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The Effects of Fast ForWord Language on the Phonemic Awareness and Reading Skills of School-Age Children With Language Impairments and Poor Reading Skills

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Abstract

Purpose—To examine the efficacy of Fast For-Word Language (FFW-L) and 2 other interventions for improving the phonemic awareness and reading skills of children with specific language impairment with concurrent poor reading skills.

Method—A total of 103 children (age 6;0 to 8;11 [years;months]) with language impairment and poor reading skills participated. The children received either FFW-L computerized intervention, a computer-assisted language intervention (CALI), an individualized language intervention (ILI), or an attention control (AC) computer program.

Results—The children in the FFW-L, CALI, and ILI conditions made significantly greater gains in blending sounds in words compared with the AC group at immediate posttest. Long-term gains 6 months after treatment were not significant but yielded a medium effect size for blending sounds in words. None of the interventions led to significant changes in reading skills.

Conclusion—The improvement in phonemic awareness, but not reading, in the FFW-L, CALI, and ILI interventions limits their use with children who have language impairment and poor reading skills. Similar results across treatment conditions suggest that acoustically modified speech was not a necessary component for improving phonemic awareness.

Keywords

Fast ForWord Language; specific language impairment; phonological awareness; word reading; evidence-based intervention

As children with language impairment enter elementary school, they are at risk for problems in developing reading skills (Bishop & Adams, 1990; Catts, 1993; Catts, Fey, Zhang, &

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Tomblin, 2001; Magnuson & Naucler, 1990; Menyuk et al., 1991; Nathan, Stackhouse, Goulandris, & Snowling, 2004; Snowling, Bishop, & Stothard, 2000; Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998). Only a few intervention studies conducted with children who displayed both reading and concurrent language impairment have shown an improvement in reading skills (Torgesen et al., 2001; Williams, 1980). As such, there is a continued need to evaluate intervention programs that may improve reading for school-age children who display a dual diagnosis of poor reading skills and language impairment.

According to the National Reading Panel (NRP; National Institute of Child Health and Human Development [NICHD], 2000), interventions that target phonemic awareness improve the word reading, pseudoword reading (i.e., nonsense word), and reading comprehension of children with a wide range of abilities. Phonemic awareness is a type of phonological awareness skill. Both are metalinguistic skills that require a child to talk about and maneuver phonological parts of speech (Justice & Schuele, 2004). Phonological awareness encompasses large parts of speech, such as sentences and words, and can be targeted through activities such as rhyming, segmenting multisyllabic words, and segmenting words into sentences. In contrast, phonemic awareness occurs at the level of the phoneme and includes tasks such as identifying, deleting, blending, and segmenting phonemes.

Elementary school–age children are especially important to study because it is during this time period that instruction in reading takes place. Difficulties with phonological awareness and phonemic awareness have been documented to be associated with poor reading skills (Snyder, 1997; Stahl & Murray, 1994; Swank & Catts, 1994). An auditory processing deficit is one explanation for reading difficulties in children with language impairment (Tallal, 1980, 2000; Tallal & Piercy, 1974). Tallal suggests that the underlying cause of language impairment is a deficit in the ability to process brief, rapidly occurring sounds and frequency changes. Processing speech and nonspeech stimuli involves the mechanisms of attention, discrimination, sequencing, and memory. Tallal suggests that poor processing leads to an impaired ability to segment words. As a result, phonological awareness and letter-to-sound correspondence may not develop normally, and reading may be impaired.

Fast ForWord Language (FFW-L)

FFW-L intervention was developed by Tallal and her colleagues on the premise that the processing constraints associated with language impairment could be remediated by improving the attention, sequencing, discrimination, and memory of the auditory signal (Agocs, Burns, DeLey, Miller, & Calhoun, 2006). It is based on an interactive processing model of language development and is designed to improve cognitive and perceptual abilities that are assumed to serve as the foundation for language to develop adequately. The perceptual focus of FFW-L was built on two assumptions. The first is that children with language impairment are impaired in their ability to perceive rapidly successive information from a speech signal and to store speech sounds. The second is that intensive training can improve children’s attention, discrimination, sequencing, and memory, which in turn will improve processing skills (Agocs et al., 2006).

FFW-L was designed to decrease perceptual constraints in children with language impairment by using an acoustically modified speech signal during its computer exercises. The acoustically modified speech makes rapid consonant transitions longer and increases the amplitude of some transitions (Nagarajan et al., 1998). As the child progresses in the computerized exercises, the speech presented as input to the child becomes less acoustically modified until it eventually becomes the same processing rate and loudness as typical speech. The computerized program adapts the level of difficulty of the exercises as well as the level of acoustically modified speech according to the success of the child on multiple trials. The adaptive learning provided by FFW-L helps the child to be successful at one level and then automatically adjusts the level to be more challenging once the child is successful. Another key element of FFW-L is the assumption that multiple trials change the brain's neuroplasticity and as a result improve the learning and retention of language skills (Merzenich, Tallal, Person, Miller, & Jenkins, 1999).

Initial piloting of a prototype of FFW-L was conducted with 11 children with language-learning disorders (Merzenich et al., 1996; Tallal et al., 1996). The children in the pilot study made 1–2-year gains in their language comprehension and speech discrimination skills after completing 3 hr of daily intervention over 4 weeks. Notably, this pilot study did not measure gains in phonemic awareness or reading, although the authors suggested that improvement in language skills targeted in the FFW-L prototype would lead to gains in reading.

