ABSTRACT: Seven children between the ages of 7 and 9 years with auditory processing difficulties participated for 20 days in intensive treatments designed to improve auditory processing skills. Three children participated in Fast ForWord Language (Scientific Learning Corporation, 2001a) computer-based intervention, 2 children participated in Earobics (Cognitive Concepts, 2000a) computer-based intervention, and 2 children participated in a “traditional” intervention using games, worksheets, and hands-on activities. Tests of auditory processing and spoken and written language were administered before and after treatment. All children showed evidence of improvement on auditory processing measures. No consistent improvement in spoken or written language measures was observed. The results of this set of case studies suggest that controlled experimental research into the efficacy of each of the treatments is warranted, with particular attention to outcome measures and manipulation of the intensity of intervention.

KEY WORDS: auditory processing disorder, auditory training, intervention

Case Studies of Auditory Training for Children With Auditory Processing Difficulties: A Preliminary Analysis

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Speech-language pathologists (SLPs) find themselves called on to provide intervention for children who, despite normal hearing, have problems processing auditory stimuli. Many such children are diagnosed with auditory processing disorder (APD; American Speech-Language-Hearing Association [ASHA], 1996; Bellis, 2004; Chermak & Musiek, 1997; Jerger & Musiek, 2000). There is debate in the literature regarding the nature of APD and its relationship to other communication disorders (Cacace & McFarland, 1998), as well as what diagnostic criteria should be used (Jerger & Musiek, 2002). Despite these questions, SLPs must recommend or provide intervention for children who experience difficulty in processing auditory input. Behaviorally, these children often have difficulty following directions, reduced ability to listen in the presence of background noise, and problems understanding degraded speech, among other listening problems (Jerger & Musiek, 2000). APD is often associated with language-related learning disabilities, and it has been suggested that auditory processing deficits play a causal role in these disorders, at least for some individuals (Chermak & Musiek, 1997; McArthur & Bishop, 2004).

INTERVENTION FOR APD

Several approaches to intervention for children with APD have been proposed. These include management of

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symptoms through environmental intervention (e.g., providing personal amplification technology, using visual aids), instruction in compensatory strategies, and remediation of skills (Bellis, 2003). One approach to skill remediation is auditory training (AT). Chermak and Musiek (2002; see also Musiek, 1999) described formal and informal AT. Formal AT provides extensive practice with controlled acoustic stimuli, using computers or specialized instrumentation, to develop such skills as auditory discrimination, auditory closure, lateralization, and localization. Informal AT is presented by a clinician and uses minimal instrumentation (but is nonetheless systematic). Computer programs that provide formal AT are commercially available. Among these are Fast ForWord Language (FFW) by Scientific Learning Corporation (2001a) and Earobics Step 2 by Cognitive Concepts (2000a). Therapy materials for informal AT are also available, including the Central Auditory Processing Kit1 (CAPK; Mokhemar, 1999). These three intervention packages were used in the present study.

Some characteristics of FFW and Earobics that make them formal AT programs are the computer-controlled presentation of stimuli and the use of algorithms to adapt the difficulty level to individual users. Correct and incorrect answers are recorded, and the difficulty level is increased as the user responds correctly. Incorrect responses cause the difficulty level to be reduced. Both programs include several different exercises, most of which use speech stimuli. One FFW exercise, “Circus Sequence,” is an exception, presenting tones that “sweep” through a range of frequencies. Children are required to determine the order in which two “sound sweeps” are presented. The speech stimuli used in the other FFW exercises, ranging from syllables to sentences, are acoustically modified to selectively lengthen and amplify certain phonetic transitions (Nagarajan et al., 1998; Tallal, 2000). As the child progresses through the exercises, the acoustic modifications are reduced until eventually the child is responding to natural speech. Earobics uses speech stimuli in all exercises, ranging from phonemes to sentences. Acoustic modifications are used in only one exercise, to enhance discrimination of consonants in consonant–vowel (CV) syllables, and the modification is faded as the child’s performance improves.

The CAPK materials also use speech stimuli, ranging from syllables to sentences. Here, though, stimuli are presented by a clinician rather than by a computer. In our implementation, specific objectives were identified and children’s performance was recorded trial by trial. As no specialized instrumentation or software are used in the CAPK, it fits the description of informal AT. All three intervention programs, as implemented in the current study, are described further in the Method section.

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1This article contains words and phrases (i.e., Fast ForWord, Earobics, the Central Auditory Processing Kit) that are or are asserted to be proprietary terms or trademarks. Their inclusion does not imply that they have acquired for legal purposes a nonproprietary or general significance, nor is any other judgment implied concerning their legal status.

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PREVIOUS RESEARCH

A few studies have examined FFW and Earobics as treatments for children with APD. Battin, Young, and Burns (2000) examined the clinical files of 15 children who had been diagnosed with central auditory processing disorder (CAPD) who had participated in FFW. As a group, the children’s standard scores on the Filtered Words, Auditory Figure-Ground, and Competing Words subtests of the Test for Auditory Processing Disorders in Children—Revised (SCAN–C; Keith, 2000) increased significantly after treatment. Battin et al. also found increases for 7 of the 15 children on the Oral Vocabulary, Grammatical Understanding, and Sentence Imitation subtests of the Test of Language Development (Newcomer & Hammill, 1977), although these data were not evaluated statistically. Tallal (2000) reported that in field trials of FFW, a group of 51 children with CAPD (as identified by clinicians using tests of their choice) showed significant improvement on standardized language measures following treatment, moving from more than 1 SD below the mean for their age to within 1 SD.

Wertz and Hall (2002) reported data from four case studies of children aged 8 to 12 with APD. Three received treatment with FFW and one with Earobics. All of the children showed improvement greater than 1 SD on two or three SCAN–C subtests and on a dichotic listening task. All children also improved on measures of receptive language and phonological awareness, but not expressive language.

Children with APD may demonstrate language and/or reading impairments (Chermak & Musiek, 1997). Several studies have examined FFW as a treatment for children with specific language impairment (SLI) (Friel-Patti, DesBarres, & Thibodeau, 2001; Gillam, Crofford, Gale, & Hoffman, 2001; Loeb, Stoke, & Fey, 2001; Thibodeau, Friel-Patti, & Britt, 2001). In general, some clinically significant improvements on language measures were observed, although the changes were not as impressive as those reported for tests of an early version of FFW (Tallal et al., 1996) and for field tests of FFW (Tallal, 2000), and there was no clear advantage for FFW over another computer-based treatment (Gillam et al., 2001).

