.

Phonological Awareness Tests. The Odd Word Out task was designed to test the awareness of intrasyllabic units and was based on that of Bowey and Francis (1991) but using pictures. The examiner presented a list of four pictures and asked the children to name the pictures. The instructions were, "I am going to show you some pictures. Look at these pictures. Tell me the names of the pictures. There is an /oveja/ (*sheep*), an /oso/ (*bear*), an /ojo/ (*eye*), and an /araña/ (*spider*). Now we have to guess which pictures begin with a different sound. Here is an /oveja/, does it begin with /o/? Yes, it does. Now, here is an /oso/, does it begin with /o/? Yes, it does. Now, here is an /ojo/, does it begin with /o/? Yes, it does. Now, here is an /araña/, does it begin with /o/? No, it does not begin with /o/." The examiner did not provide any additional help in the task, and the child had to identify the picture that began with a different sound. This task had 3 examples and 10 items. Each item had four pictures. The phonemes that the children had to isolate on this task were the following: /r/, /l/, /ll/, /m/, /t/, /k/, /p/.

In the Phoneme Segmentation test, the children counted the phonemes of words that were presented orally, using aids such as rods. In the examples, the examiner pronounced a word and tapped the phonemes. The instructions were, "Listen: /sapo/ (*toad*). How many parts does it have? It has four parts, doesn't it? The parts are /s/, /a/, /p/, /o/. Do you understand the game? If you need some help, you can use these rods." The examiner did not help the children any further. Each word was presented individually, and the examiner asked the children how many parts the word had. This task had 2 examples and 14 items.

Finally, in the Phoneme Reversal test, the children counted the phonemes of words by reversing the order of segments in each word. In the examples, the examiner pronounced a word, and the instructions were, "Listen: /misa/ (*mass*). How many parts does it have? It has four parts, doesn't it? The parts are /a/, /s/, /i/, /m/ Do you understand the game?" The examiner did not provide any further help to the children. Each word was presented individually, and the examiner asked the children how many parts the word had. This task had 2 examples and 14 items.

For another study, Jiménez (1997) conducted a reliability analysis on the different phonological awareness tasks, and the alpha coefficient was calculated for each task. The alpha coefficient for the Odd Word Out task was .70. In the Phoneme Segmentation task, it was .98, and in the Phoneme Reversal task, .98

Visual–Phonological Reading Tasks. These tasks were adapted from a task designed by Siegel (1992). In each of these tasks, there were 32 trials in which two stimuli were presented for each trial. For the phonological task, the child was required to specify which of two visually presented pseudowords (e.g., *kiero-ciero, dotor-doktor*) sounded like a real word. For the visual task, the child was presented with a real word and a pseudoword (e.g., *sonrisa-sonrrisa, koche-coche*) and was asked to specify which of the two was a real word. A reliability analysis was used, and the alpha coefficient was calculated for each task. In the visual task, it was .81, and in the phonological task, .77

Training Procedure

All the tests were administered by psychologists in a random order, to avoid any effect of the presentation of the material. The children were randomly assigned to the experimental and control conditions.

We first conducted a general trial session, in which the children were trained in all of the TEDIS (*Tratamiento Experimental de la DISlexia*; "experimental treatment of dyslexia") program requirements. Once the treatment sessions started, the examiners were present just to guarantee the optimal technical functioning of the program. The children came to the computer room for 40 minutes per day during language arts time, to ensure the equivalent amount of reading instruction time for experimental group members and for matched untrained controls in the same class. The TEDIS computer training program is developed for the Pentium III chip set Intel Triton VX with 256 Kb synchronous cache, 150 MHz, 16 Mb EDO RAM, 1.2 Gb hard disk, S3 64V+ graphic card, and Soundblaster 16 PnP. A standard Microsoft mouse is used as pointing device. A core technical component in the TEDIS remedial program is the "talking" computer, which gives support and feedback through digitized speech. The TEDIS program provided feedback segmented into subword units (i.e., phonemes, syllables, onset-rime segments) that were sequentially highlighted and spoken by the computer. All children received orthographic and speech feedback that was presented in syllable or subsyllable units. In each session, the words were presented at the center of the screen. These words were pronounced by a professional speech trainer and recorded on tape. First of all, the computer segmented the word into subword units while a woman's voice was pronouncing them. Children were asked to attempt to pronounce each segment before clicking the mouse to hear the speech support. Then, the child had two options to choose, either to repeat the same task with the same subword units or to continue in order to pronounce the whole word. When the child was able to pronounce the word correctly, he or she had to press the keyboard to obtain the next word. When speech feedback was requested, the subword sound was immediately delivered through the headphones. When the child asked for speech feedback, only the relevant word was presented on the screen. If the child did not read the word, then he or she was asked to repeat the task by the examiner. Only when the child had three failures with the same word would the examiner press the keyboard and trigger the presentation of a new word. Every eight stimuli, the program asked a multiple choice comprehension question. Each child had to indicate with the mouse which of the pictures shown on the screen was related to the target word. The children were allowed to use the speech feedback option. Van Daal and Reitsma (1993) examined whether it is best to give feedback on all words or to allow the participants to choose. It was found that reading age–matched participants did not learn fewer words when the computer unsolicitedly delivered the spoken form of all words than when they were allowed to choose. Furthermore, the results of a series of small quasi-experimental studies indicated positive treatment effects for children with dyslexia who received computer training with speech feedback, improving their performance in reading and spelling compared to students who had access only to conventional special education (Lundberg, 1995).

