Phonological Awareness Intervention: Comparison of Fast ForWord, Earobics, and LiPS

JUDITH L. POKORNI
Pacific Institute for Research and Evaluation, Maryland

COLLEEN K. WORTHINGTON
University of Maryland

PATRICIA J. JAMISON
Prince George's County Public Schools, Maryland

ABSTRACT **Researchers have found that training in phonemic awareness (PA), a fundamental element for reading acquisition, is effective in varying degrees, depending on characteristics of the audience. In this study, the authors explored the relative effectiveness of 3 programs—Fast ForWord, Earobics, and LiPS. The authors randomly assigned 60 students with language and reading deficits to 1 of 3 interventions. Students received three 1-hr daily intervention sessions during a 20-day summer program conducted by a large school district. Measures of PA, language-, and reading-related skills were collected and analyzed. Earobics and LiPS were associated with gains on PA measures 6 weeks after intervention. No group effects were found on language or reading measures.**

Key words: Fast ForWord, Earobics, and LiPS; language and reading-related skills; phonemic awareness

During the last decade, increased attention has been given to raising the bar for academic achievement, with special emphasis on reading acquisition. In 1990, adoption of the National Education Goals resulted in state-by-state tracking of student progress in reading and mathematics. Since then, states have reported relatively slow progress in reaching proficiency levels for reading achievement at the fourth-grade level, as measured by the National Assessment of Educational Progress (NAEP; National Education Goals Panel, 1998).

In 1997, Congress asked the director of the National Institute of Child Health and Human Development (NICHD), in consultation with the Secretary of Education, to convene the National Reading Panel (NRP) to assess the effectiveness of different approaches used to teach children to read (NICHD, 2000a). At about the same time, the American Speech-Language-Hearing Association (ASHA) established the Ad Hoc Committee on Reading and Written Language Disorders. ASHA, using recommendations of the committee, published an official statement indicating that fundamental connections between spoken and written language require that interventions for language disorders address reading and writing, as well as spoken language (ASHA, 2001). Extensive research (Bashir & Scavuzzo, 1992; Bishop & Adams, 1990; Catts, Hu, Larrivee, & Swank, 1994; Joanisse & Seidenberg, 1998) has shown that language impairment is associated with significant reading difficulties.

In their efforts to improve the knowledge base regarding reading and reading instruction, researchers identified phonologic processing as a core element of reading acquisition (Morris et al., 1998; Stanovich & Siegel, 1994; Torgeson, 1999; Wagner & Torgesen, 1987). Phonological awareness has become the target for initial literacy training (Hurford et al., 1994; Vellutino et al, 1996). The explicit awareness of phonemes needed to segment, identify, or manipulate phonemes in words typically develops in children at about 6 years of age (Blachman, 1984); it has become the target for remediation when phonological awareness problems persist after first grade (Hurford, 1990; Lovett, Steinbach, & Frijters, 2000; Torgesen, 2001).

Recognizing the importance of phonemic awareness (PA) for reading acquisition, the NRP conducted a meta-analysis of research literature that examined the impact of PA instruction on reading (NICHD, 2000b). Of the 1,962 potential articles on the subject, the 52 articles that met NRP criteria for inclusion provided 96 instructional comparisons. The panel found that the overall effect size of PA instruction on PA was large (Cohen's $d = 0.86$), whereas effect size for reading and spelling outcomes was moderate ($d = 0.53$ and 0.59, respectively). The NPR concluded that direct instruction in phonemic awareness instruction can

Address correspondence to Judith L. Pokorni, Pacific Institute for Research and Evaluation, 11710 Beltsville Drive, Suite 300, Calverton, MD 20705. (E-mail: pokorni@pire.org)

help children learn to read and spell (NICHD, 2000b). When the NRP examined student characteristics, it found that disabled readers had significantly smaller gains (d = 0.62) in PA than did at-risk (d = 0.95) and normally progressing (d = 0.93) readers. The at-risk children showed bigger transfer effects (d = 0.86) in their reading than did normal (d = 0.47) and disabled (d = 0.45) readers.

For spelling outcomes, changes were large for at-risk (d = 0.76) and normal readers (d = 0.88) but small for disabled readers (d = 0.15). For age at intervention, NRP found that effect size for kindergartners on PA outcomes (d = 0.95) was greater than for first graders (d = 0.48) and second through sixth graders (d = 0.70), most of whom were disabled readers. For reading outcomes, effect size for kindergartners was the same as for second through sixth graders (d = 0.48 and 0.49, respectively). Although effect size for spelling outcomes was greater for kindergartners (d = 0.97) than for first graders (d = 0.52), there was no transfer effect to reading for second to sixth graders (d = 0.14). The meta-analysis examined intervention effects on students during their initial or primary literacy training (kindergarten and first grade) as well as on students who experienced difficulty with reading acquisition after the first grade. Fletcher and Lyon (1998) found that students who experienced difficulty reading after first grade may have been among the approximately 15% to 20% of students with reading disabilities in the United States.