In a study of FFW as a treatment for children who have poor reading skills, Hook, Macaruso, and Jones (2001) observed some gains in children who had been treated with FFW for reading-related skills, but no more than those observed in children who received different training or no special training. Another group study (Pokorni, Worthington, & Jamison, 2004) of children with reading and language difficulties compared FFW, Earobics, and the Lindamood Phonemic Sequencing Program (LiPS; Lindamood & Lindamood, 1998). The results showed that the Earobics and LiPS groups improved significantly on some phonemic awareness measures whereas the FFW group did not.

Computer-based training for children with a variety of language-related learning difficulties has been evaluated in several studies. In general, results have suggested that for some children, such programs can be effective for improving auditory processing, spoken language, and reading
skills, but when FFW and Earobics are compared to other programs (computer-based or not), they do not show marked advantages.

**PURPOSE OF THE STUDY**

The purpose of this study was to add to the small body of data regarding the use of formal and informal AT for children with auditory processing deficits. Like much of the research that has been described, this investigation used a case study approach. We used a variety of measures to describe the participants’ spoken and written language skills, as well as their auditory processing skills, before intervention. We assessed change following intervention in measures of auditory processing, phonological processing, and reading skills.

The SCAN–C (Keith, 2000) and the Staggered Spondaic Word (SSW) Test (Katz, 2001) were used to assess auditory processing. The SCAN–C measures performance under several conditions: degraded input (Filtered Words), speech in the presence of background noise (Auditory Figure–Ground), and input to both ears simultaneously (Competing Words and Competing Sentences). The SSW compares performance on competing and noncompeting verbal stimuli. These instruments do not measure all aspects of auditory processing, but they sample binaural integration and separation as well as processing of a nonredundant speech signal.

A nonword repetition task was used as a measure of phonological processing. There is debate about what nonword repetition measures—it taps phonological encoding, memory, and representation, and probably other processes as well (Ellis Weismer et al., 2000). Despite this uncertainty, nonword repetition has been shown to be a useful index of language disorder (e.g., Bishop, North, & Donlan, 1996; Conti-Ramsden & Hesketh, 2003; Dollaghan & Campbell, 1998; Ellis Weismer et al., 2000; Gathercole & Baddeley, 1990). The Letter–Word Identification and Spelling of Sounds subtests of the Woodcock-Johnson III Tests of Achievement (WJ–III; Woodcock, McGrew, & Mather, 2001) provide measures of phonemic decoding and encoding, respectively (Mather & Woodcock, 2001; McGrew & Woodcock, 2001). The Gray Oral Reading Tests—Fourth Edition (GORT–4; Wiederholt & Bryant, 2001) were used as a comprehensive measure of reading ability, which takes into account rate, fluency, accuracy, and comprehension (Wiederholt & Bryant, 2001). A parent questionnaire was also administered to obtain parents’ perceptions of changes in their child over the treatment period.

**METHOD**

**Participants**

Seven right-handed monolingual English-speaking children, 4 males and 3 females, participated in the study. They ranged in age from 7;0 (years;months) to 9;0 at the pretest phase. Participants were referred by school SLPs or from the records of children between 7 and 9 years of age who had recently received an auditory processing evaluation at the university’s hearing clinic. Families of potential participants received a letter describing the study and inviting them to contact the researchers for further information. Nine children participated in a screening process. One was excluded from the study because of prior enrollment in Earobics through school; the other chose not to participate.

Clinic records for 4 children, aged 6 to 9 years, who had been evaluated two times for auditory processing were also examined, as described below in the case study summary section.

**Measures**

Each child participated in an auditory processing evaluation at the Penn State Hearing Clinic, conducted by an ASHA-certified audiologist (author EAU). One (APD06) had been evaluated 8 months before the study; the others had been evaluated no more than 4 months before the study. All had hearing ability within normal limits, normal tympanometry, and normal otoacoustic emissions. All children received the SCAN–C (Keith, 2000) and the SSW (Katz, 2001). Other tests, such as the Phonemic Synthesis Test (Katz, 2001), Pitch Pattern Sequencing (see Bellis, 2003), Dichotic Digits (Musiek, 1983), and Denver Auditory Phoneme Sequencing Test (Aten, 1979), were used for clinical purposes as appropriate but are not reported in this article. All children were identified as likely to have APD based on the overall test profile, including number and patterns of errors, as well as a detailed case history including the child’s behavior and academic strengths and weaknesses.

The pretesting process included evaluation of language, cognition, and reading and spelling achievement. In order to rule out cognitive deficits as an explanation for auditory and language difficulties, nonverbal IQ was measured using the Universal Nonverbal Intelligence Test (UNIT; Bracken & McCallum, 1998). All children scored 85 or greater on the UNIT. Parents completed the Gilliam Autism Rating Scale (GARS; Gilliam, 1995), and the presence of autism spectrum disorders was ruled out for all children. Parents also completed the parent version of the Conners’ ADHD/DSM–IV Scales (CADS–P; Conners, 1999) to assess attention deficit symptoms. The differential diagnosis of APD and attention deficit hyperactivity disorder (ADHD) is difficult (Chermak & Musiek, 1997). Inattention and distractibility, especially for auditory stimuli, are part of the APD profile. The CADS–P is not designed to differentiate between APD and ADHD, but it was administered in order to document the extent to which the parents perceived their children as having problems with attention.

To assess language, either the Test of Language Development—Primary: Third Edition (TOLD–P:3; Newcomer & Hammill, 1997) or the Test of Language Development—Intermediate: Third Edition (TOLD–I:3; Hammill & Newcomer, 1997) was administered. The Digits Forward, Digits Backward, and Manual Imitation subtests of the Test of Memory and Learning (TOMAL; Reynolds & Bigler, 1994) were administered to assess working memory. The
GORT–4 (Wiederholt & Bryant, 2001) and the following WJ–III (Woodcock et al., 2001) subtests—Letter-Word Identification, Story Recall, Spelling of Sounds, Sound Awareness, Writing Fluency, and Word Attack—were used to assess skills related to reading and writing. A nonword repetition task was administered, using stimuli from Dollaghan and Campbell (1998), and was scored for percentage of phonemes correct (PPC) following Dollaghan and Campbell’s scoring procedure.