Fifteen sessions completed the TEDIS program. If we consider the coded activities reflecting direct instruction in the synthesis reviewed by Swanson (1999), our program offers this model of instruction because it included the following codes:

1. breaking down a task into steps,
2. administering feedback repeatedly,
3. allowing for independent practice and individually paced instruction,
4. breaking the instruction down into simpler phases, and
5. providing individual child instruction.

In each session, the reading materials used consisted of 40 nouns and were classified as a function of different linguistic parameters: word length (short vs. long), word frequency (familiar vs. nonfamiliar), and word linguistic structure (consonant-vowel, CV, vs. consonant-consonant-vowel, CCV). During the computer-based word reading, we collected information about the number of accurately read words, the amount of speech feedback, and reading time. The reading time of each stimulus was measured from the time the word appeared on the screen until the child pronounced the word successfully.

Results

Pretest–Posttest Measures

A 3 × 2 Group (dyslexia, garden-variety poor readers, control) × Time (pretest, posttest) mixed analysis of variance (ANOVA) was performed on the word recognition, reading comprehension, phonological awareness, and visual–phonological tasks. Table 1 reports means and standard deviations for the three groups on each of the pretest–posttest measures.

Word Reading. The main effect of time was reliable, $F(1, 67) = 33.47$, $p < .001$, $MSE = 185.50$, $ES = .33$, but was subsumed under a significant Group × Time interaction, $F(2, 67) = 4.23$, $p < .019$, $MSE = 23.43$, $ES = .11$. Tests of simple main effect confirmed that there was an improvement on word recognition in children with dyslexia, $F(1, 67) = 23.2$, $p < .001$, $MSE = 128.57$, and in garden-variety poor readers, $F(1, 67) = 10.48$, $p < .05$, $MSE = 58.06$. However, there were no differences between pretest and posttest scores in the control group, $F(1, 67) = 2.63$, $p = .10$, $MSE = 14.58$ (see Figure 1).

Phonological Awareness. Both the main effect of group, $F(6, 128) = .82$, $p < .04$, $MSE = 146.56$, $ES = .09$, and the main effect of time, $F(3, 64) = .03$, $p < .001$, $MSE = 125.47$, $ES = .96$, were significant. However, the Group × Time interaction was reliable, $F(6, 128) = .82$, $p < .04$, $MSE = 4.0$, $ES = .09$. Subsequent tests of simple main effects confirmed that there were differences at posttest between garden-variety poor readers and the control group, $F(3, 64) = .85$, $p < .01$, $MSE = 150.81$, and between garden-variety poor readers and children with dyslexia, $F(3, 64) = .87$, $p < .03$, $MSE = 125.43$. However, there were no differences between the dyslexia group and the control group at posttest, $F(3, 64) = .91$, $p = .14$, $MSE = 109.32$. These results indicate that garden-variety poor readers benefited from the training because they improved their phonological awareness skills (see Figure 2).

Reading Comprehension. A main effect of time was reliable, $F(1, 66) = 25.04$, $p < .001$, $MSE = 20.34$, $ES = .28$, indicating that posttest scores were higher in comparison to pretest scores.

Visual Task. Both the main effect of group, $F(2, 67) = 4.58$, $p < .05$, $MSE = 157.36$, $ES = .12$, and the main effect of time, $F(1, 67) = 16.39$, $p < .001$, $MSE = 122.16$, $ES = .19$, were significant. The main effect of group indicated that garden-variety poor readers showed a better performance than other groups in the visual task. The main effect of time revealed that posttest scores were higher than pretest scores on the visual task.

Phonological Task. The main effect of time, $F(1, 67) = 10.21$, $p < .002$, $MSE = 114.08$, $ES = .13$, indicated that posttest scores were higher than pretest scores on the phonological task. A Group × Time interaction was reliable, $F(2, 67) = 3.09$, $p < .052$, $MSE = 34.55$, $ES = .09$, but did not reach conventional levels of statistical significance. The differences between pretest scores and posttest scores on this task were greater for garden-variety poor readers.

Training Sessions Measures

Design 1: Word Linguistic Structure. A 2 × 2 × 15 Group (dyslexia vs. garden-variety poor readers) × Word Linguistic Structure (CV vs. CCV) × Word Set (1 to 15) mixed ANOVA was performed on the number of accurately

TABLE 1
Means and Standard Deviations of Pretest and Posttest Demographic and Reading Measures by Group

Measure	Control *M*	Control *SD*	Dyslexic *M*	Dyslexic *SD*	GVPR *M*	GVPR *SD*
Age (months)	103.3	9.04	103.6	8.46	107.7	6.75
IQ	108.6	16.70	123.7	13.48	111.6	14.21
Odd word out						
Pretest	7.04	2.62	6.50	2.31	7.26	1.83
Posttest	7.54	2.45	7.79	2.01	8.52	1.59
Phoneme segmentation						
Pretest	7.48	1.97	7.07	3.15	7.35	2.60
Posttest	8.42	2.02	9.43	1.09	9.42	0.92
Phoneme reversal						
Pretest	3.93	3.41	5.57	4.03	5.74	2.74
Posttest	5.96	3.32	7.71	3.52	8.39	2.58
Visual task						
Pretest	20.74	5.69	18.50	4.36	23.06	4.05
Posttest	22.56	4.85	21.29	3.93	24.48	4.02
Phonological task						
Pretest	24.89	6.91	26.29	4.86	25.23	5.84
Posttest	27.16	4.81	27.36	5.31	29.00	3.21
Reading comprehension						
Pretest	2.40	1.38	1.93	1.33	2.53	1.43
Posttest	3.16	1.21	2.93	1.54	3.20	1.03
Pseudoword reading						
Pretest	18.00	7.52	14.61	5.58	21.76	3.64
Posttest	23.86	4.72	24.22	5.11	26.32	3.66
Word reading						
Pretest	26.19	6.61	23.57	4.80	27.00	3.92
Posttest	28.12	3.07	27.86	2.25	28.94	1.09

Note. GVPR = garden-variety poor readers.

read words, the amount of speech feedback, and reading time. Means and standard deviations for the three groups are presented in Table 2 for the amount of speech feedback received, in Table 3 for reading time, and in Table 4 for the number of words read accurately by word set.