With the increased attention on reading acquisition in general, and on PA in particular, it is not surprising that the number and type of intervention programs addressing PA has grown rapidly during the last decade. In this study, we compared the effectiveness of three intervention programs on 9-year-old students who had language learning problems and reading deficits. We investigated the effects of a 20-day summer intervention on PA, reading-related skills, and language skills. Two programs—Fast ForWord (FFW; Scientific Learning Corporation, 1999) and Earobics Step 2 (Cognitive Concepts, Inc., 1998)—were delivered by computer. The third program—Lindamood Phonemic Sequencing Program (LiPS; Lindamood & Lindamood, 1998)—was delivered by a trained instructor to a small group of students. We chose those interventions because of their focus on PA, a core element of reading acquisition (Stanovich & Siegle, 1994), and because of the publishers' claims about dramatic improvements in language and reading skills that result from use of the programs.

Scientific Learning Corporation (1999; developer of FFW) claims that individuals with language and reading problems make 1.5- to 2-year gains after 4 to 8 weeks of FFW training and that these gains last. Developers of the FFW program published several studies in which a few of the FFW exercises were used as prototypes and reported significant gains in language comprehension and expression (Merzenich et al., 1996; Tallal et al., 1996). Published studies involving the commercially available FFW program, which is based on the assumption that temporal processing of speech and speech sounds is impaired in children with PA deficits, have been limited to several clinical trials and a group intervention comparing FFW with Orton Gillingham training. The case study investigations (Friel-Patti, DesBarres, & Thibodeau, 2001; Frome Loeb, Stoke, & Fey, 2001; Gillam, Crofford, Gale, & Hoffman, 2001) resulted in inconsistent improvement on various language measures. The group study (Hook, Macaruso, & Jones, 2001) examined the effects of intervention on written and spoken language skills and found inconsistent results; FFW participants made immediate gains in phonemic awareness and no gains in word attack or word identification skills. Long-term gains in phonemic awareness and all areas of reading were found for the FFW program and the less intensive Orton Gillingham training, leading the authors to suggest that the structured training provided by both programs may have resulted in increased auditory attention for participants irrespective of intervention program.

There are no published research studies that test the effectiveness of Earobics in improving PA, reading, or language. Nonetheless, the developers of Earobics state that the Earobics Step 1 and Step 2 (the latter was used in this study) systematically teach PA and result in significant skill improvement for most students in areas required for reading success, including language-processing skills, attention, and memory (Cognitive Concepts, Inc., 2000a). Of the three interventions used in this study, LiPS—formerly called the ADD (Auditory Discrimination in Depth) Program (Lindamood & Lindamood, 1984)—has been used most frequently in published studies of PA, reading, and language (Kennedy & Blackman, 1993; McGuinness, McGuinness, & Donohue, 1995; Torgesen, 2001; Wise, Ring, & Olson, 1999). In contrast to the other two auditory-based interventions used in this study, LiPS incorporates an articulatory approach in its format. Torgesen and colleagues (1999) demonstrated large increases (more than 25 standard score points) in word attack and word identification skills for first graders at high risk for reading failure in two instructional groups: the ADD program and the Read, Write, and Type program (Herron, 1995). An earlier study comparing ADD with an embedded PA approach, a classroom-based tutorial program, and a no-treatment control also demonstrated strong gains in word attack and word identification for a group of kindergarteners at risk for reading failure. Recently, investigations of older students (8 to 10 years old) with learning disabilities have demonstrated sizable gains in reading achievement after intervention with either ADD or an embedded phonics program that stresses application to reading (Torgesen, 2001).

In this study, we examined FFW, Earobics, and LiPS, and addressed the following two research questions:

1. Does one or more of the three intervention programs result in greater gains than the other programs in phonemic awareness, language, or reading-related skills?
2. Did the students in individual intervention groups make gains in phonemic awareness, language, or reading-related skills?

Method

Participants

All students were recruited from a school district of approximately 135,000 students who were 77% African American, 11.5% White American, 7.5% Hispanic, 3.3% Asian/Pacific Islander, and .5% American Indian. The proportion of the student body living at or below the poverty level (as measured by number of students receiving free or reduced-price meals) was approximately 42%; the mobility rate of students exceeded 34% (including student entrants and withdrawals). Table 1 summarizes the demographics of study participants.

At the time of enrollment, school speech and language pathologists (SLPs) nominated students who were (a) 7.5 to 9 years of age, (b) receiving school-based speech/language services outlined in an individualized education plan, (c) reading more than 1 year below grade level according to their school records and teacher reports, (d) from English-speaking families, and (e) not known to have a hearing impairment. In addition, all students scored more than one standard deviation lower than the mean on at least one of the three pretest language subtests—Concepts and Directions, Recalling Sentences, and Listening to Paragraphs (Clinical Evaluation of Language Fundamentals-3). See Table 2 for language scores at pretest.