Postintervention data were collected 1 to 2 weeks after intervention concluded. The SCAN–C and SSW were administered to all children at posttest, as were the nonword repetition task, the GORT–4, and the Spelling of Sounds and Letter-Word Identification subtests of the WJ–III. Four children returned 3 to 6 months after the conclusion of intervention for follow-up testing of auditory processing only.

### Description of Intervention Programs

Table 1 shows the exercises and targeted skills for FFW and Earobics. FFW consists of seven exercises, each targeting a subset of the following skills: working memory, sound sequencing ability, processing speed, phoneme discrimination, sustained and focused attention, auditory word recognition, listening comprehension, and syntax (Scientific Learning Corporation, 2001b). The exercises are framed as computer games with animation and sound designed to sustain interest and motivation. A key feature of FFW is that the speech stimuli are acoustically altered “to stretch and emphasize the rapidly changing phonetic elements within natural speech” (Scientific Learning Corporation, 2001b, p. 56).

Earobics Step 2 consists of five exercises, also framed as computer games. Each exercise targets skills such as

<table>
<thead>
<tr>
<th>Program/exercise</th>
<th>Description</th>
<th>Targeted skills</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fast ForWord Language</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block Commander</td>
<td>Follow spoken instructions</td>
<td>Rate of auditory processing; listening comprehension; syntax; working memory</td>
</tr>
<tr>
<td>Circus Sequence</td>
<td>Identify a sequence of two sound sweeps</td>
<td>Rate of auditory processing; working memory; sound sequencing</td>
</tr>
<tr>
<td>Language Comprehension Builder</td>
<td>Match the correct picture to a sentence</td>
<td>Rate of auditory processing; language and listening comprehension; syntax; morphology</td>
</tr>
<tr>
<td>Old MacDonald’s Flying Farm</td>
<td>Identify when a new syllable interrupts a repeated syllable</td>
<td>Rate of auditory processing; phoneme discrimination; sustained &amp; focused attention</td>
</tr>
<tr>
<td>Phoneme Identification</td>
<td>Identify a syllable that matches a target syllable</td>
<td>Rate of auditory processing; working memory; phoneme identification &amp; discrimination</td>
</tr>
<tr>
<td>Phonic Match</td>
<td>Match sounds</td>
<td>Rate of auditory processing; working memory; word recognition; phoneme discrimination</td>
</tr>
<tr>
<td>Phonic Words</td>
<td>Match the correct picture to a word</td>
<td>Rate of auditory processing; word recognition</td>
</tr>
<tr>
<td><strong>Earobics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calling All Engines</td>
<td>Follow spoken instructions</td>
<td>Auditory sequential &amp; short-term memory; following oral directions; language comprehension; auditory performance with competing signals; auditory attention</td>
</tr>
<tr>
<td>Paint by Penguin</td>
<td>Count, segment, and manipulate sounds and words</td>
<td>Phonological segmentation, sequencing, &amp; manipulation; auditory sequential &amp; short-term memory; auditory temporal ordering &amp; resolution; auditory pattern recognition</td>
</tr>
<tr>
<td>Hippo Hoops</td>
<td>Identify a target phoneme or syllable among a sequence of distractors</td>
<td>Auditory &amp; phoneme discrimination; phoneme identification; auditory vigilance; phonological sequencing</td>
</tr>
<tr>
<td>Pesky Parrots</td>
<td>Blend phonemes and syllables</td>
<td>Phonological blending; word closure; auditory performance with degraded signals; auditory &amp; phoneme discrimination; auditory short-term memory</td>
</tr>
<tr>
<td>Duck Luck</td>
<td>Identify a phoneme or syllable that matches a target</td>
<td>Rhyming; phonological blending, segmentation, &amp; manipulation; phoneme identification; word closure; sound-symbol correspondence; auditory sequential &amp; short-term memory; auditory &amp; phoneme discrimination</td>
</tr>
</tbody>
</table>
auditory processing (e.g., auditory attention, temporal ordering), phonology (e.g., phoneme discrimination, segmentation, and blending); word closure, following directions, and rhyming (Cognitive Concepts, 2000b). One exercise includes speech sounds that have been acoustically altered “to make critical cues more easily heard” (Cognitive Concepts, 1999, p. 8). Both the FFW and Earobics computer programs adapt the difficulty level to the child’s performance. Exercises begin at a relatively easy level, and as the child performs more accurately, the difficulty increases.

The CAPK materials (Mokhemar, 1999) include a variety of activities that target skills in auditory memory, auditory discrimination, auditory closure, auditory synthesis, auditory figure-ground, and auditory multisensory integration. These materials, along with other materials such as games and worksheets that reinforced target skills, were used in a therapy program designed by author JJCB, assisted by a graduate clinician who was responsible for delivering the intervention. This program will be referred to as the “traditional” program because its purpose was to represent the treatment that an SLP might devise for a client with APD. Acoustic alteration of stimuli was not used; however, background noise was sometimes introduced (e.g., electric fan, classical music). Within each skill area, specific objectives were formulated. Table 2 lists the skill areas, with descriptions of activities and targeted skills. Like FFW and Earobics, there was a repetition of trials, which gradually increased in difficulty, but the trials were embedded in a greater variety of games and activities. The traditional program allowed for more flexibility in choosing games that the child preferred, relaxing the intensity when the child was fatigued and adjusting objectives based on the child’s progress.

**Procedure**

Unlike the other two intervention programs used, FFW has a schedule for intervention delivery that is set by the developer, Scientific Learning Corporation. For the first 3 days, children participate in the games for 60 min each day. On days four and five, children participate for 80 min each day. From then on, children participate in five exercises for a total of 100 min per day, 5 days a week, for a total of 4 to 6 weeks. In order to maintain consistency across interventions, Earobics and the traditional program were administered on the same schedule. All of the children participated in intervention for 4 weeks (20 days). Some children skipped 1 or 2 days for various reasons, but all completed 20 days of intervention. A graduate student clinician was present at all times. For FFW and Earobics, the clinician instructed the children in how to play the games; if necessary, provided motivation, reinforcement, and encouragement; and managed the intervention schedule. For the traditional program, the clinician administered all intervention activities and provided motivation, encouragement, and structure.

The FFW and Earobics programs provide records of the child’s performance for each exercise, session by session. In the traditional program, the clinician (aided by an assistant), recorded performance for each goal within each session. FFW provides “percent completion” for each exercise, which “is calculated based on the number of levels in an exercise that participants have mastered” (Scientific Learning Corporation, 2001b, p. 174). If performance becomes worse, percent completion can decrease.