The current FFW-L program is different from the prototype, although it still targets the language skills that are hypothesized to improve reading skills. It is a computerized language intervention for children from 4 years of age to adulthood. It was not until 2001, in a special forum in the *American Journal of Speech-Language Pathology* (*AJSLP*), that several case and single-subject design studies evaluated FFW-L (Friel-Patti, DesBarres, & Thibodeau, 2001; Gillam, Crofford, Gale, & Hoffman, 2001; Loeb, Stokes, & Fey, 2001). The studies in the *AJSLP* special forum brought to light the need for further study of FFW-L. Since that time, FFW-L was evaluated in a national field trial conducted by the Scientific Learning Corporation (1998), the company that publishes FFW-L. The trial included 35 sites with 409 children who had language impairment with a variety of etiologies. They found significant improvements on expressive and receptive language measures; however, the lack of a control group, randomization, and blinding limits claims of efficacy (Agocs et al., 2006). Recently, three randomized controlled trials (RCTs) from independent laboratories have evaluated the efficacy of FFW-L (W. Cohen et al., 2005; Gillam et al., 2008; Pokorni, Worthington, & Jamison, 2004). The next section describes the results of these RCTs. Together, the studies indicate the need for further study of FFW-L and its impact on phonemic awareness and reading.

Changes in Phonological Awareness and Reading Skills Following FFW-L With Children With Language Impairment

Pokorni et al. (2004) studied 60 children with severe mixed (expressive and receptive) language impairments and reading difficulties. They randomly assigned children to an FFW-L condition, an Earobics condition, or a Lindamood Phoneme Sequencing Program (LiPS) condition. Following intervention, they found significant improvement in blending and segmenting in the Earobics and the LiPS groups, but not in the FFW-L group. No gains were present for any group in regard to word reading skills. These results called into question the efficacy of FFW-L with children who displayed both language impairment and reading disorders.

In another RCT of FFW-L, W. Cohen et al. (2005) studied 77 children with severe mixed (receptive and expressive) language impairments. The children were not required to be impaired in phonological awareness or reading to participate. They randomly assigned children to three conditions: FFW-L, a computer intervention without modified speech, and a control condition. The computer intervention study without modified speech consisted of games that focused on rhyming, phonics, spelling, reading, vocabulary, syntax, and morphology. During the study, all of the children continued to receive therapy services in their schools. Cohen et al. evaluated changes in language, phonological awareness, and reading immediately after the interventions and again 6 months later. They found gains in language for all of the groups, including the control group, suggesting that the additional computer therapies did not benefit the children. Cohen et al. also evaluated phonological awareness skills—including rhyming, alliteration, and spoonerisms (i.e., switching of words or sounds, such as in “wave the sails” for “save the whales”)—and reading skills. They found no significant improvement in either phonological awareness or reading skills immediately after FFW-L intervention. However, children in the FFW-L group demonstrated significantly greater improvement in rhyming than children in the school-treatment control group 6 months after the intervention. These results suggested that FFW-L was not any more beneficial than the children’s current school services for language gains. Similar to Pokorni et al.’s (2004) results, they did not support the use of FFW-L for improving phonological awareness and reading skills.

In contrast to Pokorni et al. (2004) and W. Cohen et al. (2005), Gillam et al. (2008) found significant improvement in blending skills for children who participated in FFW-L intervention compared with an attention control (AC) computer program group immediately after intervention and 6 months later. Significant gains also were evident for two other treatment groups, a computerized program that did not use acoustically modified speech, and a language and literacy program administered by a speech-language pathologist (SLP). Gillam et al. studied 216 children who displayed diagnoses of language impairment and were not required to have impairments in reading or phonological awareness. The larger number of children in the Gillam et al. study compared to the smaller number of participants in Pokorni et al. and Cohen et al. may have been the reason for the significant results in phonemic awareness. However, improvement in reading skills was not reported in Gillam et al.; thus, we do not have a full picture of the possible contribution of FFW-L to the phonemic awareness and reading skills of the children in their study.

Together, the three latter RCT studies leave an unclear picture of the effects of FFW-L on the phonemic awareness and reading skills for children with dual diagnosis of language impairment and poor reading skills. Because a large percentage of preschool children with language impairment continue on to be elementary children with language impairments who are at risk for reading disorders, it is imperative that we evaluate interventions that may facilitate phonemic awareness and reading skills.

In this study, we aim to extend our understanding of the efficacy of FFW-L for improving phonemic awareness and reading in children with both language impairments and poor word reading skills using a subsample of the children in the Gillam et al. (2008) study. We compare the reading and phonemic awareness skills of children who participated in one of the four conditions: FFW-L, a computer condition without modified speech, an SLP-administered literacy and language program, and an AC group that provided academic instruction via computer games.

Our research question was as follows: To what extent does FFW-L improve the short- and long-term phonemic awareness and reading skills of children with language impairment and poor word reading skills as compared to alternative approaches to language intervention and an AC condition? We hypothesized that if acoustically modified speech improves the phonological awareness and reading skills of children with language impairment and poor reading skills, then the children in the FFW-L condition would show improvements greater than the AC and the other interventions that did not have acoustically modified speech.

Method

Participants

For the current study, we selected a subgroup of 103 children who displayed language impairment and poor reading skills from a larger sample of 216 children with language impairments who participated in an RCT (see Gillam et al., 2008). Because this study involved subgroups from the original RCT, the present study does not have a randomized component, and as such presents a quasi-experimental design. Not all of the children in the Gillam et al. study displayed both poor reading and impaired language skills. By selecting a subgroup from Gillam et al., we could evaluate the efficacy of FFW-L and two other interventions with children who may be at risk for later reading disorders.