We identified a pool of 62 eligible students from 34 schools within the district's central and northern areas; two of the schools were identified as intervention sites. Thirty-two students were enrolled at the northern site; 30 students were enrolled at the central site. We eliminated students living in the southern area because of a lower rate of nomination and the difficulty of establishing a third bus route for a small number of students. Students in each of the two geographic areas were assigned randomly to one of the intervention programs: FFW, Earobics, or LiPS. FFW and Earobics interventions were delivered in computer labs with groups of 5 to 6 students each. LiPS was delivered in separate rooms to groups of 4 students. One professional (an experienced SLP, a special educator, or general education teacher) provided each intervention under the direction of an intervention supervisor. Of the original 62 students, 2 children did not participate in the intervention because 1 child demonstrated repeated behavioral outbursts during the first hours of attendance and was removed from the program, and 1 child did not show up for the program. We analyzed

TABLE 1. Demographic Information by Intervention Group

Variable	FFW	Earobics	LiPS
Age in months (*SD*)	106.1 (4.1)	104.5 (4.8)	103.1 (5.5)
Gender			
Male	17	10	16
Female	3	6	2
Racial composition			
African American	80.0%	75.0%	77.8%
White	20.0%	25.0%	16.7%
Hispanic	0	0	5.6%
Free or reduced-price lunches	40.0%	50%	66.7%
Days in program			
Mean (*SD*)	18.3 (1.3)	17.7 (2.4)	18.1 (1.9)

Note. FFW = Fast ForWord. LiPS = Lindamood Phoneme Sequencing Program.

TABLE 2. Pretest Language Scores by Intervention Group

	FFW		Earobics		LiPS	
Subtest	Mean SS	*SD*	Mean SS	*SD*	Mean SS	*SD*
CELF-3 pretest scores						
Concepts & Directions	71.5	22.8	68.1	22.9	64.4	22.8
Recalling Sentences	74.5	25.0	74.4	19.7	65.0	28.3
Listening to Paragraphs	66.5	23.5	63.8	29.0	58.9	17.8

Note. CELF-3 = Clinical Evaluation of Language Fundamentals-Third Edition. *SD* = standard deviation. SS = standard score. FFW = Fast ForWord. LiPS = Lindamood Phoneme Sequencing Program.

data on 54 of the 60 students who received an intervention. Six children were eliminated for the following reasons: (a) 1 child had a hearing loss in one ear, (b) 1 child left the program on Day 9 after being diagnosed with chickenpox, (c) 2 children moved out of the district before the 6-week posttest was administered, and (d) 2 children scored higher than the cutoff of one standard deviation below the mean on at least one of the three CELF-3 language subtests at the pretest administration. Table 3 displays the intervention sites and group assignments.

Procedures

Program schedule. A 20-day summer program was conducted for participants; they were transported by school bus to and from their assigned site. The summer program ran 5 hr a day, with three 1-hr intervention periods per day for all participants. Intervention periods were alternated with lunch (which the children brought with them), snacks provided through the program, and recreational activities. Two intervention periods were held in the morning and one in the afternoon, with a 40-min lunch at midday. Intervention groups (Fast ForWord, Earobics, and LiPS) were housed in separate rooms. All participants received their assigned intervention during the same three 1-hr intervention periods. No other reading activities were conducted during the summer sessions. No books were used for either leisure reading or structured reading activities during the summer school sessions. The three 1-hr blocks were limited to the specified activities of the phonological awareness intervention program in use. Arrival and departure times, dependent on the district's bus transportation schedules, differed at the two intervention sites. Table 4 includes the daily schedule of activities for each site.

Program staff. Three licensed SLPs, working as intervention supervisors, were trained and experienced in their respective intervention programs. They coordinated the training of group leaders who were each assigned to a specific group of children for whom they conducted the daily intervention program. Group leaders for FFW and Earobics received 2 days of training in how to use the software program, maintain student records, and supervise students. LiPS group leaders, previously trained and experienced in using the LiPS program, received 3 days of refresher training. All intervention staff were experienced professionals employed by the school district during the regular school year and the summer session.

TABLE 3. Intervention Sites and Group Assignments

Site and program	Groups	Students	Students in final analyses
Northern			
FFW	2	10	10
Earobics	2	10	9
LiPS	3	12	12
Central			
FFW	2	10	10
Earobics	2	10	7
LiPS	2	8	6
Total	13	60	54

Note. FFW = Fast ForWord. LiPS = Lindamood Phoneme Sequencing Program.

TABLE 4. Daily Schedule by Sites

Activity	Northern site	Southern site
Arrival	9:30–10:00	8:00–8:30
Intervention Session I	10:00–11:00	8:30–9:30
Break	11:00–11:20	9:30–9:50
Intervention Session II	11:20–12:20	9:50–10:50
Lunch	12:20–1:00	10:50–11:30
Intervention Session III	1:00–2:00	11:30–12:30
Dismissal preparations	1:00–2:30	12:30–1:00

Interventions. Students who received the FFW intervention were each assigned a computer station with stereo headphones in a computer laboratory set up for this study. A group leader supervised each group of 5 students during the intervention period as well as during breaks and at lunchtime. FFW is an Internet- and CD-ROM-based program that consists of a series of adaptive, interactive exercises that use acoustically processed speech and speech sounds. Table 5 describes the tasks and language areas associated with each of the 7 FFW games. Each day, students used their computers to play approximately three 20-min games during each of the three 1-hr intervention periods. Each child's games were selected by Scientific Learning Corporation according to their previous day's performance data, which were sent electronically to the company for analysis.