The SCAN–C and SSW were administered and scored by, or under the direct supervision of, a certified audiologist. The GORT–4, UNIT, and WJ–III were administered and scored by school psychologists holding master’s degrees. The TOLD–P:3, TOLD–I:3, TOMAL, and nonword repetition task were administered and scored by students enrolled in a master’s degree speech-language pathology program, and the calculation of subtest and composite scores was checked by a second scorer. At both pretest and posttest, the nonword repetition task was audiotaped, with one exception when there was a recording malfunction. Tapes were reviewed by a second judge whose transcriptions were regarded as authoritative. At posttest, the nonword repetition task was in some cases administered by student clinicians who had conducted intervention; however, no clinician assessed a child for whom she had provided intervention.

**Table 2.** Description of “traditional” intervention using Central Auditory Processing Kit (CAPK; Mokhemar, 1999) skill areas.

<table>
<thead>
<tr>
<th>Skill area</th>
<th>Description of activities</th>
<th>Targeted skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory memory</td>
<td>Recall words, sentences, and paragraphs</td>
<td>Immediate and delayed recall of words, sentences, and paragraphs</td>
</tr>
<tr>
<td>Auditory discrimination</td>
<td>Make same-different judgments, identify words that share designated sounds</td>
<td>Discrimination of phonemes, words, and phrases</td>
</tr>
<tr>
<td>Auditory closure</td>
<td>Complete words, phrases, and sentences given varying amounts of context</td>
<td>Ability to predict information by using contextual cues</td>
</tr>
<tr>
<td>Auditory synthesis</td>
<td>Identify and blend phonemes and syllables</td>
<td>Phonological segmentation and blending</td>
</tr>
<tr>
<td>Multimodal integration</td>
<td>Combine auditory information with other modalities (e.g., through touch, drawing)</td>
<td>Ability to integrate information from a variety of sources</td>
</tr>
<tr>
<td>Auditory figure-ground</td>
<td>Follow directions presented with background noise</td>
<td>Ability to attend to pertinent information while ignoring irrelevant input</td>
</tr>
</tbody>
</table>

Miller et al.: Case Studies of Auditory Processing Treatments 97
Data Analysis

In case study investigations, it is important to set criteria for what will be considered a clinically significant change. The SCAN–C, GORT–4, and WJ–III provide standard errors of measurement, permitting computation of confidence intervals. In these cases, we computed 90% confidence intervals for pretest and posttest scores. When these confidence intervals did not overlap, we regarded the change as significant, and the scores are marked accordingly in Tables 3 and 4. For the SSW, standard deviations were available from norming data, and differences > 1 SD were considered significant. Changes >1 SD and >2 SD are marked in Table 3. The nonword repetition stimuli created by Dollaghan and Campbell (1998) have not been normed; however, Ellis Weismer et al. (2000) collected data using those stimuli from 359 typically developing children with a mean age of 7;11 (SD = 4.8 months). We compared the nonword repetition scores of our participants to the means and standard deviations reported for this group of children, and changes greater than 1 SD were considered significant.

In the sections that follow, the descriptions of participants are divided into three parts:

- Pretest data include parent report data; auditory processing scores (Table 3); scores on the GORT–4, the WJ–III Letter-Word Identification and Spelling of Sounds subtests, and the nonword repetition task (Table 4); and scores of other spoken language, literacy, and memory tests (Tables 5 and 6).

- Treatment progress describes the participant’s performance in intervention.

- Posttest data describe changes, if any, observed in the principal measures of interest (see Tables 3 and 4).

Table 3. Pretest, posttest, and follow-up scores for auditory processing tests.

<table>
<thead>
<tr>
<th>Task</th>
<th>APD01</th>
<th>APD04</th>
<th>APD08</th>
<th>APD05</th>
<th>APD09</th>
<th>APD03</th>
<th>APD06</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Foll</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>SSW</td>
<td>35</td>
<td>16不用担心</td>
<td>32</td>
<td>18不用担心</td>
<td>8不用担心</td>
<td>28</td>
<td>20不用担心</td>
</tr>
<tr>
<td>SCAN–C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FW</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>10不用担心</td>
<td>10不用担心</td>
<td>7</td>
<td>10不用担心</td>
</tr>
<tr>
<td>AFG</td>
<td>7</td>
<td>11不用担心</td>
<td>7</td>
<td>9不用担忧</td>
<td>10不用担心</td>
<td>7</td>
<td>8不用担忧</td>
</tr>
<tr>
<td>CW</td>
<td>4</td>
<td>11不用担忧</td>
<td>3</td>
<td>6不用担忧</td>
<td>12不用担忧</td>
<td>8</td>
<td>10不用担忧</td>
</tr>
<tr>
<td>CS</td>
<td>9</td>
<td>9不用担忧</td>
<td>6</td>
<td>8不用担忧</td>
<td>10不用担忧</td>
<td>8</td>
<td>10不用担忧</td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td>98不用担忧</td>
<td>70</td>
<td>88不用担忧</td>
<td>110不用担忧</td>
<td>83</td>
<td>96不用担忧</td>
</tr>
</tbody>
</table>

Note. Follow-up testing was not conducted for APD01, APD05, or APD06. FFW = Fast ForWord; SSW = Staggered Spondaic Word Test (Katz, 2001), total number of errors; SCAN–C = Test for Auditory Processing Disorders in Children—Revised (Keith, 2000); FW = Filtered Words subtest; AFG = Auditory Figure-Ground subtest; CW = Competing Words subtest; CS = Competing Sentences subtest; Pre = pretest score; Post = posttest score; Foll = follow-up score; scale for subtest scores; M = 10, SD = 3; scale for total score: M = 100, SD = 15.不用担心 change >2 SD compared to pretest;不用担心 change >1 SD compared to pretest;不用担心 90% confidence interval did not overlap with 90% confidence interval of pretest.

CASE STUDIES: FFW

APD01

Pretest data. APD01, a female, was 9;0 at the time of pretesting and had completed third grade. She was reported by her mother to have difficulty with reading and spelling and described herself as not being a good reader; however, her GORT–4 score was within normal limits (see Table 4). She was also reported to have trouble understanding directions in the presence of background noise and to occasionally make grammatical errors when speaking or writing. She had received speech therapy and reading assistance. A younger sibling also received speech therapy.