Participant Eligibility—To be included in the study, the children were required to meet specific inclusionary and exclusionary criteria. The participants had to have a standard score between 75 and 125 (±1.66 *SD*s) on the Matrices subtest of the Kaufman Brief Intelligence Test (K–BIT; Kaufman & Kaufman, 1990). The Matrices subtest measures nonverbal intelligence. Our cutoff score for the nonverbal intelligence on the K–BIT was more than 1 *SD*, and thus we included some children who were in the mild mental retardation range. Our rationale for extending the nonverbal intelligence limits was based on reports that children with cognitive skills in the range we selected were as successful in language therapy as those who were within the normal range (Cole, Coggins, & Vanderstoep, 1999; Fey, Long, & Cleave, 1994). The children also had to have a standard score at or below 81 on two or more quotients from the Test of Language Development—Primary, Third Edition (TOLD–P:3; Newcomer & Hammill, 1997). The criterion for language scores is based on the epiSLI model (Tomblin et al., 1997), which is currently the best validated criterion for determining language impairment in school-age children. Finally, the children in this study also had to display poor reading skills. We defined poor reading skills as being at or below the 25th percentile on any of the three subtests (Word Attack, Word Identification, and Passage Comprehension) from the Woodcock Reading Mastery Tests—Revised (WRMT–R; Woodcock, 1987; for cutoff rationale, see Fletcher et al., 1994; Stanovich & Siegel, 1994).

Exclusionary criteria required that none of the children displayed hearing loss, emotional/ social impairment, or gross neurological impairments. The children's primary language had to be English. We also excluded children who had participated in a total of 8 or more hours of language intervention or classroom activities using FFW-L, computer-assisted language intervention (CALI) software, or Lindamood-Bell auditory discrimination training. Our rationale for excluding children who had received the latter approaches was that previous experience with these interventions could have led to potential confounds in the present study. Finally, parents were asked not to enroll their child in any other language intervention during the treatment phase of the current study.

Participant Characteristics—The 103 children who participated consisted of 66 boys and 37 girls. They ranged in age from 6;0 to 8;11 (years; months), with a mean age of 7;5 (*SD* = 10 months). A majority of the children were White (48%, 49/103), and the second largest racial/ethnic group was African American (30%, 31/103). Hispanic Americans represented 15% of the sample (15/103). The Other category consisted of Asian Americans, Native Americans, and biracial children, and composed 7% of the sample (8/103). Parent education level was determined based on parent report. There were three possible categories: (a) no parent had attended college (low parental education), (b) at least one parent had attended college (middle parental education), and (c) one or both parents had earned a college degree (high parental education). The children were largely from homes of middle parental education level (44%, 45/103). Thirty-one percent of the children were from homes with a high parental education level (32/103). Twenty-six of the children (25%) were from homes with a low parental education level.

With respect to nonverbal intelligence scores, the children displayed a mean standard score of 95.20 on the Matrices subtest of the K–BIT, which was within normal limits. The TOLD–P:3 (Newcomer & Hammill, 1997) was used to evaluate language skills before the intervention was initiated. The TOLD–P:3 evaluates expressive and receptive language. The Listening Quotient is computed by summing the receptive subtests on the TOLD–P:3 in the areas of vocabulary and understanding sentences. The Semantic Quotient combines expressive and receptive vocabulary measures. The Syntax Quotient combines receptive and expressive morphology and syntax measures. In general, the TOLD–P:3 standard scores indicated that the children, as a group, displayed receptive language skills that were within normal limits (the Listening Quotient mean standard score was 85.05), but had impaired expressive language skills in the areas of syntax and semantics (a Syntax Quotient mean standard score of 71.26 and a Semantic Quotient mean standard score of 75.27).

The children were assigned to one of the following conditions: FFW-L, CALI, individualized language intervention (ILI), or AC. These four conditions are described in the *Treatment Procedures* subsection below. Table 1 displays the children's characteristics with respect to the four conditions. In each of the conditions, males outnumbered the females. There were no significant differences between conditions with respect to age, $F(3, 102) = 0.83$, $p = .48$. In regard to race/ ethnicity, the four treatment groups each had similar distributions, with the majority of children being White (47.5%). The next largest group represented was African American (30%) and then Hispanic/Latino (14.5%). The Other category (8%) was the smallest.

In each condition, the majority of the children were from the middle parental education group (44%). High parental education was the next most frequent category (31%), and homes with a low parental education made up 25% of the sample. There was no significant difference between the number of children in the three parental groups across the four conditions, $\chi^2(6, N = 103) = 3.60$, $p = .73$.

Mean nonverbal intelligence scores were within normal limits and did not differ across conditions, $F(3, 102) = 1.09$, $p = .36$. With respect to language scores, group means were at least 1.5 *SD*s below the mean on their Spoken Language Composite on the TOLD–P:3 and did not differ across the four conditions, $F(3, 102) = 0.76$, $p = .52$. The Spoken Language Composite on the TOLD–P:3 consists of six subtests that measure both receptive and expressive semantics and syntax. The Listening Composite Quotient did not differ across conditions, $F(3, 102) = 0.30$, $p = .83$, and in general yielded mean performances that were within or close to within normal limits. The Speaking, Semantic, and Syntax Composite Quotient group means were all 1.5 *SD*s or more below the mean. None of the TOLD–P:3 quotients significantly differed between conditions, $F(3, 102) = 1.15$, $p = .33$; $F(3, 102) = 1.95$, $p = .13$; $F(3, 102) = 0.50$, $p = .68$, respectively.

In addition, the four groups did not differ on their phonemic awareness pretest mean standard scores as measured by the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999) for Elision, $F(3, 99) = 0.11$, $p = .95$, or Blending Sounds in Words, $F(3, 99) = 1.50$, $p = .21$. They also did not differ statistically on their single word and nonword reading as measured by the WRMT–R (Woodcock, 1987) pretest mean standard scores on Word Identification, $F(3, 99) = 2.01$, $p = .12$, or Word Attack, $F(3, 99) = 1.00$, $p = .40$. However, the groups differed significantly on the Passage Comprehension subtest, $F(3, 99) = 4.51$, $p = .005$. Post hoc Dunnett's *t* tests indicated that the CALI and the ILI groups had higher scores than the AC group at pretest (p = .032 and .017, respectively). The FFW-L group did not differ from any of the other groups.