Participants who received the Earobics Step 2 intervention were each assigned a computer station with stereo headphones in a computer laboratory set up for this study. Earobics Step 2 is designed for developmental ages 7–10 years and features 5 interactive games with nearly 600 levels of play. Table 6 outlines the tasks and concepts associated with each Earobics Step 2 game. A group leader supervised each group of 5 students during the intervention period as well as during breaks and at lunchtime. Students used their computers to play each of the five games three times during each 1-hr intervention period.

Participants who used the LiPS program were assigned to a group of 4 students. Each group was assigned a group leader who conducted the program throughout the intervention period. Group leaders also supervised students during breaks and at lunchtime. Intervention was provided during

TABLE 5. Fast ForWord Exercise Tasks and Targeted Language Areas

Game title	Task	Targeted language and reading skill
Old MacDonald's Flying Farm	Clicks and holds the flying animal to hear a repeated sound. Releases the animal when the sound changes	Phoneme discrimination; sustained and focused attention; processing speed
Block Commander	Follows verbal instructions to identify and manipulate objects of various colors and shapes	Listening comprehension and syntax; working memory; processing speed
Circus Sequence	Identifies a sequence of sounds by clicking buttons that correspond to the sound sweeps	Working memory; sound sequencing ability; processing speed
Phonic Match	Matches sounds represented by a grid of tiles by clicking on one tile and finding another tile with the identical word	Auditory word recognition; phoneme discrimination; working memory; processing speed
Phonic Word	Clicks the picture that represents the object that the exercise instructs the player to identify	Auditory word recognition; phoneme discrimination; working memory; processing speed
Phoneme Identification	Identifies the character that matches the target sound	Working memory; phoneme discrimination; processing speed
Language Comprehension Builder	Clicks the picture that has the most accurate representation of the sentence	Listening comprehension and syntax; working memory; processing speed

Note. The information in this table was extracted from *Guide to implementation for training programs Fast ForWord, 4wd, Step 4word*, by Scientific Learning Corporation, 2000, Berkeley, CA: Author.

TABLE 6. Earobics Step 2 Games and Targeted Concepts

Game title	Task	Concept
Calling All Engines	Recalling and sequencing numbers, works, vowels, and consonant sounds	Following directions; auditory memory; sound recognition
Paint by Penguins	Counting and sequencing speech sounds; segmenting and sequencing sounds in a word; manipulating speech sounds	Segmenting sounds
Pesky Parrots	Blending 2, 3, and 4 syllables into a word; blending 3 and 4 phonemes into a word; word closure	Blending sounds; word closure
Hippo Hops	Discrimination of vowels; discrimination of consonants in minimal pair CV syllables; recognition of diphthongs, tense vowels, and lax vowels in a word; identification of consonant sound position in a word	Discrimination of vowel and consonant sounds
Duck Luck	Recognizing word endings and beginnings; blending onsets with rimes; segmenting and deleting phonemes, onsets, and rimes	Recognizing word endings and beginnings

Note. The information in this table was extracted from *Earobics /step 2—specialist/clinicians resource*, by Cognitive Concepts, Inc., 2000b, Evanston, IL: Author.

the same three 1-hr periods held each day for all participants. Each LiPS group was housed in a separate room at the intervention site. The LiPS program divides auditory processing into five general processes: sensory input, perception, conceptualization, storage, and retrieval. Group leaders used those processes to build phonemic awareness at the articulatory level. The CD-ROM exercises were not used during this study. Table 7 outlines the major concepts taught in the LiPS program.

In summary, each student was assigned an intervention (Fast ForWord, Earobics Step 2, or LiPS); throughout the summer session, the only instruction that the student

TABLE 7. LiPS Major Concepts and Tasks

Concept	Task
Introducing the concept of "selective listening"	Identifying surrounding sounds in the environment; developing an awareness of sound
"Setting the climate" for students	Understanding the methodology and its rationale
Identifying and classifying speech sounds by place and manner of articulation	Discovering the oral-motor features of sounds and their relationships; labeling "brother" sounds, "cousin" sounds, and "borrower" sounds
Introducing, practicing, and tracking consonants	Demonstrating sound, label, and letter association for consonant pairs; discriminating consonant pairs; tracking simple sequences of consonant sound in terms of same, different, and number
Introducing, practicing, and tracking vowels	Identifying vowels by oral-motor features; classifying vowels into four categories; demonstrating sound, label, and letter association for vowels; discriminating vowel sounds; tracking simple sequences of vowels in terms of same, different, and number
Tracking, spelling, and reading simple syllables and words	Tracking simple syllables and words; reading simple words; spelling simple words