The CADS–P indicated that APD01’s behaviors with regard to attention problems were mildly to markedly atypical. Her auditory processing evaluation scores are shown in Table 3. Her SCAN–C total score was more than 1 SD below the mean, and the number of errors on the SSW was more than 7 SD greater than the mean for her age. Her standard score on the UNIT was 96; at pretest, her TOLD–I:3 Listening Quotient was 85 and her Speaking Quotient was 74 (Table 5). As her expressive score was >1 SD below the mean, she could be considered to have expressive SLI. As shown in Table 4, APD01 performed within 1 SD of the mean on the Letter-Word Identification and Spelling of Sounds subtests as well as on the GORT–4, and she produced 62 PPC on the nonword repetition task, which is more than 2 SD below the mean according to Ellis Weismer et al. (2000). APD01 scored within normal limits on the other subtests of the WJ–III, and all three subtests of the TOMAL, although the scores for Forward and Backward Digit Span subtests were at the lower end of the normal range (Table 6).

Treatment progress. APD01 enjoyed FFW for the most part and she performed very well, reaching 100%
with reading and writing, which was reflected in his GORT–4 and WJ–III scores (Table 4). APD04 was reported to often have difficulty understanding directions in the presence of background noise. At birth, he was treated for low oxygen levels. He was reported to have had ear infections that were treated with antibiotics, and allergies and asthma that were treated with prescription medication. His mother reported that he did not speak until age 3 1/2, when he spoke in sentences. No member of his immediate family was reported to have language-related learning difficulties, but two uncles did. APD04’s mother reported that he had been examined by an optometrist and his “eyes [did] not work in tandem.”

The CADS–P indicated that APD04’s behavior was mildly to moderately atypical with regard to attention. His SCAN–C total score was more than 1 SD below the mean, and the number of errors on the SSW was more than 3 SD greater than the mean for his age (Table 3). He received a Listening Quotient on the TOLD–I:3 of 87 and a Speaking Quotient of 70 (Table 5); therefore, he could be considered to have expressive SLI. His nonword repetition PPC score was 68, more than 1.5 SD below the mean (Table 4). His TOMAL scores were within 1 SD of the mean (Table 6).


<table>
<thead>
<tr>
<th>Task</th>
<th>FFW</th>
<th>Earobics</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APD01</td>
<td>APD04</td>
<td>APD08</td>
</tr>
<tr>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>GORT–4 Oral Reading Quotient</td>
<td>100</td>
<td>91*</td>
<td>55</td>
</tr>
<tr>
<td>Letter-Word Identification</td>
<td>86</td>
<td>92</td>
<td>72</td>
</tr>
<tr>
<td>Spelling of Sounds</td>
<td>88</td>
<td>80</td>
<td>62</td>
</tr>
<tr>
<td>Nonword repetition (percent phonemes correct)</td>
<td>62</td>
<td>70</td>
<td>68</td>
</tr>
</tbody>
</table>

Note. Scale for GORT–4 Oral Reading Quotient and WJ–III subtests: M = 100, SD = 15.  
*90% confidence interval did not overlap with 90% confidence interval of pretest, change was in negative direction; 90% confidence interval did not overlap with 90% confidence interval of pretest, change was in positive direction; change >1 SD compared to pretest; change >2 SD compared to pretest.

Posttest data. Following intervention, APD01’s score on the SSW improved by more than 4 SD, and the 90% confidence intervals of her overall SCAN–C score before and after intervention did not overlap (Table 3). In contrast, the only significant change among the GORT–4, WJ–III subtests, and nonword repetition task was in a negative direction, as her GORT–4 score decreased (Table 4). APD01’s mother reported that her daughter showed more confidence in reading following treatment, although improvement in reading and spelling skills was not observed by the parents.

APD04

Pretest data. APD04, a male, was 8;0 at the time of pretesting. He was home schooled and had great difficulty completion on Phoneme Identification; 99% completion on Block Commander, Language Comprehension Builder, and Phonics Words; 97% on Old MacDonald’s Flying Farm; 94% on Phonics Match; and 65% on Circus Sequence. Although she was challenged by some of the games, she was motivated by the points awarded by the computer program and usually tried hard.

Table 5. Pretest scores on the Test of Language Development—Primary: Third Edition (TOLD–P:3) and the Test of Language Development—Intermediate: Third Edition (TOLD–I:3).

<table>
<thead>
<tr>
<th>TOLD–P:3</th>
<th>FFW</th>
<th>Earobics</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APD08</td>
<td>APD09</td>
<td>APD03</td>
</tr>
<tr>
<td>Picture Vocabulary</td>
<td>11</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Relational Vocabulary</td>
<td>11</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Oral Vocabulary</td>
<td>10</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Grammatic Understanding</td>
<td>13</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Sentence Imitation</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Grammatic Completion</td>
<td>9</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Listening Quotient</td>
<td>103</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Speaking Quotient</td>
<td>88</td>
<td>88</td>
<td>91</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TOLD–I:3</th>
<th>FFW</th>
<th>Earobics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APD01</td>
<td>APD04</td>
</tr>
<tr>
<td>Picture Vocabulary</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Word Ordering</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Sentence Combining</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Generals</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Grammatic Comprehension</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Malapropisms</td>
<td>8</td>
<td>6</td>
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<tr>
<td>Listening Quotient</td>
<td>85</td>
<td>87</td>
</tr>
<tr>
<td>Speaking Quotient</td>
<td>74</td>
<td>70</td>
</tr>
</tbody>
</table>

Note. Scale for subtest scores: M = 10, SD = 3; scale for quotients: M = 100, SD = 15; # = score not available due to examiner error.
His performance was ≥1 SD below the mean on the Letter-Word Identification, Word Attack, Spelling of Sounds, and Sound Awareness subtests, and he was unable to complete the Writing Fluency subtest. His Story Recall subtest score was within normal limits.

**Treatment progress.** APD04 had considerable difficulty with FFW and did not enjoy it. He needed constant encouragement and motivation to remain on task and was allowed 2 days off during the intervention period but completed 20 days of training. He achieved 99% completion on Block Commander, Language Comprehension Builder, and Phonics Words; 55% on Old MacDonald’s Flying Farm; and 30% on Phonics Match. His performance on Phoneme Identification peaked around 65% on his ninth day of training, ending at 32%, and he ended intervention with only 3% completion on Circus Sequence, having peaked at 10%.