Treatment Procedures

The treatment took place over the course of three summers with three different cohorts of children. Each child was assigned to only one intervention condition. Each intervention was 6 weeks in duration, for a total of 30 sessions. During the 6-week period, each child attended a morning program 5 days a week, for 3½ hr. Of this time, 1 hr 40 min per day were devoted to the treatment. For the remainder of the time, the children participated in a classroom setting. Crafts, games (such as Lego blocks), recess, and snacks were provided when the children were in the classroom. Table 2 describes the intervention conditions.

For the computer conditions (i.e., FFW-L, CALI, and AC), the children were seen for intervention in a small group setting. Four to 5 children were seen in one room, with each having his or her own computer area. The children played the games while wearing headphones in a quiet environment. One SLP and two monitors were available to the children in the FFW-L and CALI computer conditions. The SLPs were trained in how to administer the FFW-L and CALI conditions. In addition, SLPs who participated in the FFW-L condition received CrossTrain, a program available from the Scientific Learning Corporation (2001) that teaches how to implement FFW-L. The monitors were graduate students. One monitor was present for the AC condition. The monitors and SLPs made sure that the children played the correct games for the specified period of time. Both the monitors and the SLP provided encouragement to the children through verbal and nonverbal praise as they played the computer games. However, they did not provide the correct answer.

The ILI condition was delivered by an SLP who worked individually with each child in a quiet room. The SLPs received training in how to provide the intervention.

Treatment Schedules and Reinforcement

Children could choose the order of the computer games for a given day for treatments that involved computer games; however, they had to play specific games on specific days. In particular, the FFW-L program has specific days that specific computer games must be played. We developed a similar schedule for the CALI and the AC games. In the ILI condition, the SLP could modify activities and their order to maintain the child's interest.

Children in all conditions received intermittent rewards such as verbal praise, a sticker, or a Pokemon card for good behavior. At the end of every day, children received a sticker if they were compliant (i.e., completed their schedule of games/activities). At the end of the week, the children who had five stickers could select a toy from a prize board.

FFW-L Intervention

In its current form, FFW-L consists of seven computer games that have acoustically modified speech (see Veale, 1999, for a thorough description). Children assigned to the FFW-L condition played the seven different computer games. There were four computer games that specifically targeted discrimination of sounds at the phoneme, syllable, or word level (Old MacDonald's Flying Farm, Phoneme Identification, Phonic Match, and Phonic Words). Not every computer game was played each day. Instead, the schedule of daily games was designated by the Scientific Learning Corporation. The computer games that focused specifically on sound awareness and discrimination were played for a total of 33 hr (see Table 2).

The speech and nonspeech stimuli in all the FFW-L computer games were modified by an algorithm that prolonged segments and differentially amplified particular frequencies. The acoustic modifications were gradually decreased as children improved on each game. Children received trial-by-trial feedback for correct and incorrect responses via the computer. Correct responses were rewarded by points, jingles, and extra animations.

CALI

CALI consisted of seven computerized instructional modules, five selected from the Earobics Step 1 and Step 2 software (Cognitive Concepts, 2000a, 2000b) and two from the Laureate Learning software (Following Directions: Semel, 2000; Micro-LADS: Wilson & Fox, 1997). The games targeted similar language, nonspeech, and speech discrimination skills as the seven FFW-L computer games. However, none of the speech stimuli in any of the CALI modules were modified acoustically (see Table 1). Each module in the CALI treatment was presented for 20-min periods (a total of 1 hr 40 min per day), 5 days per week for 6 weeks. The children started at the beginning of the CALI programs. When a child attained 80% correct at a particular level for 2 days in a row, the level of the exercise was considered to be mastered, and the next level was presented. The mastery criterion for the CALI computer games was 90% completion of all possible levels of the exercises.

Similar to FFW-L, four Earobics computer games targeted phoneme awareness (Earobics Step 1 C.C. Coal Car, Earobics Step 2 Paint by Penguins, Earobics Step 2 Hippo Hoops, and Earobics Step 2 Duck Luck). The C.C. Coal Car and the Duck Luck game also had letters that corresponded to the words displayed during the games. We designed the schedule of which games in the CALI condition were to be played each day to be similar to the FFW-L schedule. The computer games that focused specifically on sound awareness and discrimination were played for 32 hr (see Table 2).

ILI

ILI was based on tenets from the social interactionist theory. Various language facilitation techniques consistent with the social interactionist perspective, such as scaffolding, focused stimulation, recasting, and expansions, were provided by the SLP during intervention. The ILI targeted goals in the areas of semantics, syntax (morphosyntax and clause structure), narration, and phonological awareness. The ILI units were developed around picture books that had topics and illustrations that were interesting to school-age children, that could be read in a 10-min period, and that contained a variety of vocabulary words that ranged in difficulty level for children 6 to 9 years old. A minimum of 6 book units, usually one per week, were used with each child over the 6-week course of intervention.

The amount of time dedicated to phonological and phonemic awareness in the ILI condition was an average of 16 min per day (8 hr total; see Table 2). Activities to improve phonological and phonemic awareness were available at three levels of difficulty. The activities included rhyming and sound matching at Level 1, initial/final sound identification and blending/segmenting words at Level 2, and blending/ segmenting nonwords and making words at Level 3. We began at Level 1 for all children. The mastery criterion for moving to a higher level of difficulty was determined by the amount of effort from the SLP and the amount of responsiveness from the child (Miller, Gillam, & Peña, 2001). Each day, the SLP noted teaching effort on a scale of high, moderate, and low, and also noted student responsiveness on a scale of high, moderate, and low. The targeted area was considered mastered once it was judged low effort/high responsiveness for 2 consecutive days.