Accuracy reading. A Group × Word Linguistic Structure interaction was reliable, $F(1, 51) = 7.58$, $p < .008$, $MSE = 2.52$, $ES = .12$. Subsequent tests of simple main effect confirmed that word linguistic structure had a greater effect on the dyslexia group, who were more affected by CCV words than CV words, $F(1, 51) = 16.21$, $p < .001$, $MSE = 5.40$. There was also a significant Group × Word Set interaction, $F(13, 663) = 4.59$, $p < .001$, $MSE = 1.28$, $ES = .33$, indicating that reading accuracy was greater for garden-variety poor readers. Finally, a Word Linguistic Structure × Word Set interaction was reliable, $F(13, 663) = 2.74$, $p < .001$, $MSE = .47$, $ES = .43$. A test of simple main effect confirmed that during the training, the accuracy of reading was greater for CV words, $F(13, 663) = 9.75$, $p < .001$, $MSE = 2.71$.

Speech feedback. This analysis yielded a main effect of word linguistic structure, $F(1\ 51) = 9.72$, $p < .003$, $MSE = 15.90$, $ES = .16$, and a main effect of word set, $F(14, 714) = 12.75$, $p < .001$, $MSE = 50.35$, $ES = .49$. These results indicated that the amount of speech feedback was greater for CCV words than for CV words and that the number of feedback requests varied during computer-based word reading.

Reading time. This analysis yielded a main effect of word linguistic structure, $F(1, 59) = 15.7$, $p < .001$, $MSE = 961.29$, $ES = .21$, indicating that the reading time for CCV words was significantly greater than for CV words. Also, the main effect of word set was significant, $F(14, 826) = 19.21$, $p < .001$, $MSE = 2{,}624.56$, $ES = .65$, but this was subsumed under a significant Group × Word Set interaction, $F(14, 826) = 2.14$, $p < .009$, $MSE = 292.28$, $ES = .34$. Tests of simple main effect confirmed that reading time varied during computer-aided reading in the dyslexia group, $F(14, 826) = 10.19$, $p < .001$, $MSE = 1{,}392.04$.

Design 2: Word Frequency. A 2 × 2 × 15 Group (dyslexia vs. garden-

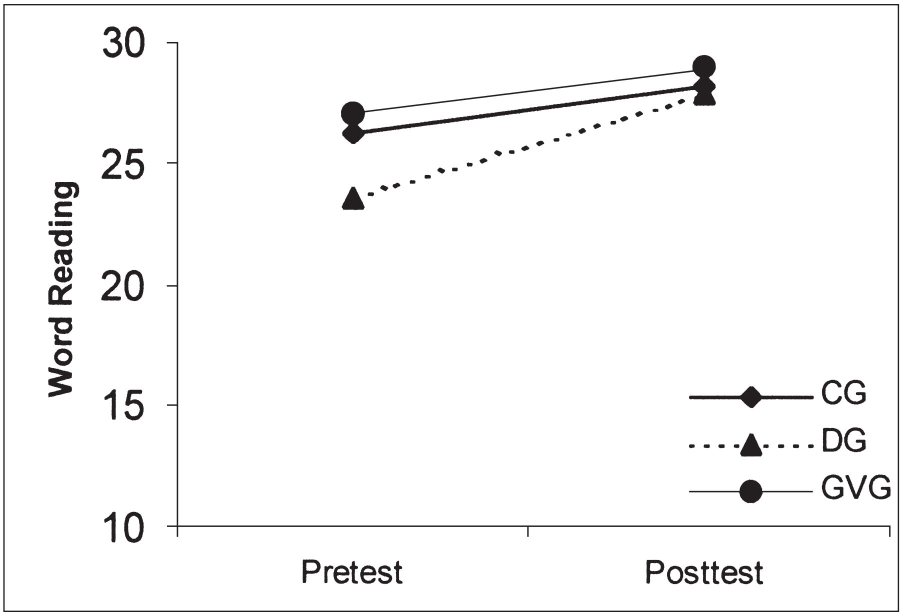

FIGURE 1. Interaction between group and time on word reading. CG = control group; DG = dyslexia group; GVG = garden-variety poor readers' group.