**Posttest data.** APD04’s posttest score on the SSW improved by more than 2 SD, and by the time he returned 6 months later for a follow-up, it had improved still more. His mother reported that he received reading intervention during that time. His SCAN–C total score also improved at posttest and at follow-up (see Table 3). Both test scores were within normal limits by the time of follow-up. His nonword repetition score was 84, a significant improvement of more than 1 SD (Table 4). APD04’s mother observed that his ability to listen in the presence of background noise had improved, but she did not observe change in his reading skills.

### APD08

**Pretest data.** APD08, a male, was 8:0 at the time of pretesting and had completed second grade. His parents reported that he had difficulty producing /s/, sometimes had difficulty understanding directions, and often made grammatical errors in speaking and writing. He had received speech therapy and assistance with reading and had made marked improvement in both areas. No other family members were reported to have speech or language problems. The CADS–P indicated that APD08’s behavior was slightly atypical with regard to attention. His SSW and SCAN–C total scores, shown in Table 3, were outside normal limits. On the TOLD–P:3, his Listening Quotient was 103 and his Speaking Quotient was 88 (Table 5); thus, the difficulties with spoken language observed by his parents were not detected by this instrument. He also scored within 1 SD of the mean on the GORT–4, all of the WJ–III subtests, and the nonword repetition task. His Forward Digit Span performance, however, was quite low (see Tables 4 and 6).

**Treatment progress.** APD08 also disliked FFW and needed to be encouraged and redirected consistently. Like APD04, he was allowed 2 days off but completed 20 days of training. APD08 reached 98% completion on Phonics Words, 97% on Language Comprehension Builder, 71% on Circus Sequence, 35% on Old MacDonald’s Flying Farm, and 32% on Phonics Match. His performance on Phoneme Identification peaked at 60% and ended at 51%.

**Posttest data.** APD08’s SSW posttest score was an improvement of more than 1 SD, and this change was maintained when he returned for a follow-up 4 months later, although the score was still not within 1 SD of the mean. His SCAN–C total score at posttest was within normal limits, but the change did not exceed the 90% confidence interval; however, at follow-up, it did (Table 3). His scores on the GORT–4 and the WJ–III subtests did not improve significantly (Table 4); however, they were within normal limits at pretest. His nonword repetition PPC decreased by less than 1 SD, from 91 to 83 (Table 4). APD08’s mother reported improvement in reading, spelling, and following directions. She noted that he continued to struggle with oral expression.

### Case Studies: Earobics

#### APD05

**Pretest data.** APD05, a male, was 8:0 at the time of pretesting and had completed second grade. His mother...
reported an eventful birth history. APD05 was born prematurely and had a blood clot in the left cerebral hemisphere and bleeding in the right hemisphere. He had heart surgery, eye surgery, and hernia repair. He also had feeding problems due to acid reflux. APD05 experienced ear infections at age 1 to 2 years, and his tonsils and adenoids were removed. His first words were produced during the period between 18 and 24 months, but his language development was otherwise unremarkable and he did not receive speech-language therapy. He struggled with reading and received assistance in that area. His mother reported that he sometimes had trouble understanding directions and he liked to turn up the radio or television louder than other family members preferred. His father was reported to have a history of speech or language difficulties.

APD05’s medical history may have played a causal role in his problems with reading, understanding directions, and listening that his mother reported. However, his score of 101 on the UNIT was within normal limits, as were his Listening Quotient (98) and Speaking Quotient (89) on the TOLD–I:3 (Table 5). As his functioning was not depressed overall, he was included in the study. According to the CADS–P, his behavior was not consistent with ADHD. His SSW and SCAN–C total scores were outside normal limits (Table 3). On the GORT–4, his score was 76 (Table 4). His score on the Spelling of Sounds subtest was outside normal limits. When he returned for a follow-up 5 months later, his SSW score was 1 SD greater than the mean. On the SCAN–C, his Filtered Words subtest improved significantly at posttest, but the total score did not; however, the total score was within normal limits (Table 3). His scores on the Spelling of Sounds subtest and the nonword repetition task (Table 4). His Forward Digit Span score was within normal limits, in contrast to Backward Digit Span (see Table 4). His Forward Digit Span score was below normal limits, in contrast to Backward Digit Span and Manual Imitation (Table 6).

**Treatment progress.** APD05 was able to maintain attention and motivation reasonably well throughout intervention. He often tried to talk with the clinician during the exercises, but responded to reminders and positive reinforcement, and this behavior decreased. He sometimes complained of a headache and seemed uninterested in the games, but the clinician’s system of token reinforcement usually kept him motivated. He completed all 15 learning objectives for Pesky Parrots, 7 of 14 learning objectives for Calling All Engines, 3 of 7 objectives for Paint by Penguin, 5 of 12 objectives for Hippo Hoops, and 5 of 9 objectives for Duck Luck.

**Posttest data.** On the SSW, APD09 showed improvement of more than 2 SD at posttest, putting him within normal limits. When he returned for a follow-up 5 months later, his SSW score was 1 SD greater than the mean. On the SCAN–C, the Filtered Words subtest improved significantly at posttest, but the total score did not; however, the total score was within normal limits (Table 3). His scores on the Spelling of Sounds subtest and the nonword repetition task improved significantly, but his scores on the GORT–4 and the Letter-Word Identification subtest did not (Table 4). His father reported that APD09 had “picked up some better ways to express himself” and had improved in his persistence and determination to complete a task. APD09’s father also noticed some improvement in grammaticality of spoken language.

**CASE STUDIES: TRADITIONAL THERAPY**

**APD03**

**Pretest data.** APD03, a female, was 7;4 at the time of pretesting and had completed first grade. Her mother reported that she experienced ear infections between the
ages of 10 months and 2 years. Birth history and language development were unremarkable. APD03 struggled with reading and spelling; her mother reported that she wrote some letters backwards and had trouble sounding out words. She received reading assistance at school. Her mother also reported that APD03 had problems understanding and remembering instructions, especially in the presence of background noise. APD03 had been examined by an optometrist, who reported “visual perceptual problems” in the areas of eye movement control, eye hand coordination, visual directional concepts, and form reproduction. The clinician delivering intervention also noted difficulty with understanding of right and left and worked on these concepts daily during treatment. Both parents were reported to have had problems with reading, writing, and spelling.