AC

The activities in the AC condition were not designed to improve specific phonological or phonemic awareness or reading skills. The intensity of the AC condition was consistent with the other treatment conditions (i.e., 1 hr 40 min per day, 5 days a week for 6 weeks). The major difference for the children in the AC group was that the computer games focused on mathematics, social studies, and science. The games were not void of vocabulary, direction following, and visual or verbal input; however, they did not target specific areas in a systematic manner. The computer games were: The Magic School Bus Discovers Flight (Scholastic, 2001a), The Magic School Bus: Whales and Dolphins (Scholastic, 2001b), Coin Critters (Nordic Software, 1999), Zurk's Rain-forest Lab (Soleil Software, 1998), My Amazing World Explorer (Dorling Kindersley, 1999), Dinosaur Adventure 3D (Knowledge Adventure, 1999), and selected games from Arthur's 1st Grade (TLC Educational Properties, 1999a) and Arthur's 2nd Grade (TLC Educational Properties, 1999b). No mastery criteria were set for the AC computer games.

Treatment Fidelity

During the summer program, each site coordinator, who was a licensed SLP, randomly videotaped one intervention session every day for each of the treatment conditions. Each week, one videotape for each treatment condition was randomly selected at each site, and those four tapes were sent to another site for review. The videotapes were reviewed for specific criteria, and the results of the review were faxed to the corresponding intervention site before the next treatment session. The person reviewing the videotapes was either a graduate student in speech-language pathology or the site coordinator. The fidelity criteria were: the number of minutes per computer game or ILI target, use of positive reinforcement, the presence of a quiet and nondistracting environment, using facilitative talk (in the ILI intervention), wearing of headphones (for the computer conditions), and not providing answers to the children. The review was sent to the site immediately, and any suggestions resulting from the fidelity review were discussed with the staff and implemented at the intervention site.

Measurement of Phonemic Awareness and Reading Skills

We collected phonemic awareness and reading outcome measures from three different points of testing: before treatment, immediately after treatment (i.e., 6 weeks after pre-testing), and 6 months after treatment.

Phonemic Awareness Measures—Raw scores from two subtests from the CTOPP—Elision and Blending Sounds in Words—were selected because of their strong psychometric properties. These subtests provide information concerning a child's phonemic awareness skills. The Elision subtest is a phoneme deletion task that requires the child to repeat a word and then say the same word without one of its sounds. For example, one of the earlier items has the child say the word "tan" and then say the word without the "t" sound. The Blending Sounds in Words subtest requires the child to listen to phonemes with a pause in between them and to figure out what word was produced. For example, the examiner would say, "What word do these sounds make: /b/ /o/ /t/?"

Reading Measures—Raw scores from three subtests from the WRMT–R were used for outcome measures: Word Identification, Word Attack, and Passage Comprehension. These subtests were chosen because they evaluate critical areas that influence reading—phonics (Word Attack), word knowledge (Word Identification), and word identification in sentences (Passage Comprehension)—and because of their strong psychometric properties. These tests were selected because they measure beginning reading skills in children within the age range of our study. The Word Attack subtest evaluates the ability to decode nonsense words, and the Word Identification sub-test evaluates the student's sight-word vocabulary. The Passage Comprehension subtest evaluates the ability to provide words missing from text using a cloze procedure and has been found to be highly correlated with decoding in first and second grades (Frances, Fletcher, Catts, & Tomblin, 2005).

There was no particular order for test administration. Once administered, the outcome measures were rescored and checked for adding accuracy by three independent scorers. All examiners and scorers were blind to the children's treatment assignments.

Results

We used a generalized linear model (GLM) repeated measures analysis to evaluate the changes in phonemic awareness and reading across treatment conditions over time. Using the GLM repeated measures analysis, a significant Group × Time interaction would indicate that the treatment conditions differed. Statistical data and post hoc tests were conducted for those effects that reached a .05 significance level. However, we reported effect sizes (*d*; J. Cohen, 1988) in the instances where medium effect sizes were present but statistical significance was not achieved. The effect sizes were reported because with more participants, the significance level may have been obtained.

A total of 103 children participated in the pretest to immediate posttest assessment. Six of the 103 children did not participate in the 6-month follow-up testing, resulting in 97 children for the follow-up analyses. The assignment of the 6 children who did not continue in the study at 6 months had the following distribution: FFW-L = 1, CALI = 2, ILI =1, and AC = 2.

Phonemic Awareness Measures

Change from pretest to immediate posttest—Raw scores from the Blending Sounds in Words and Elision subtests from the CTOPP were the dependent variables for the phonemic awareness analysis (see Table 3). A significant Group × Time interaction was present only for the Blending Sounds in Words subtest, $F(3, 99) = 4.17$, $p = .008$. The effect size was a *d* value of .71, which is moderate. A post hoc Dunnett's *t* test indicated that the three intervention groups differed significantly from the AC condition: FFW-L versus AC, $p = .01$, $d = .61$; CALI versus AC, $p = .02$, $d = .55$; and ILI versus AC, $p = .01$, $d = .58$. All of these effect sizes are moderate. The children scored higher on the Blending Sounds in Words subtest compared with the AC group. Post hoc tests comparing the three intervention groups to each other yielded no statistically significant differences.

Change from posttest to 6-month follow-up—Table 4 displays the raw scores from immediate posttest to 6-month posttest. The change among the three groups from the AC group on the Blending Sounds in Words subtest from post-test to 6-months posttest was not significant, $F(3, 93) = 2.56$, $p = .06$; however, the effect size was medium ($d = .50$).

Reading Measures

Change from pretest to immediate posttest—Raw scores from the Word Identification, Word Attack, and Passage Comprehension subtests from the WRMT–R were the dependent variables for the reading analysis (see Table 3). There were no significant Group × Time interactions for any measure at the immediate posttest period.

Change from posttest to 6-month follow-up—A comparison of posttest and 6-month follow-up raw scores indicated no significant Group × Time interaction. Although the

Passage Comprehension subtest was not significant, $F(3, 93) = 2.30$, $p = .08$, there was a medium effect size ($d = .58$). Table 4 shows the means and standard deviations for each condition.