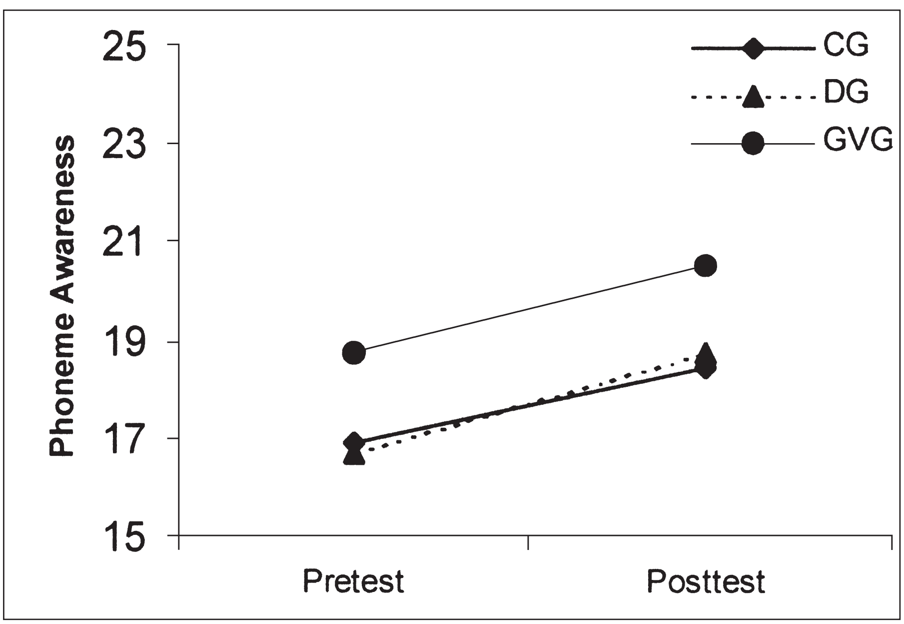

FIGURE 2. Interaction between group and time on phonological awareness. CG = control group; DG = dyslexia group; GVG = garden-variety poor readers' group.

variety poor readers) × Word Frequency (familiar vs. nonfamiliar) × Word Set (1 to 15) mixed ANOVA was performed on the number of accurately read words, the amount of speech feedback, and reading time.

Accuracy reading. This analysis yielded a main effect of word set, $F(11, 572) = 11.01$, $p < .001$, $MSE = 3.29$, $ES = .46$, but this was subsumed under a significant Word Frequency × Word Set interaction, $F(11, 572) = 1.88$, $p < .039$, $MSE = .29$, $ES = .36$, and a significant Group × Word Set interaction, $F(11, 572) = 4.90$, $p < .001$, $MSE = 1.46$, $ES = .33$. Tests of simple main effect confirmed that the number of accurately read words was higher for familiar words than for nonfamiliar words, $F(11, 572) = 6.07$, $p < .001$, $MSE = 1.14$, and the accuracy of reading was greater in garden-variety poor readers, $F(11, 572) = 1.90$; $p < .03$, $MSE = .57$.

Speech feedback. There was a main effect of word set, $F(13, 663) = 13.54$, $p < .001$, $MSE = 53.67$, $ES = .46$, but it was subsumed under a significant Word Frequency × Word Set interaction, $F(13, 663) = 1.95$, $p < .023$, $MSE = 1.92$, $ES = .44$. Tests of simple main effect confirmed that speech feedback was requested more frequently for nonfamiliar words than for familiar words, $F(13, 663) = 10.19$, $p < .001$, $MSE = 24.42$.

Reading time. A Group × Word Set interaction was reliable, $F(13, 767) = 1.90$, $p < .02$, $MSE = 264.89$, $ES = .30$, but this was subsumed under a significant Group × Word Frequency × Word Set interaction, $F(13, 767) = 2.11$, $p < .012$, $MSE = 36.72$, $ES = .35$. Subsequent tests of simple main effect revealed that reading time was longer for children with dyslexia than for garden-variety poor readers on nonfamiliar words during computer-based reading, $F(13, 767) = 8.36$, $p < .001$, $MSE = 742.62$ (see Figure 3).

Design 3: Word Length. A 2 × 2 × 15 Group (dyslexia vs. garden-variety poor readers) × Word Length (short vs. long) × Word Set (1 to 15) mixed ANOVA was performed on the number of accurately read words, the amount of speech feedback, and reading time.

Accuracy reading. This analysis yielded a main effect of word length, $F(1, 51) = 18.04$, $p < .001$, $MSE = 14.02$, $ES = .26$, and a main effect of word set, $F(11, 561) = 10.02$, $p < .001$, $MSE = 3.03$, $ES = .44$. Also, there was a significant Group × Word Length × Word Set interaction, $F(11, 561) = 3.21$, $p < .001$, $MSE = .68$, $ES = .28$. Subsequent tests of simple main effect revealed that the dyslexia group was more affected by long words during computer-based reading, $F(11, 561) = 5.50$, $p < .001$, $MSE = 1.17$ (see Figure 4).

Speech feedback. There was a main effect of word length, $F(1, 51) = 13.75$, $p < .001$, $MSE = 22.70$, $ES = .21$, and a main effect of word set, $F(14, 714) = 12.75$, $p < .001$, $MSE = 50.35$, $ES = .49$, but these were subsumed under a significant Word Length × Word Set interaction, $F(14, 714) = 2.55$, $p < .001$, $MSE = 2.95$, $ES = .50$. Subsequent tests of simple main effect confirmed that the number of feedback requests was higher for long words during computer-based reading, $F(14, 714) = 9.05$, $p < .001$, $MSE = 21.53$.

Reading time. There was a main effect of word length, $F(1, 59) = 30.94$, $p < .001$, $MSE = 2{,}317.64$, $ES = .34$, but it was subsumed under a significant Group × Word Length interaction, $F(1, 59) = 6.07$, $p < .017$, $MSE = 454.45$, $ES = .09$. Subsequent tests of simple main effect revealed that there were differences between groups in reading time for short words, $F(14, 826) = 17.77$, $p < .003$, $MSE = 232.46$. There was also a main effect of word set, $F(14, 826) = 19.21$, $p < .001$, $MSE = 2{,}624.56$, $ES = .65$, but this was subsumed under a significant Word Length × Word Set interaction, $F(14, 826) = 3.6$, $p < .001$, $MSE = 77.99$, $ES = .39$, and a significant Group × Word Set interaction, $F(14, 826) = 2.14$, $p < .009$, $MSE = 292.28$, $ES = .34$. Tests of simple main effect confirmed that reading time was longer for long words, $F(1, 59) = 22.33$, $p < .001$, $MSE = 1{,}672.19$, and that reading time in the dyslexia group varied during computer-based reading, $F(14, 826) = 10.19$, $p < .001$, $MSE = 1{,}392.04$.