The CADS–P indicated average to mildly atypical attentional behaviors. APD03’s pretest score on the SCAN–C total was within 1 SD of the mean; the SSW score was more than 6 SD above the mean (Table 3). Her TOLD–P:3 Listening Quotient was 100 and her Speaking Quotient was 91 (Table 5). Forward Digit Span was 1 SD below the mean; Backward Digit Span and Manual Imitation were within normal limits (Table 6). Consistent with the reported reading problems, her GORT–4 score was 76 (Table 4). Her nonword repetition PPC was 71, more than 1 SD below the mean. Her WJ–III and TOMAL subtest scores were within 1 SD of the mean (Tables 4 and 6).

**Treatment progress.** APD03 enjoyed the intervention for the most part, although at times she was resistant, especially when asked to do tasks that were difficult for her. She met 7 of 8 Auditory Memory learning objectives (learning objectives were met when 90% accuracy or better was achieved), 15 of 17 Auditory Discrimination objectives, 12 of 12 Auditory Closure objectives, 10 of 10 Auditory Synthesis objectives, 8 of 10 Auditory Multisensory Integration objectives, and 5 of 9 Auditory Figure-Ground objectives.

**Posttest data.** APD03 showed improvement on both auditory processing measures (Table 3). Her SSW errors decreased by more than 6 SD at posttest, putting her within 1 SD of the mean for her age, and this change was maintained at follow-up 3 months later. Although her SCAN–C total score was within normal limits at pretest, improvement exceeded the 90% confidence interval at posttest and at follow-up. No significant change was observed on the GORT–4 or the WJ–III subtests, although her nonword repetition score increased by more than 2 SD (Table 4). APD03’s mother observed changes in her daughter’s ability to remember multistep directions in the context of intervention but did not observe similar changes at home.

APD06

**Pretest data.** APD06, a female, was 7:0 at the time of pretesting and had completed kindergarten. Her mother reported that she had ear infections at age 5, at which time her tonsils and adenoids were removed and pressure equalization tubes were inserted. No concerns with speech and language development were reported, but her parents had concerns about reading and spelling, and understanding and remembering instructions, particularly in the presence of background noise. Her father was reported to have dyslexia, and an older sibling to have dysgraphia.

The CADS–P indicated average to slightly atypical attentional behaviors. APD06’s pretest score on the SCAN–C total was within 1 SD of the mean; the diagnosis of APD was based on the SSW, which was more than 3 SD above the mean (Table 3), and other measures not reported here. Her TOLD–P:3 Listening Quotient was 112 (Table 5). The Speaking Quotient could not be computed because a ceiling was not reached on Oral Vocabulary; however, based on the information available, it was at least 97. APD06 received a 70 on the GORT–4, scored 1 SD below the mean on the Letter-Word Identification and Spelling of Sounds subtests of the WJ–III, and scored more than 1 SD below the mean on the nonword repetition task (Table 4). Her Forward Digit Span score was also low (Table 6).

**Treatment progress.** APD06 enjoyed the intervention and almost always participated fully and enthusiastically. She met 7 of 9 Auditory Memory learning objectives, 16 of 17 Auditory Discrimination objectives, 9 of 11 Auditory Closure objectives, 11 of 11 Auditory Synthesis objectives, 11 of 11 Auditory Multisensory Integration objectives, and 6 of 10 Auditory Figure-Ground objectives.

**Posttest data.** On the SSW, APD06 improved by more than 2 SD at posttest, putting her score within normal limits. Significant change in the SCAN–C was not observed; however, the pretest score was within normal limits (Table 3). Significant change was observed on the Spelling of Sounds subtest and the nonword repetition task (Table 4). APD06’s mother observed dramatic improvement in her daughter’s listening skills, on-task behavior, and effort in reading and writing. She reported that APD06 was more reflective, was trying harder, and showed increased interest in reading for herself as opposed to being read to.

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**CASE STUDIES: SUMMARY**

Three children participated in FFW, 2 in Earobics, and 2 in a traditional therapy program using commercially available materials. Immediately following intervention, significant improvement was found for all children on the SSW; on the SCAN–C total score, improved scores were found for 2 children in FFW, 1 child in Earobics, and 1 child in traditional therapy (see Figure 1). The second child in Earobics improved significantly on the SCAN–C Filtered Words subtest. By the time a follow-up evaluation was completed, the third FFW child had improved significantly on the total SCAN–C. For all children who participated in the follow-up assessment, improvements observed at posttest were maintained at follow-up.

The GORT–4, Letter-Word Identification and Spelling of Sounds subtests, and nonword repetition task did not show a consistent pattern of improvement. Clinically significant changes were sparse, with six instances of significant increases and three instances of significant decreases. All of the increases were on either Spelling of Sounds or nonword...
repetition. Profiles of individual children did not suggest systematic improvement, as can be seen in Figure 2. It is noticeable, however, that there is a general trend toward improvement on the nonword repetition task, with the exception of APD08.

The auditory processing results were compared to data from 4 children who were seen in the hearing clinic for auditory processing evaluations but who did not participate in the treatment study. At their initial evaluation, these children were 6 to 9 years of age; they were tested again about a year after their first evaluation. Their SSW and SCAN–C scores are shown in Table 7. For each of these children, the change in SCAN–C total score was within the 90% confidence interval. The SSW scores of 2 children (1 and 4) improved by more than 4 SD and more than 1 SD, respectively. None of the SSW scores was within normal limits by the second time of testing. We do not know if the comparison children received treatment for APD elsewhere. It appears that some improvement in auditory processing scores is to be expected over a year’s time, but the treatments administered in our study may have resulted in more consistent or rapid improvement than would otherwise be expected.

**DISCUSSION**

We have reported data from 7 children who participated in three treatments, including both formal and informal AT. Our results, in combination with other available data, suggest that intervention can positively affect performance on auditory processing tasks. There is reason to expect that a controlled efficacy study of any of the three treatments
we investigated would find improvements in auditory processing performance attributable to intervention, and these improvements could persist for some time. It will be important to investigate several different measures of auditory processing as it is possible that the auditory processing changes we observed were due to “teaching to the test.” All three treatment programs included practice in listening under conditions of competing and/or degraded signals—conditions that figure largely in the SCAN–C and SSW tests. More generally, the three treatments emphasized, and rewarded, sustained and focused attention to auditory stimuli.