Note. The information in this table was extracted from *The Lindamood Phoneme Sequencing Program for Reading, Spelling, and Speech, the LiPS Program, Third Edition*, by P. Lindamood and P. Lindamood, 1998, Austin, TX: Pro-Ed.

received was in the assigned program. Students were supervised closely and assisted in remaining actively involved in their assigned intervention during the three 1-hr intervention periods. For both Fast ForWord and Earobics Step 2, interventions consisted of playing computer games designed to develop phonemic awareness. The sequence of games played was determined through electronic analysis of each student's prior performance. A trained professional provided the LiPS intervention to small groups of 3–4 students. Tables 5–7 summarize tasks and content covered during daily sessions. No additional books or reading instruction were available to any participant. All three groups received high levels of concrete and verbal reinforcement for attending to instruction. Reinforcement was given by the computer or an instructor. Also, adults redirected a student's attention to instruction when needed. Students were given a lunch break and 20-min blocks of supervised indoor and outdoor playtime during which numerous age-appropriate games and leisure activities were available. However, students had no access to books during their time at the school site.

Measures

Hearing Screen

Faculty and graduate students from the Department of Hearing and Speech Sciences, University of Maryland at College Park, screened all children with an audiometer for normal hearing at 25 dB for 500 to 4000 HZ, according to standards set by the American Speech-Language-Hearing Association (1996).

Phonemic Awareness

Two subtests of the Phonological Awareness Test (PAT; Robertson & Salter, 1997) were administered: Phoneme Blending and Phoneme Segmentation. The subtests required the student to blend and segment sounds at the phoneme level. In our analyses, we used raw scores for the PA subtests because standard scores lower than 51 for Phoneme Blending and 77 for Phoneme Segmentation were not available, and many participants scored below these cutoffs.

Language-Based Skills

Three subtests of the Clinical Evaluation of Language Fundamentals-3 (CELF-3; Semel, Wiig, & Secord, 1995) were administered. Concepts & Directions assesses the ability to interpret, recall, and execute oral commands of increasing length and complexity that contain concepts requiring logical operations. Recalling Sentences assesses recall and reproduction of sentence surface structure as a function of syntactic complexity. Listening to Paragraphs assesses comprehension, recall, and interpretation of factual, inferential, sequential, and predictable information presented orally. Standard scores for the language subtests were used in the analyses.

Reading-Related Skills

Four subtests of the Woodcock Language Proficiency Battery–Revised (Woodcock, 1991; WLPB-R) were administered. Letter-Word Identification measures symbolic learning and ability as well as skills in identifying isolated

letters and words. Passage Comprehension measures skill in reading a short passage and identifying a missing key word. Word Attack measures skill in applying phonic and structural analysis strategies to the pronunciation of unfamiliar printed words. Spelling measures skills in producing correct spellings and detecting incorrect spellings in written passages. Standard scores for the reading-related subtests were used in the analyses.

Assessment Schedule

Three test sessions were conducted. Pretest measures (T1) were administered 4–to 6 weeks before the intervention began. Posttest measures (T2) were administered 6–8 weeks after intervention ended. Although long-term posttest measures (T3) were administered 11 months after intervention, the scores were not used because participants' reading intervention programs during the school year before the long-term posttests varied greatly and were not monitored. Graduate students from the Department of Hearing and Speech Sciences, University of Maryland at College Park, conducted all test sessions at each participant's school. All assessors remained blind to intervention-group membership. Each graduate student received 12 hr of training and was required to demonstrate proficiency in test administration and scoring. Licensed SLP faculty members supervised groups of one to three assessors at school sites. All measures were double scored by an independent examiner.

Results

Table 8 provides the pretest and posttest means for the three intervention groups. The results address the two research questions: (1) Was one or more of the interventions more effective than the others? (2) How effective were the individual interventions?

Differential Effects of the Three Interventions

To determine whether any of the interventions were more effective than the other interventions, we conducted three repeated measures multivariate analysis of variance (MANOVAs) using pretest (T1) and posttest (T2) scores. The dependent measures were grouped into three clusters: phonemic awareness, language, and reading-related skills. PAT subtests (Phoneme Blending and Phoneme Segmentation) were used for the phonemic awareness cluster. Raw scores were used for PAT subtests because standard scores lower than 51 and 77 were not available, and many participants scored lower than these cutoff scores. We used CELF-3 subtests (Concepts & Directions, Recalling Sentences, and Listening to Paragraphs) for the language cluster, and WLPB-R subtests (Letter-Word Identification, Passage Comprehension, Word Attack, and Spelling) for the reading-related cluster. We used standard scores for the CELF-3 and WLPB-R measures. We found that the number of days a child attended the program was unrelated to outcome scores and, therefore, we did not use attendance as a covariate. We also found that race and free or reduced-price lunches (indicator of low income) were unrelated to pretest scores, so we did not use them as covariates. Gender, however, was correlated with the WLPJ-R measures and was used as a covariate to analyze the reading-related measures.