Discussion

This study was designed to analyze whether the effects of computer-assisted reading practice differed between children with reading disabilities with and without an IQ–achievement discrepancy. We hypothesized that if IQ could differentially predict treatment outcomes, then our findings could offer empirical evidence in favor of the IQ–achievement discrepancy definition of RD. However, our findings suggest that IQ may be irrelevant for predicting intervention outcomes. The results indicated that computer-assisted practice was as beneficial to the garden-variety poor readers' group as to the dyslexia group. We found that children with RD with and without IQ–achievement discrepancy improved their performance on word reading in comparison to the control group. We would like to emphasize this result, because it demonstrates that "when one treats a child's word recognition problems with phonics instruction, the most valid test of the child's ability to read is a test of real-word recognition and not performance on pseudowords or phonics measures" (Swanson, 1999, p. 505). Similar results were obtained by Hurford et al. (1994), who also found that the training in phonological processing proved to be as beneficial to the trained garden-variety poor readers' group as it was to the trained dyslexia group. Also, Vellutino et al. (2000) found that IQ scores did not distinguish between poor readers and typical readers or between poor readers who were difficult to remediate and poor readers who were readily remediated.

Nevertheless, we found that children with dyslexia had more difficulties than garden-variety poor readers during computer-based word reading under conditions that required extensive phonological computation, because they were more affected by low-frequency words and long words. Therefore, the dyslexia group showed a different pattern in comparison to garden-variety poor readers, because the number of accurately read words was smaller for long words, and their reading time was longer when they had to read nonfamiliar words. Another finding was that the garden-variety poor readers improved their phonological awareness skills. This result contradicts the hypothesis that poor readers with high IQ scores are somehow more remediable than poor readers with low IQ scores. On the other hand, there were no differences between the groups on requests for speech feedback. Olofsson (1992) found that the number of help requests decreased after several sessions, and he interpreted this fact by considering that children with RD did not seem to have sufficient metacognitive skills to benefit from computer-aided practice. In the study reported here, the analysis of the learning process showed that the participants were selective when requesting speech feedback. The frequency of requests for speech feedback was significantly related to word frequency and word length, suggesting that metacognitive skills were used by children with RD. There were more help requests for long words and nonfamiliar words from children with RD. Similarly, Van Daal and Reitsma (1993) found that poor readers were more selective in requesting speech feedback, because they better discriminated hard-to-read words from easy-to-read words.

On the other hand, in the meta-analysis conducted by Swanson (1999), half of the interventions that measured word recognition used some type of word segmentation in the presentation of the treatment. Studies clearly varied in their level of phoneme segmentation (e.g., letter sounds, intrasyllabic units); however, all these variations were coded in the synthesis as an example of segmentation and were not examined separately. Effect sizes were higher for word recognition when studies included direct instruction. In the present study, we were not interested in making a systematic comparison between different types of segmentation at the analytic level (i.e., syllables, phonemes, onset-rime). Our training program computer provided different forms of orthographic units based on the empirical evidence. So, for instance, within both the dual route and analogy frameworks, there has been debate over the kinds of multiletter units that readers use (Treiman & Zukowski, 1988). Treiman (1992) pointed out that correspondences between print and speech are not restricted to the level of whole words or to the level of single phonemes. In addition to word-specific associations and grapheme–phoneme correspondences, readers

TABLE 2
Means and Standard Deviations for Amount of Speech Feedback During Training by Group and Linguistic Parameters

	Dyslexia		GVPR		Dyslexia		GVPR	
Word set	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
	Familiar words				**Unfamiliar words**			
1	4.67	5.21	3.09	3.73	4.71	5.13	2.21	2.86
2	2.88	3.05	1.34	2.03	2.46	2.86	1.80	2.81
3	2.00	2.93	1.37	2.10	2.08	2.70	1.31	2.25
4	1.42	2.50	1.31	2.21	1.35	1.98	1.06	1.55
5	1.46	2.06	0.93	1.46	1.69	1.81	1.43	2.24
6	1.64	2.10	0.74	1.46	1.28	1.37	1.20	2.11
7	1.04	2.20	1.00	1.93	1.12	1.48	1.17	1.90
8	0.65	1.55	0.69	0.90	0.77	1.42	0.40	0.85
9	0.77	1.21	0.91	1.15	0.77	1.14	0.83	1.10
10	1.46	2.55	0.49	1.01	0.58	0.64	0.54	0.89
11	0.54	0.95	0.34	0.54	0.88	1.14	0.59	0.96
12	1.04	1.49	0.57	1.04	0.80	1.47	0.54	1.15
13	0.96	1.06	0.60	1.09	0.88	1.36	0.40	0.95
14	0.84	1.21	0.34	0.59	1.20	1.87	0.86	1.29
15	0.54	0.93	0.31	0.76	0.75	1.11	0.74	1.04
	Short words				**Long words**			
1	4.33	4.66	2.24	3.79	5.04	5.68	3.06	2.94
2	1.54	2.34	1.31	1.92	2.81	3.58	1.83	3.09
3	2.12	2.86	1.43	2.30	1.96	3.01	1.26	2.03
4	1.42	2.40	0.89	1.32	1.35	1.94	1.49	2.08
5	1.15	1.46	1.00	2.10	1.96	2.55	1.43	2.30
6	1.44	1.69	1.06	1.63	1.48	1.90	0.89	1.78
7	0.73	1.66	1.00	1.64	1.42	2.18	1.17	1.76
8	0.73	1.51	0.51	0.89	0.69	1.57	0.57	0.92
9	0.46	0.90	0.60	1.24	1.08	1.13	1.14	1.31
10	1.15	2.13	0.60	1.06	0.88	1.21	0.43	0.74
11	0.54	0.71	0.32	0.77	0.88	1.07	0.60	0.85
12	1.00	1.50	0.54	1.29	0.84	1.25	0.57	1.01
13	1.04	1.06	0.37	1.14	0.80	1.58	0.63	0.97
14	0.52	0.82	0.29	0.57	1.52	2.10	0.91	1.50
15	0.33	0.82	0.31	0.63	0.96	1.00	0.74	1.01
	CCV words				**CV words**			
1	4.58	4.84	2.58	2.96	4.79	5.68	2.73	3.58
2	2.04	2.36	1.71	2.73	2.31	3.34	1.43	2.28
3	2.15	2.98	1.26	2.21	1.92	2.76	1.43	2.48
4	1.54	2.18	1.34	2.34	1.23	2.25	1.03	1.20
5	2.00	2.48	1.14	1.87	1.12	1.63	1.29	2.49
6	1.60	2.06	0.80	1.68	1.32	1.60	1.14	1.80
7	1.35	2.54	1.17	1.82	0.81	1.23	1.00	1.96
8	0.85	1.64	0.60	1.19	0.58	1.27	0.49	0.95
9	0.77	1.11	0.83	1.36	0.77	1.14	0.91	1.17
10	1.46	2.53	0.37	0.73	0.58	0.76	0.66	1.14
11	0.77	0.95	0.59	1.02	0.65	0.80	0.34	0.54
12	1.00	1.35	0.54	1.31	0.84	1.49	0.57	0.85
13	1.04	1.84	0.60	1.14	0.80	0.82	0.40	0.98
14	1.32	2.12	0.83	1.40	0.72	1.14	0.37	0.69
15	0.83	1.24	0.71	1.02	0.46	0.93	0.34	0.68