We did not observe consistent improvement on our tests of phonological processing and literacy skills. There was some suggestion of improvement on nonword repetition, with 4 children across the three treatments making significant gains. Nonword repetition taps several aspects of phonological processing, so further research is needed to determine which aspects might be responsive to the treatments.

**Alternative Account of Improved Scores**

It should be noted that regression to the mean is a potential explanation for improvement from pretest to posttest. All of the children showed improvement in auditory processing, but they were selected to participate in the study based on their poor performance on these tests. Therefore, due to

**Table 7. Auditory processing scores of comparison participants.**

<table>
<thead>
<tr>
<th>Task</th>
<th>Comparison 1</th>
<th></th>
<th>Comparison 2</th>
<th></th>
<th>Comparison 3</th>
<th></th>
<th>Comparison 4</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>Time 1</td>
<td>Time 2</td>
<td>Time 1</td>
<td>Time 2</td>
<td>Time 1</td>
<td>Time 2</td>
<td>Time 1</td>
<td>Time 2</td>
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<tr>
<td>SSW</td>
<td>61</td>
<td>43</td>
<td>25</td>
<td>29</td>
<td>15</td>
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</tr>
<tr>
<td>SCAN-C Total</td>
<td>68</td>
<td>79</td>
<td>84</td>
<td>92</td>
<td>75</td>
<td>78</td>
<td>96</td>
<td>86</td>
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</tbody>
</table>

**Figure 2.** Pretest and posttest scores for all participants on the GORT–4 Oral Reading Quotient (top left), nonword repetition task (bottom left), WJ–III Spelling of Sounds subtest (top right), and WJ–III Letter-Word Identification subtest (bottom right); solid lines denote FFW participants, dashed lines Earobics participants, and dotted lines traditional therapy participants.
measurement error alone, it is to be expected that a second test score would be closer to the population mean (Campbell & Stanley, 1963). There are two sources of evidence relevant to regression to the mean. One is comparison to comparable, untreated children, as described above. These children provide an estimate of how much improvement, or regression toward the mean, is to be expected when tests are performed a second time. Another source of evidence is the follow-up testing completed by 4 of the treated children. The follow-up scores were consistently comparable to posttest scores and, in some cases, greater. If changes in scores are due mainly to measurement error, such a pattern is not to be expected.

APD06 was the only child whose parents reported dramatic improvements during and after treatment. APD06 was the youngest participant, and her auditory processing evaluation was conducted before her seventh birthday, several months before the beginning of the study. Due to neurological immaturity and lack of reliable behavioral tests for young children, diagnosis of APD for children under age 7 is considered difficult (Bellis, 2003), and it is possible that the changes that APD06’s mother observed were mainly due to maturation.

**FUTURE RESEARCH DIRECTIONS**

The results of these case studies suggest questions for controlled experimental research. Several case studies of FFW and similar treatments are available for children with language impairment (Friel-Patti et al., 2001; Gillam et al., 2001; Loeb et al., 2001; Thibodeau et al., 2001), and group studies of FFW intervention for children with reading disorders have been published (Hook et al., 2001; Pokorni et al., 2004). For children with APD, however, the only data come from our own case studies, case studies by Wertz and Hall (2002), retrospective data (Battin et al., 2000), and field trials including children with many communication disorders and little control over the inclusion criteria (Tallal, 2000).

Studies using rigorous group designs are needed to evaluate the effects of formal AT treatment packages such as FFW and Earobics. Based on the outcomes of our case studies, as well as our clinical observations, we suggest that informal AT should be compared with commercial formal AT programs. Dependent variables should include auditory processing measures that assess a range of functions (e.g., binaural integration, binaural separation, frequency and duration discrimination; see ASHA, 1996; Jerger & Musiek, 2000) and stimuli (both verbal and nonverbal) to determine if intervention effects are circumscribed or broad-ranging. The measures used in this study provided only a limited sample of processes; temporal processes in particular were not assessed but should be, especially in light of claims that FFW improves temporal processing specifically (Tallal, 2000).

In future studies, whether group or small n designs, individual profiles of auditory processing should be taken into account. We characterized our participants broadly as having “auditory processing difficulties,” which may have some ecological validity for SLPs who receive referrals accompanied by little detailed audiological testing information. Such an approach, however, is not consistent with best practices for diagnosis and treatment (ASHA, 1996, 2005; Bellis, 2003; Jerger & Musiek, 2000). Specific auditory processing deficits can be included as independent variables or covariates in group designs in order to investigate which treatment method is most efficacious for a particular auditory processing problem. Such investigations would have both theoretical and clinical significance.

We observed that the informal AT procedures were more enjoyable and motivating for the children than the computer programs. If similar results can be obtained for many children using informal AT, it may be preferred for this reason. In addition, it does not require the outlay of funds that FFW and Earobics do; on the other hand, the computer programs are less time-consuming for the clinician to manage, and a clinician can administer the intervention to more than one client at a time.

Although we did not observe consistent improvement on spoken language and reading measures, dependent variables in these domains should be used in future research. Measures of phonological processing may be of particular interest. We observed indications that nonword repetition may have benefited from treatment, and both FFW (Scientific Learning Corporation, n.d.) and Earobics (Cognitive Concepts, 1999) claim to improve phonological and/or phonemic awareness, which is considered crucial for literacy development (e.g., Goswami, 2000; Snow, Burns, & Griffin, 1998). Therefore, measures of phonemic awareness, phonological memory, and phonological representation would be appropriate outcome measures, along with reading measures related to decoding, that are thought to be dependent on phonemic awareness.

For both formal and informal AT intervention programs, research is needed to determine “dosage”; that is, how often should intervention be administered, for how long per session, and for how many days, weeks, or months. The schedule adopted for this study was very intensive. This intensity, we believe, contributed to the discontent experienced by the FFW participants, and to a lesser extent, the Earobics participants. In order to make intervention as enjoyable as possible, and for reasons of cost effectiveness, it is important to learn what intervention schedule is most efficient and when it is appropriate to discontinue intervention.

This set of case studies adds to the small body of empirical data regarding auditory training for children with auditory processing deficits. The results suggest that controlled experimental studies are warranted. A number of commercial intervention programs are available, and parents as well as service providers need high-quality data to help them determine how their money, time, and effort may be best invested.

**ACKNOWLEDGMENTS**

The authors gratefully acknowledge the Children, Youth, and Families Consortium at Penn State, which provided funding for the
study; the students who assisted in conducting it; and especially the children and parents who participated.

REFERENCES


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