TABLE 8. Group Means

	Fast ForWord (n = 20)				Earobics (n = 16)				LiPS (n = 18)			
Subtest	Time 1	*SD*	Time 2	*SD*	Time 1	*SD*	Time 2	*SD*	Time 1	*SD*	Time 2	*SD*
Blending Phonemes	5.1	2.7	4.9	3.3	6.0	2.6	6.6	2.0	3.8	2.3	5.7	2.5
Segmenting Phonemes	1.2	1.7	1.6	1.8	1.3	1.4	3.2	2.5	1.4	1.9	2.6	1.8
Concepts & Directions	71.5	22.8	72.5	23.6	68.1	22.9	69.4	21.7	64.4	24.8	62.2	20.7
Recalling Sentences	74.5	25.0	79.0	32.6	74.4	19.7	80.0	24.2	65.0	28.3	62.8	30.4
Listening to Paragraphs	66.5	23.5	74.0	33.9	63.8	29.0	74.4	26.8	58.9	17.8	70.0	19.7
Letter–Word Identification	83.5	12.3	80.3	13.6	85.3	14.6	83.9	14.1	90.1	12.5	87.9	12.2
Passage Comprehension	87.3	11.7	86.0	13.8	87.3	15.2	86.1	14.1	92.6	9.5	89.6	8.2
Word Attack	82.0	13.3	78.9	11.8	82.6	9.4	85.1	10.5	85.2	8.8	85.9	11.8
Spelling	84.5	14.0	80.8	12.1	82.5	16.6	81.6	10.1	88.2	15.5	86.8	13.5

Note. LiPS = Lindamood Phoneme Sequencing Program.

The repeated measures MANOVA in which we used the Phonemic Awareness measures resulted in a significant Group by Time effect, $F(2, 51) = 3.89$, $p < .01$; Cohen's $d = 0.79$. Post hoc tests indicated that the Group by Time difference was caused by significant increases in Blending Phonemes from T1 to T2 for LiPS, $F(2, 51) = 6.42$, $p < .01$; Cohen's $d = 1.00$, but not FFW or Earobics. The repeated measures MANOVA in which we used the language measures resulted in no significant Group by Time effect, indicating that no group was more effective than the others in improving language. The repeated measures MANOVA in which we used the reading measures with gender as a covariate also resulted in no significant Group by Time effect, indicating that none of the groups was more effective than the others in increasing reading-related skills. In our comparison of the three interventions, we found that the significant Group by Time difference for PA was attributable to the LiPS intervention that demonstrated greater effectiveness in teaching blending of phonemes.

Effects of Individual Interventions

To determine if individual interventions produced significant gains from pretest (T1) to posttest (T2), we conducted a series of repeated measures MANOVAs for each of the three intervention groups. In the area of phonemic awareness, we found significant increases for Earobics, $F(1, 15) = 6.06$, $p < .05$, Cohen's $d = 1.80$, and LiPS, $F(1, 17) = 11.83$, $p < .01$, Cohen's $d = 2.43$. Univariate tests indicated that the effect in the Earobics group was attributed to significant increases in phoneme segmentation, $F(1, 15) = 10.32$, $p < .01$; Cohen's $d = 1.66$. For the LiPS group, univariate tests indicated significant increases for Phoneme Blending, $F(1, 17) = 22.851$, $p < .01$, Cohen's $d = 2.32$, and Phoneme Segmentation, $F(1, 17) = 7.59$, $p < .05$, Cohen's $d = 1.33$. In the area of Language, the repeated measures MANOVA revealed no significant increases for any of the three interventions. For Reading, with gender as a covariate, the repeated measures MANOVAs again revealed no significant increases for any of the three interventions. These analyses of individual interventions revealed significant increases within individual intervention groups that were limited to the area of phonemic awareness. The LiPS group increased significantly on Phoneme Blending; the Earobics and LiPS groups increased significantly on Phoneme Segmentation. We found no transfer effect to language or reading-related skills.

Unfortunately, the percentage of students with standard scores less than 90 on the measures used in this study remained high after intervention, indicating that the majority of the students (46.3% to 93.8%) continued to experience serious deficits in the three areas studied. Table 9 lists the percentages of standard scores lower than 90 for each intervention group at T1 and T2. Those figures are in stark contrast to the findings of Torgesen (2001) who moved approximately 50% of his students into the normal range with scores approaching or at 100.