Discussion

Our research question was to evaluate the extent that FFW-L intervention affected the short- and long-term phonemic awareness and reading skills of children with language impairment and poor word reading skills as compared to alternative approaches to language intervention and an AC condition. We found that one phonemic awareness skill, blending sounds in words, but not reading skills, improved for the children in the FFW-L condition in the short-term. The improvement in blending validates and extends the previous finding in Gillam et al. (2008). Long-term improvement was not statistically significant for any outcome measure. However, moderate effect sizes were present for blending and passage comprehension at 6-month testing. Unfortunately, the lack of statistical significance does not allow us to compare interventions; thus, we are limited in our interpretation of the long-term outcomes.

This study contributes to our knowledge of outcomes in phonemic awareness and reading skills in children with language impairment and poor reading abilities. In addition, it provides insight to our clinical practice. FFW-L intervention was designed to improve a processing deficit presumed to be present in children with language impairment. The acoustically modified speech in FFW-L is hypothesized to be an important element for improving sound perception. However, Tallal (2000) stated that it is not clear which of the intervention elements in FFW-L (i.e., acoustically modified speech, intensive training, attention, or motivation) were responsible for gains in its initial studies. Our study provides insight on two aspects of FFW-L: the utility of acoustically modified speech and the intensity of training. The similar findings for FFW-L and CALI lead to the conclusion that acoustically modified speech is not a necessary component to improve phonemic awareness skills. This conclusion converges with evidence from other studies with different methodologies and children who have a variety of characteristics (Agnew, Dorn, & Eden, 2003; W. Cohen et al., 2005; Gillam et al., 2001, 2008; Hook, Macaruso, & Jones, 2001; Pokorni et al., 2004; Rouse & Krueger, 2004; Segers & Verhoeven, 2004; Troia & Whitney, 2003).

With respect to intensity, it also does not appear that the length of the phonemic awareness training affected outcome. According to the NRP report (NICHD, 2000), programs that consist of 5 to 18 hr of phonemic awareness training had the greatest effect sizes compared to programs that had fewer or more hours. The NRP also reported that transfer to reading occurred most often in those programs that were shorter than 20 hr. The length of a single session is also a consideration. Most of the studies analyzed by the NRP had treatment sessions that were 25 min. The NRP cautions about using these time values as guidelines because a number of possible factors could have influenced the study outcomes in addition to time of therapy. With this caution in mind, all of the interventions in our study that showed significant results for blending had different durations. ILI had the shortest, a total of 8 hr of training. In contrast, CALI and FFW-L had 32 and 33 hr of training, respectively. In our study, the length of time daily varied from 16 min for ILI to 80 min for FFW-L and CALI. Despite these differences in daily session times and overall amount of treatment times, similar effects were present. Thus, it did not appear that session or program intensity affected short-term therapy outcomes for phonemic awareness.

At first glance, it appears that our data call into question Tallal's hypothesis of an underlying processing deficit for children with language impairment. However, our study was not

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designed to evaluate the auditory processing deficit hypothesis, and we can report only on the effectiveness of the interventions that we studied. Based on our data, we can state that FFW-L, an intervention that was developed to improve auditory perception processing, was not any more effective than programs that were not designed with this assumption.

Different Effects for the Phonemic Awareness Measures

Clinicians working with children in the area of phonemic awareness often have to choose which phonemic awareness tasks they will teach. There is little evidence in the literature which indicates that phonemic awareness improvement will generalize from one type of task to another. In our study, we did not find generalization from one phonemic awareness skill to another. Recall that we found significant improvement only in blending and not for phoneme deletion. There is some evidence from the literature that working on one area of phonemic awareness does not transfer to other areas of phonemic awareness (Davidson & Jenkins, 1994). For example, children with and without language impairment who received training to improve blending skills have been found to increase blending, but this improvement has not been found to generalize to other phonemic awareness skills such as segmenting (O’Connor, Jenkins, Leicester, & Slocum,1993; Torgesen, Morgan, & Davis, 1992). However, O’Connor et al. (1993) found that children with severe language delays who were trained in segmenting improved in both segmenting and blending. Both CALI and ILI contained blending and segmenting activities. In addition, CALI contained practice with phoneme deletion. Given that there are no studies that support the idea that training blending and segmenting should lead to improvement in phoneme deletion, the lack of practice with phoneme deletion tasks may have led to the nonsignificant finding for this area. Clinicians who teach blending to children need to be aware that working on this one area of phonemic awareness may not transfer to other areas of phonemic awareness.

A different explanation is warranted for the FFW-L intervention, because it does not directly train blending, segmenting, or phoneme deletion. Instead, it targets the child’s ability to detect differences between sounds with the aim of improving the child’s perception. If changes underlying perception occur, then we would expect improvement in both areas of phonemic awareness that we tested. This was not the case. We found significant effects for blending, but not phoneme deletion following FFW-L. Our finding is similar to that of Troia and Whitney (2003), who found that children with weak academic performance, some who had language impairment, made gains in blending but not phoneme deletion after receiving FFW-L. They suggested that the differential results for blending and phoneme deletion were due to the difficulty of the phonemic task. Specifically, based on the work of Yopp (1988), they suggested that blending is an easier task, whereas phoneme deletion is a more difficult task. Yopp (1988) reported that phoneme blending was one of the easiest phonemic awareness tasks for typically developing kindergartners and phoneme deletion was the most difficult. Future studies that evaluate training and generalization of phonemic awareness in children with dual diagnoses of language impairment and reading disorders are needed to more fully understand how phonological representations can be improved in these children.