Note. GVPR = garden-variety poor readers.

TABLE 3
Means and Standard Deviations for Reading Time During Training by Group and Linguistic Parameters

Word set	Dyslexia *M*	Dyslexia *SD*	GVPR *M*	GVPR *SD*	Dyslexia *M*	Dyslexia *SD*	GVPR *M*	GVPR *SD*
	Familiar words				Unfamiliar words			
1	27.57	16.08	28.45	12.56	29.34	19.26	29.75	12.29
2	22.32	12.40	22.05	12.49	26.13	16.17	24.12	15.94
3	22.20	15.83	20.44	10.62	26.27	22.19	20.27	10.81
4	21.50	16.18	17.77	11.78	19.98	15.54	19.09	12.17
5	17.95	12.44	16.70	12.05	24.49	19.45	18.06	10.73
6	16.76	11.41	16.38	10.33	18.71	12.58	19.63	16.47
7	15.85	10.13	14.92	14.24	15.83	10.46	14.95	13.52
8	16.07	12.30	16.20	9.12	15.57	11.16	16.36	9.51
9	16.16	10.50	14.01	7.54	17.29	8.91	17.16	11.40
10	13.67	8.72	14.62	9.26	14.19	9.95	14.46	9.55
11	11.23	6.92	11.46	7.97	12.28	10.10	13.90	10.75
12	9.54	6.44	11.96	9.18	10.84	9.49	11.68	9.04
13	14.26	9.87	14.31	9.55	16.03	11.75	13.76	10.54
14	12.57	9.65	13.01	8.83	14.44	10.82	14.72	10.79
15	13.87	12.30	13.49	9.46	14.69	9.36	14.79	10.09
	Short words				Long words			
1	26.62	15.62	26.33	10.97	30.29	20.03	31.87	14.93
2	21.41	10.79	21.23	11.59	27.05	17.89	24.94	18.49
3	22.03	16.30	19.12	9.22	26.44	21.86	21.59	12.26
4	19.97	13.79	17.61	10.12	21.51	18.47	19.24	13.66
5	19.66	12.45	17.26	10.08	24.10	19.42	17.53	10.80
6	17.31	10.80	16.87	11.67	19.35	14.13	19.45	16.63
7	15.50	10.07	13.99	13.01	16.19	10.69	15.89	14.68
8	15.21	9.76	15.65	9.22	16.42	13.73	16.91	9.83
9	14.80	7.81	15.18	8.65	18.65	11.03	15.99	10.25
10	12.78	8.07	13.26	7.30	15.08	10.76	15.82	12.12
11	11.56	7.84	13.23	10.46	11.94	9.26	12.13	7.82
12	9.41	7.48	11.99	9.39	10.97	8.21	11.65	8.88
13	15.49	10.85	13.22	8.76	14.79	10.38	14.86	11.61
14	12.80	8.94	12.68	8.37	14.40	11.77	15.05	11.61
15	13.64	9.87	13.07	8.52	14.92	11.64	15.21	11.25
	CCV words				CV words			
1	28.57	18.08	29.54	14.55	28.35	16.57	28.65	11.67
2	23.39	13.11	22.56	15.83	25.07	16.31	23.61	13.71
3	25.04	21.03	20.76	11.18	23.43	17.16	19.94	10.24
4	21.63	17.93	18.36	11.48	19.86	14.27	18.49	12.45
5	24.29	17.61	17.80	11.47	19.48	14.60	16.99	9.61
6	19.37	13.44	19.44	15.54	17.29	11.43	16.88	12.76
7	15.98	9.89	15.91	15.83	15.70	11.65	13.97	11.94
8	16.27	12.65	16.74	9.94	15.37	10.95	15.82	9.13
9	17.66	11.00	16.51	11.20	15.79	8.07	14.65	7.86
10	14.15	9.80	15.84	12.32	13.71	8.90	13.25	7.35
11	12.09	8.51	12.36	8.72	11.41	8.62	13.00	9.85
12	10.73	8.13	13.17	10.80	9.66	7.84	10.47	7.62
13	15.79	10.84	15.39	11.46	14.50	10.36	12.69	8.68
14	14.74	11.68	14.97	11.27	12.26	8.67	12.75	8.50
15	14.88	12.46	15.01	11.11	13.67	9.19	13.27	8.58

Note. GVPR = garden-variety poor readers.