Discussion

In this study, we compared the effectiveness of three interventions (FFW, Earobics, and LiPS) on PA, language skills, and reading-related skills for a group of language-impaired 9-year-old children with reading deficits. Those programs were chosen because of their focus on phonemic awareness, now recognized as a key element in reading acquisition, and because of the claims of drastic improvements in language and reading made by developers of at least two of the programs. This study was designed to address two research questions: For the first question (Does one or more of the three intervention programs result in greater gains than the other programs in phonemic awareness, language, or reading-related skills?) we found a significant effect of group in phonemic awareness only. In that

TABLE 9. Percentage of Children in Each Intervention Group With Standard Scores Below 90

Subtest	FFW		Earobics		LiPS		Total	
	T1	T2	T1	T2	T1	T2	T1	T2
Blending Phonemes	80.0	75.0	62.5	68.8	88.9	72.2	77.8	72.2
Segmenting Phonemes	90.0	80.0	93.8	56.3	83.3	83.3	88.9	74.1
Concepts & Directions	65.0	75.0	75.0	81.3	77.8	88.9	72.2	81.5
Recalling Sentences	60.0	55.0	81.3	56.3	83.3	72.2	74.1	61.1
Listening to Paragraphs	90.0	75.0	81.3	68.8	88.9	72.2	87.0	72.2
Letter–Word Identification	70.0	75.0	87.5	87.5	50.0	61.1	68.5	74.1
Passage Comprehension	60.0	55.0	50.0	62.5	27.8	50.0	46.3	55.6
Word Attack	70.0	85.0	75.0	62.5	77.8	72.2	74.1	74.1
Spelling	60.0	85.0	62.5	87.5	55.6	64.9	59.3	79.2

Note. FFW = Fast ForWord. LiPS = Lindamood Phoneme Sequencing Program. T1 = Time 1. T2 = Time 2.

case, the LiPS intervention did a significantly better job than the other two interventions to improve students' ability to blend phonemes. Intervention groups did not differ substantially in their ability to improve performance on other measures: segmenting phonemes, language subtests, or reading-related subtests. The effect for PA (Cohen's $d = 0.79$) was somewhat smaller than the NRP overall effect size (Cohen's $d = 0.86$) on PA (NICHD, 2000b). However, the effect size of the present study was somewhat larger than the effect size found by the NRP for disabled readers (Cohen's $d = 0.62$); the subset of NRP students most closely resembled the older, disabled readers in our study.

The second question (Did students in individual intervention groups make gains in phonemic awareness, language, or reading-related skills?) focused on whether individual intervention groups made gains in the target areas. Once again, significant gains were limited to the area of PA; the Earobics group improved in segmenting phonemes, and the LiPS group improved in segmenting and blending phonemes. In those cases, the effect size as measured by Cohen's d ranged from 1.33 to 2.32. The high effect sizes of the repeated measures MANOVA may have been similar to higher effect sizes found in some studies lacking a nontreatment control group relative to studies in which a control group was used (Bus & van Ijzendoorn, 1999; NICHD, 2000b). In addition, the high correlation between blending and segmenting phonemes ($r = .428$) also may have contributed to large effect sizes in this study.

We found that both Earobics and LiPS were associated with gains in PA as measured 6 weeks after the summer intervention. The two programs were more effective than the FFW program in improving PA. None of the programs were associated with significant transfer effects to language or reading at the 6-week posttests (T2). In interpreting the results, we discuss student and program characteristics because both have been shown to be associated with various outcomes in other PA intervention studies (Torgesen, 2000; NICHD, 2000b).

Student Characteristics

Regarding student characteristics, all participants in our study were receiving school-based speech-language services at the time of their referral. Our total group mean pretest language standard scores were low, ranging from 63 to 69. Also, all participants were identified with reading deficits, although these were less serious than their language deficits. Although the school staff who referred the students to the program indicated that the students were of average intelligence, no IQ scores were available. The resulting group included the wide range of cognitive and verbal functioning typically found in large school districts within primary-level general education classes. It is possible that the students in this study may represent the 2% to 5% of students considered "treatment resisters" who often remain deficient in reading even after intensive intervention (Lovett, Borden, Lacerenza, Benson, & Brackstone, 1994; Torgesen, 2000). Those students with a mean age of 8 years 10 months ($SD = 4$ months) at enrollment had not mastered basic reading skills during their initial literacy training and, therefore, most closely resembled the NRP's group of disabled readers (as opposed to the at-risk and normally progressing, younger groups). Intervention effects cited in NRP's meta-analysis showed lower effectiveness on almost all variables for disabled readers than for at-risk and normally progressing readers. The NRP effect size for PA outcomes dropped 25 points, from $d = 0.95$ for kindergartners to $d = 0.70$ for older, disabled readers, whereas effect size for reading dropped more than 40 points from $d = 0.86$ for at-risk readers to $d = 0.45$ for older, disabled readers (NICHD, 2000b). A majority of our study participants (52%) qualified for lunch benefits, a marker for low-income households. Children from similar backgrounds have been found to be at somewhat higher risk for reading failure than other children (Hecht, Burgess, Torgesen, Wagner, & Rashotte, 2000; Scarborough, 1998).