Lack of Gains in Reading Outcomes

According to the NRP report (NICHD, 2000), phonemic awareness training leads to improved reading skills in children. This is in contrast to the children in our study who made gains in phonemic awareness but not in reading. This finding was also present for Pokorni et al. (2004). The NRP report states that studies of phonemic awareness that yielded large effect sizes were more likely to result in improvements in reading. In our study, we found medium but not large effect sizes for blending skills. The lack of large effect sizes for phonemic awareness and the lack of widespread, statistically significant gains for reading in our study suggest that our interventions may not have been robust enough to lead to changes in the children's reading. However, Pokorni et al. found large effect sizes for phonemic awareness change in the LiPS program and yet no gains in reading. On closer examination of the 96 studies in the meta-analysis for the NRP report, only 15 evaluated both phonemic awareness and reading outcomes in children with reading disorders. It is not clear how many of these children also had language impairments. Of those 15 studies that evaluated children with reading disorders, 7 showed significant gains in phonemic awareness with an effect size of .3 or above. Of those 7 studies, only 3 also showed gains for reading. Viewed in light of the NRP report and based on our results, we hypothesize that children with language impairment and poor reading skills need a more comprehensive approach to improve their reading skills that extends beyond an emphasis on phonemic awareness. Two previous studies published after the NRP report support this hypothesis (Hook et al., 2001; Torgesen et al., 2001).

Hook et al. (2001) found effects for phonemic awareness following FFW-L intervention, but not in the area of reading, with a group of children with reading disorders only. In contrast, the children assigned to the Orton Gillingham treatment (Gillingham & Stillman, 1997) in their study made gains in both phonemic awareness and reading (i.e., word attack subtest). Hook et al. suggested that children with reading disorders require phonemic awareness training in addition to practice with the alphabetic principle. The results of Torgesen et al. (2001) lead to a similar conclusion. They evaluated the efficacy of two interventions, Auditory Discrimination in Depth (ADD; Lindamood & Lindamood, 1984) and Embedded Phonics (EP; Torgesen et al., 2001), with children who had a dual diagnosis of language and reading impairment. The ADD and EP programs had three common elements. They each had explicit instruction in phonemic awareness, sight word recognition, and phonemic decoding abilities. Both interventions resulted in significant short-term and long-term effects in the areas of phonemic awareness, language skills, and reading abilities. Retesting at 1 year and 2 years after intervention showed maintenance of all improved skills.

None of the interventions in our study contained the three elements that ADD and EB contained. The computer interventions in our study (i.e., FFW-L and CALI) did not provide explicit training in sight word recognition or phonemic decoding. The ILI intervention included phonemic awareness training and phonemic decoding abilities. However, the way that the ILI intervention was structured, a child may have only focused on phonemic awareness and not advanced to decoding activities if he or she were still struggling with phonemic awareness. Clinicians who plan to use FFW-L, CALI, or ILI should consider supplementing these interventions with training in sight word recognition and phonemic decoding.

Limitations of the Study and Future Directions

There were limitations to the present study that warrant a cautious interpretation of the results. The lack of participant randomization reduces the study's internal validity. The internal validity of an intervention study is critical to make a conclusion about the causal relationship between the intervention and student progress. However, internal validity can be improved if the groups that receive the interventions are equivalent prior to receiving the intervention. Recall that in this study, the groups did not differ with respect to gender, race/ethnicity, or parental education. Nor did they differ significantly on pretest scores in the areas of language, phonemic awareness, or reading. One exception was the Passage Comprehension subtest. Prior to intervention, we found that the children in the AC group had lower Passage Comprehension scores compared to the children in the CALI and ILI intervention groups. Despite this, no significant differences were observed for the Passage Comprehension subtest immediately after intervention. The higher scores of the CALI and ILI groups did not lead to a significant finding due to inequality at pretest.

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Another limitation of the study was the small number of children in each condition. The small number of participants may have led to the lack of significant results. In particular, this may have been the case for the long-term effects for blending, which yielded a medium effect size, but not statistically significant results. Future studies should target a larger number of children with both language impairments and poor reading skills who are randomized to conditions.

We would be remiss not to note that since we began our study, the Scientific Learning Corporation has published additional software to be used after FFW-L to assist with reading development. Future RCTs that include the family of FFW-L programs as well as studies that incorporate training in phonemic awareness, sight word reading, and decoding skills in a comprehensive program are needed to determine their efficacy with children displaying language impairment and poor reading skills.

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TABLE 1

Pretest characteristics of the children with poor reading skills (*N* = 103) in each of the treatment conditions.

Characteristic	FFW-L (*n* = 24)	CALI (*n* = 29)	ILI (*n* = 25)	AC (*n* = 25)
Age (years;months)	7;5 (9.97)	7;4 (11.35)	7;7 (8.72)	7;4 (10.48)
Nonverbal IQ	94.17 (9.63)	94.93 (9.76)	93.80 (8.0)	97.88 (7.74)
TOLD–P:3 Spoken Language Quotient	70.04 (8.63)	73.69 (9.48)	71.52 (7.46)	71.28 (10.21)
TOLD–P:3 Listening Quotient	83.50 (9.57)	84.79 (12.18)	86.08 (9.20)	85.84 (11.07)
TOLD–P:3 Speaking Quotient	71.87 (10.35)	76.00 (10.76)	71.08 (10.95)	73.60 (10.17)
TOLD–P:3 Semantic Quotient	75.29 (7.79)	79.76 (10.52)	74.68 (9.51)	74.16 (10.38)
TOLD–P:3 Syntax Quotient	69.04 (11.74)	71.24 (12.22)	72.28 (9.05)	72.48 (10.40)
CTOPP Elision	6.12 (2.17)	6.21 (1.90)	6.44 (1.73)	6.20 (2.24)
CTOPP Blending Sounds in Words	7.04 (1.73)	7.17 (2.36)	7.48 (2.04)	8.24 (2.40)
WRMT–R Word ID	82.75 (7.89)	86.79 (7.02)	88.04 (7.03)	86.16 (9.53)
WRMT–R Word Attack	85.75 (7.67)	89.31 (9.07)	87.80 (7.35)	89.40 (9.74)
WRMT–R Passage Comprehension	81.83 (6.25)	85.03 (7.13)	85.64 (6.94)	79.04 (8.63)
Gender				
Male	14	17	17	18
Female	10	12	8	7
Race/ethnicity				
White	15	13	10	11
African American	5	9	9	8
Hispanic American	1	5	5	4
Other	3	2	1	2
Parental education				
High	5	11	7	9
Middle	12	11	10	12
Low	7	7	8	4