TABLE 4
Means and Standard Deviations for Reading Accuracy During Training by Group and Linguistic Parameters

Word set	Dyslexia *M*	Dyslexia *SD*	GVPR *M*	GVPR *SD*	Dyslexia *M*	Dyslexia *SD*	GVPR *M*	GVPR *SD*
	Familiar words				**Unfamiliar words**			
1	19.29	1.43	19.64	0.74	18.79	1.41	19.55	1.09
2	19.62	0.70	19.86	0.43	19.73	0.60	19.69	0.68
3	19.54	0.76	19.77	0.77	19.50	0.95	19.63	0.88
4	19.69	0.62	19.89	0.32	19.54	0.86	19.77	0.69
5	19.81	0.42	19.89	0.31	19.73	0.53	19.69	0.76
6	19.96	0.20	19.86	0.43	19.76	0.60	19.83	0.38
7	20.00	0.00	19.94	0.24	19.92	0.27	19.83	0.57
8	19.92	0.27	19.97	0.17	19.96	0.20	19.94	0.24
9	19.85	0.37	19.89	0.32	20.00	0.00	19.91	0.28
10	19.81	0.49	19.91	0.28	19.69	0.97	19.89	0.40
11	20.00	0.00	20.00	0.00	19.92	0.27	19.97	0.17
12	19.88	0.44	19.86	0.49	19.88	0.33	19.91	0.28
13	19.96	0.20	20.00	0.00	20.00	0.00	19.89	0.32
14	20.00	0.00	20.00	0.00	19.72	0.61	19.71	0.79
15	19.83	0.48	19.94	0.24	19.79	0.51	19.86	0.43
	Short words				**Long words**			
1	19.50	0.98	19.82	0.46	18.58	2.32	19.36	1.34
2	19.92	0.27	19.91	0.28	19.42	0.95	19.63	0.81
3	19.62	0.70	19.86	0.43	19.42	0.99	19.54	1.17
4	19.54	0.81	19.80	0.53	19.69	0.68	19.86	0.13
5	19.96	0.20	19.91	0.37	19.77	0.51	19.66	0.80
6	19.92	0.28	19.91	0.28	19.80	0.50	19.77	0.49
7	19.96	0.20	19.94	0.24	19.96	0.20	19.83	0.57
8	20.00	0.00	20.00	0.00	19.88	0.33	19.91	0.28
9	19.96	0.20	19.97	0.17	19.88	0.33	19.83	0.45
10	19.92	0.27	19.97	0.17	19.58	1.14	19.83	0.51
11	19.96	0.20	20.00	0.00	19.96	0.20	19.97	0.17
12	19.92	0.28	19.91	0.28	19.84	0.47	19.86	0.49
13	20.00	0.00	20.00	0.00	19.96	0.20	19.89	0.32
14	20.00	0.00	20.00	0.00	19.72	0.61	19.71	0.79
15	19.96	0.20	19.97	0.17	19.67	0.82	19.83	0.45
	CCV words				**CV words**			
1	18.96	1.60	19.61	0.86	19.13	1.42	19.58	0.97
2	19.58	0.81	19.74	0.56	19.77	0.51	19.80	0.53
3	19.31	0.97	19.60	1.09	19.73	0.60	19.80	0.53
4	19.35	1.09	19.69	0.83	19.88	0.33	19.97	0.17
5	19.77	0.51	19.74	0.61	19.96	0.20	19.83	0.62
6	19.76	0.60	19.97	0.17	19.96	0.20	19.71	0.62
7	19.92	0.27	19.91	0.28	20.00	0.00	19.86	0.55
8	19.96	0.20	19.94	0.24	19.92	0.27	19.97	0.17
9	19.85	0.37	19.89	0.32	20.00	0.00	19.91	0.28
10	19.65	0.89	19.86	0.43	19.85	0.46	19.94	0.24
11	19.92	0.27	20.00	0.00	20.00	0.00	19.97	0.17
12	19.76	0.52	19.77	0.73	20.00	0.00	20.00	0.00
13	19.96	0.20	19.91	0.28	20.00	0.00	19.97	0.17
14	19.76	0.60	19.80	0.58	19.96	0.20	19.91	0.28
15	19.67	0.82	19.83	0.57	19.96	0.20	19.97	0.17

Note. GVPR = garden-variety poor readers.

use mappings that involve intrasyllabic units. As Treiman (1992) suggested, "the basic notion that print represents speech might be more easily understood, especially by children with poor phonological skills, if it were introduced by reference to a larger, more accessible unit of sound" (p. 98). So, for instance, in Spanish, there are some linguistic units that seem to be more important for word recognition. One of these units is the syllable, as Spanish syllables are well defined, and the syllable boundaries are always clear (Alvarez, Carreiras, & de Vega, 1992). In fact, there is empirical evidence in Spanish about the effect of syllable frequency in learning to read (Jiménez, Guzmán, & Artiles, 1997). On the other hand, the type of phonological awareness that is based on recognizing syllable onset is critical in learning to read, and it could improve reading skill (Jiménez, 1997).