Program Characteristics

Program characteristics including content and intensity also have been associated with varying outcomes. This study provided three intensive 1-hr intervention periods each day for 20 days. The two computer-delivered programs were limited to awareness training and contained no direct application to decoding letters, phonemes, or words. LiPS includes reading and spelling of simple words, an element that appears important for remediation of reading deficits (Cunningham, 1990). The encouraging findings of recent prevention (Vellutino et al, 1996; Torgesen, Wagner, & Rashotte, 1997) and remedial studies (Torgesen, 2001) show that intensive, carefully constructed intervention programs can result in significant short- and long-term increases in reading skills for all but a small percentage (2%-5%) of students. In the preventive studies, students in kindergarten and first grade at highest risk for developing reading deficits were studied. For example, one remedial study (Torgesen, 2001) included two 50-min sessions five times a week for 8 to 9 weeks and reported more positive results than did our study for two groups of students: one receiving the ADD program (the precursor to the LiPS program) and one receiving an embedded phonics program. The author attributes the positive results to the intensity and breath of the intervention.

Our study differed from Torgesen's work because students in our study received a longer daily intervention period (180 vs. 100 min) over fewer (4 vs. 8–9) weeks. The extended periods in the Torgesen study (2001) may have allowed those students receiving LiPS to receive more extensive instruction on application to reading—using letters to represent sounds, spelling syllables, and eventually, decoding simple words—than the LiPS group in the present study. Also, students in the Torgesen study received 1:1

intervention, whereas in our study, each interventionist served a group of 4 students. Approximately half of the children in both intervention groups in Torgesen's study attained average-level reading skills; 40% were returned to full-time general education classrooms within 1 year following the intervention (Torgesen, 2001).

A few studies in which broader and/or more intensive interventions were used than in our study also have shown large effects on reading for this population (McGuinness, McGuinness, & McGuinness, 1996; Wise, Ring, & Olson, 1999), which suggests that interventions focused narrowly on phonological awareness with little or no application to decoding are relatively ineffective in remediating reading deficits. Apparently, remedial programs must be of sufficient intensity and include phonological awareness activities, alphabetic recognition, and decoding at the word level to result in significant gains in reading. Although our program provided intensive instruction, it was limited to instruction in phonological awareness with little exposure to decoding and other early reading skills. Although two groups (Earobics and LiPS) showed significant gains in phonemic awareness in our study, we did not find the high rates of successful transfer to reading skills initially promised by publishers of some phonological awareness programs.

Limitations of the Study

The small sample size and lack of verbal IQ scores limit the conclusions that one can draw from this study. Although the number of students in each intervention group (16–20) is higher than in published studies on FFW, it is lower than in studies in which LiPS or its precursor, ADD, was used. The subjects in this study can be characterized as language impaired, although the high variability on pretest language measures and lack of IQ scores resulted in a heterogeneous group regarding language/learning deficits. The intervention period, although intensive (3 hr per day), was relatively short (20 days) and precluded most students from either reaching criteria for games (FFW and Earobics) or fully completing the training program (LiPS). Therefore, it is difficult for one to generalize to studies in which students had completed the interventions as defined by each program. In addition, the lack of follow-up for participants who dispersed to more than 40 schools after the posttest prevented identification of possible long-term effects associated with the interventions studied in this investigation.

Implications for Further Research

Program characteristics (intensity and content) are associated with varying outcomes. Although a child's control of sounds at the phoneme level is highly predictive of decoding and spelling, our study suggests that even in large doses interventions that are focused narrowly on phonemic awareness do not automatically improve reading skills. Further studies are needed that replicate the recent work of Torgesen and colleagues (2001) in which they used interventions that couple intensive phonemic awareness training with other salient activities by applying the alphabetic principle. Such studies will provide a more precise blueprint of the essential content as well as the level of intervention required to result in the ability to manipulate phonemes and successfully decode words. Using a research design similar to the one that we used to test varying intervention packages may result in a clearer understanding of essential program characteristics needed for good outcomes across various groups of students. Such understandings will be useful for designing initial literacy training (particularly for students with language deficits) as well as remedial programs for older students.

Student characteristics also have been shown to affect the development of phonological awareness and reading skills (NICHD, 2000b). Further investigations are needed that compare intensive remedial PA interventions for lower functioning students (IQ less than 85) than those typically included in studies of PA intervention because students with IQs in the lower range receive literacy training and are expected to participate in the general education curriculum. Studies also are needed that identify which areas of language deficits act as barriers to development of phonemic awareness and early reading success. Similarly, older students with language deficits who fail in early literacy attempts need to be studied so that educators can identify which intervention approach is most effective in remediating the reading deficits. Similarly, more intervention studies involving low-income and minority students are needed. Specific factors, including the impact of reduced access to print in low-income communities and the use of African American vernacular English (Hecht et al., 2000; Neuman & Celano, 2001), need further study.

ACKNOWLEDGMENTS

Funding for this research was provided by the U.S. Department of Education, Office of Special Education Programs, Steppingstones Grant H327A990041. We would also like to thank the three intervention supervisors, Margaret Evans-Joyce, Susan Book, and Cheryl Clark, as well as the children, parents, and staff who participated in this project.

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