Note. FFW-L = Fast ForWord Language (Scientific Learning Corporation, 1998); CALI = computer-assisted language intervention; ILI = individualized language intervention; AC = attention control; TOLD–P:3 = Test of Language Development—Primary, Third Edition (Newcomer & Hammill, 1997); CTOPP = Comprehensive Test of Phonological Processing (Wagner, Torgesen, & Rashotte, 1999); WRMT–R = Woodcock Reading Mastery Tests—Revised (Woodcock, 1987). The nonverbal intelligence, TOLD–P:3, language quotients, and WRMT–R are reported as mean standard scores (with *M* = 100 and *SD* = 15). For the CTOPP subtests, *M* = 10 and *SD* = 3. Standard deviations are in parentheses. Gender, race/ethnicity, and parental education are reported in frequencies.

TABLE 2

Comparison of FFW-L, CALI, and ILI conditions.

Exercise	Targeted area	Total treatment time (hr)
FFW-L		
Circus Sequence	Discrimination of tones	10
Old MacDonald’s Flying Farm	Detection of individual phoneme changes	4
Phoneme Identification	Identifying matched syllable pairs	9
Phonic Words	Discriminating between minimal pair words	4
Phonic Match	Identifying matched syllable pairs	6
Block Commander	Recalling commands	6
Language Comprehension Builder	Comprehending grammatical morphemes and complex sentence structures	9
CALI		
Karloon’s Balloons	Discrimination and memory of nonspeech sounds	4
C.C. Coal Car	Detection of individual phoneme changes	4
Hippo Hoops	Identifying matched syllable pairs	9
Duck Luck	Discriminating between minimal pair words	9
Paint by Penguins	Phoneme discrimination and segmentation	6
Following Directions (Laureate Learning)	Recalling commands	6
Micro-LADS (Laureate Learning)	Comprehending grammatical morphemes and complex sentence structures	10
ILI		
Phonological and phonemic awareness	Level 1: Rhyming and sound matching Level 2: Initial/final sound identification and blending/segmenting words Level 3: Blending/segmenting nonwords and making words (decoding)	8
Narrative	Episode structure	23
Semantic	New word learning	9
Morphosyntax	Morphosyntax	4
Syntax-clause level	Syntax-clause level	4

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TABLE 3

Mean raw scores and standard deviations for the phonological awareness and reading measures at pretest and immediate posttest.

Subtest	FFW-L (*n* = 24)	CALI (*n* = 29)	ILI (*n* = 25)	AC (*n* = 25)
CTOPP Elision pretest	4.08 (3.67)	3.72 (2.72)	4.48 (2.47)	3.64 (2.86)
CTOPP Elision posttest	4.62 (3.54)	4.86 (3.00)	5.16 (2.79)	4.28 (3.35)
CTOPP BSW pretest	5.96 (3.38)	5.90 (3.83)	7.16 (3.75)	7.32 (4.40)
CTOPP BSW posttest	7.42 (3.46)*	7.10 (3.18)*	8.52 (3.18)*	6.24 (3.14)
WRMT–R WID pretest	14.25 (15.15)	17.72 (16.18)	22.00 (12.93)	15.40 (15.84)
WRMT–R WID posttest	12.96 (14.54)	17.48 (16.49)	20.64 (13.38)	14.32 (15.71)
WRMT–R WA pretest	4.08 (6.71)	5.00 (5.90)	5.16 (4.77)	5.12 (7.10)
WRMT–R WA posttest	3.67 (5.39)	4.21 (4.84)	4.80 (5.67)	4.56 (6.14)
WRMT–R PC pretest	7.00 (7.85)	7.52 (6.97)	8.80 (5.35)	5.60 (6.96)
WRMT–R PC posttest	5.96 (7.24)	7.10 (7.20)	7.88 (5.88)	6.36 (6.76)

Note. BSW = Blending Sounds in Words; WID = Word Identification; WA = Word Attack; PC = Passage Comprehension. Standard deviations are in parentheses. Asterisk indicates significant difference from AC group.

TABLE 4

Mean raw scores and standard deviations for the phonological awareness and reading measures at immediate posttest and 6-month follow-up.

Subtest	FFW-L (*n* = 23)	CALI (*n* = 27)	ILI (*n* = 24)	AC (*n* = 23)
CTOPP Elision posttest	4.52 (3.58)	4.81 (3.10)	5.08 (2.83)	4.43 (3.42)
CTOPP Elision 6-month posttest	5.22 (2.45)	5.37 (3.61)	5.67 (2.30)	5.26 (3.73)
CTOPP BSW posttest	7.39 (3.54)	6.96 (3.24)	8.54 (3.24)	6.09 (3.23)
CTOPP BSW 6-month posttest	9.43 (3.00)	9.00 (3.01)	8.79 (2.86)	8.39 (2.90)
WRMT–R WID posttest	12.57 (14.73)	16.74 (16.45)	20.67 (13.67)	13.13 (15.77)
WRMT–R WID 6-month posttest	21.04 (15.98)	24.74 (17.04)	30.04 (15.39)	23.91 (14.71)
WRMT–R WA posttest	3.39 (5.33)	4.07 (4.96)	4.75 (5.68)	4.39 (6.29)
WRMT–R WA 6-month posttest	6.22 (6.15)	7.41 (6.53)	7.38 (6.74)	7.26 (7.22)
WRMT–R PC posttest	6.04 (7.39)	6.81 (7.05)	7.79 (5.98)	5.87 (6.82)
WRMT–R PC 6-month posttest	8.70 (7.82)	11.37 (8.13)	13.54 (7.39)	9.70 (7.08)

Note. Standard deviations are in parentheses.