Finally, our findings are consistent with a synthesis of published reports on effective intervention for children with dyslexia, in the sense that persistent word recognition deficits are amenable to remedial training (Swanson, 1999). Nevertheless, in the synthesis published by Swanson, effect sizes were higher for reading comprehension studies compared to word recognition studies. Van der Leij (1994) reviewed six Dutch experiments on the effects of computer-assisted instruction on word and pseudoword reading. Overall, he found that the progress of the students with RD after computer-assisted instruction was quite small in comparison to control conditions. All these studies were carried out in languages with an opaque orthography. However, in the study reported here, we found transfer effects on word recognition processes in trained children in spite of the lower number of sessions. We suggest that the progress of our students with RD has been greater probably due to the transparency of Spanish orthography. As suggested by Morais (1995), languages with a highly transparent orthography might exhibit a more systematic use of phonological decoding than in the case of English. Also, Morais noted that access to phonological transcoding might be easier for languages that have a low number of vowels and few complex syllabic structures. For instance, whereas in Spanish, Cuetos (1989) found a very rapid development of the alphabetic route in children ages 5 and 6, there is evidence that this route develops more slowly in typical English readers and does not reach the level of mature readers until approximately 9 years of age (Backman, Bruck, Hebert, & Seidenberg, 1984; Siegel & Faux, 1989; Siegel & Ryan, 1988). As has been suggested by several authors (Bryson & Werker, 1989; Venezky, 1970; Werker, Bryson, & Wassenberg, 1989), because of the irregular nature of the sound–symbol correspondences in English, acquiring this knowledge is a very complex process. Finally, we did not find transfer

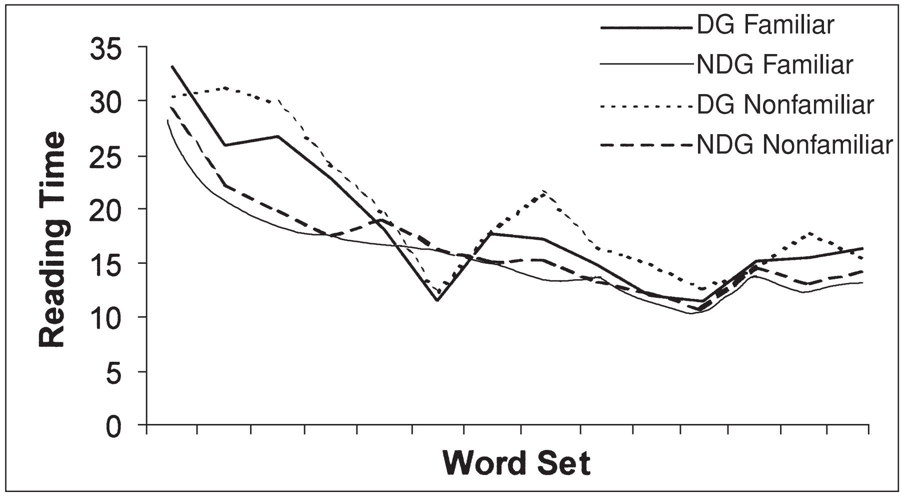

FIGURE 3. Interaction between group and word frequency and word set on reading time. DG Familiar = familiar words for dyslexia group; GVG Familiar = familiar words for garden-variety poor readers' group; DG Nonfamiliar = nonfamiliar words for dyslexia group; GVG Nonfamiliar = nonfamiliar words for garden-variety poor readers' group.

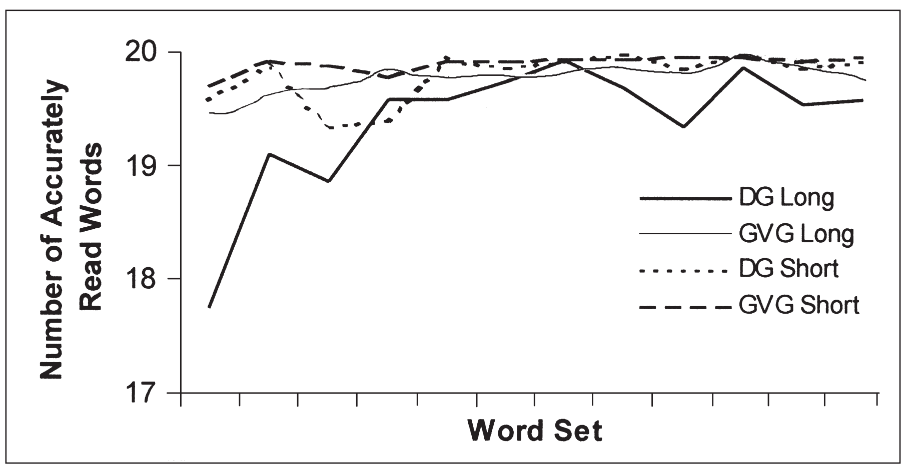

FIGURE 4. Interaction between group and word length and word set on the number of accurately read words. DG Long = long words for dyslexia group; GVG Long = long words for garden-variety poor readers' group; DG Short = short words for dyslexia group; GVG Short = short words for garden-variety poor readers' group.

effects of computer-assisted practice on word recognition to reading comprehension. In fact, research showing the generalization of isolated-word intervention to reading comprehension is limited (see Swanson, 1999, for a review).

In summary, we demonstrated that the effects of computer-assisted practice did not differ between children with RD with and without IQ–achievement discrepancy, except that low-IQ children with LD were more successful than those with high IQs in improving their phonological awareness skills. Our findings suggest that intelligence-level information may not be necessary for differentiating children with reading disabilities from garden-variety poor readers.

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AUTHORS' NOTE

This research was supported by a grant from DGICYT (Dirección General de Investigación Científica y Técnica, PB94-0587, Ministerio de Educación y Ciencia).

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