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The Impact of Fast ForWord on Phonological Awareness and Literacy Skills

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THE IMPACT OF FAST FORWORD ON PHONOLOGICAL

AWARENESS AND LITERACY SKILLS

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BY

MELISSA NULTY

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THE IMPACT OF FAST FORWORD ON PHONOLOGICAL AWARENESS AND READING SKILLS

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Abstract

This study investigated the impact of Fast ForWord on individual children's phonological awareness and reading skills as well as general language and auditory processing skills. Five children, ages six through eight years, served as experimental subjects. The duration of participation in the Fast ForWord (FFW) training program was approximately 2 hours per day, 5 days a week, for 6 to 8 weeks. Fast ForWord training was completed when the subject reached at least 90 percent completion on five of the seven training exercises or when it was determined by the Fast ForWord professional that the child had received maximum benefit from the program. Three children, within the same age range, served as control subjects and did not receive any type of speech or language training. Results indicated that significant group mean gains (a minimal increase of one standard deviation) were not evidenced by the experimental subjects on any of the five assessment measures. The largest mean standard score increases were noted on the Language Processing Test-Revised (8 points) and the Test of Language Development-Primary:2 (4 points) . Individually, two subjects increased standard scores by a minimum of one standard deviation. None of the five children reached the FFW completion rate of 90% completion on five of the seven games. Post test data for the control subjects revealed a similar, slightly larger increase in standard scores as for the experimental subjects.

Chapter I

Introduction

In the course of development, most children acquire a spoken language. This achievement normally occurs without explicit instruction by parents or other adults. During the preschool period, most children pass easily and uneventfully through the stages of uttering and understanding sounds, single words, simple two- or three- word phrases and complex sentences. A small minority (approximately 8%) of children with normal hearing, motor abilities, and nonverbal intelligence fail to develop speech and language at or near the expected age (Tomblin, 1996).

Most cultures have a fully developed spoken language, but only a minority of these languages exist in written form. When a written form does exist, many speakers do not and cannot use it effectively (Blachman, 1991). An estimated 40-75% or more of children who evidence speech and language disorders during the preschool years, continue to demonstrate language and/or learning limitations in later academic settings (Aram & Hall, 1989). Strikingly, an estimated 35 million American adults (20% of the adult population) have difficulty reading (Stedman & Kaestle, 1987).

Reading shares many of the same processes and sources of knowledge as talking and understanding. Although spoken language and reading have much in common in terms of the knowledge and processes tapped, fundamental, nontrivial differences exist between the two. Knowledge of the similarities and differences between spoken language and reading is critical for understanding how children learn to read and why some children have difficulty learning to read (Kamhi & Catts, 1991). Perhaps the most basic difference between reading and spoken language processing lies in the input. For spoken language, the input is an auditory signal, whereas for reading, the input is a visual stimuli. Reading and oral language begin to share similar knowledge domains and processes at the word recognition stage. One similarity between reading and oral language is that the reader and listener use the same storage of word knowledge. The strategies used to access the lexicon in reading depends to a large extent on the sophistication of the reader (Barron, 1981; Frith, 1985). Reading by the early phonetic strategy encourages children to attend to the position and sequence of sounds/letters in words (Barron, 1981). In a later direct access strategy, the child predominantly uses segmental composition and order as cues for word recognition. Higher order processing is necessary for the child to comprehend more fully what is written or said. Reading and oral language share linguistic and conceptual knowledge (Kintsch & Kozminsky, 1977). For example, at the sentence processing level, both rely on the same syntactic and semantic rules, as well as similar memory codes. In oral language processing, information is generally stored in a phonetic code. Although written words begin as visual stimuli, once recognized they are held in a phonetic form for further processing (Banks, Oka, & Shugarman, 1981; Conrad, 1964; Perfetti & McCutchen, 1982). Therefore, regardless of whether one is reading or listening, verbal information may be stored temporarily in a phonetic code.

Perception of phonological sequences is one aspect of phonological awareness. Phonological awareness has been defined as the explicit awareness of the sound structure of language which includes the knowledge that words are composed of syllables and phonemes and that words can rhyme or begin/end with the same sound segment (Catts, 1993). Phonological awareness has been found by numerous authors to be an important precursor to reading ability (Kamhi, Lee, & Nelson, 1985; Magnusson & Naucler, 1990; Bird, Bishop, & Freeman, 1995). Catts & Kamhi (1986) have suggested that phonological processing deficits may underlie many reading disabilities as well as language disorders. These researchers proposed that some "low-level perceptual deficits identifying and discriminating phonemes and difficulty forming accurate representations of linguistic (or linguistic-like) information" (p. 344) may be a causal factor for both language and reading difficulties.

Researchers have attempted to develop perceptual training techniques to ameliorate these basic processing problems (Merzenich, et al., 1996; Tallal, Miller, et al., 1996). Recently, several investigators have developed a computer-assisted training program, Fast ForWord, acclaimed to correct auditory perception difficulties with exceptional results in approximately 6 to 8 weeks. Previous research of Fast ForWord indicated children participating in this training program demonstrated significant gains in their receptive and expressive language abilities and discrimination abilities (Tallal & Merzenich, 1997; Miller, Merzenich, Saunders, Jenkins, & Tallal, 1996; Tallal, Saunders, et al., 1996). Children's test scores on a variety of assessment procedures revealed significant gains when comparing pre- and posttest scores following Fast ForWord training.

Despite these positive findings, a number of concerns have been cited regarding the reports of phenomenal success by the authors of the Fast ForWord program. As reported by Brady, Scarborough, and Shankweiler (1996), one concern is that not enough information was provided about the exact nature of the linguistic strengths and weaknesses of the language-impaired children that served as subjects. Additionally, recent accounts of the research in the popular press have made unsubstantiated statements that such training may aid individuals with reading impairments. The authors of Fast ForWord have not documented its effect on phonological awareness skills or reading ability. Therefore, the purpose of the present study is to determine the effectiveness of Fast ForWord on 5 children's phonological awareness and literacy skills as well as other language and auditory processing skills.

Chapter II

Review of Literature

In reviewing the literature for the present study, several areas of related research were considered. The chapter begins with a review of the relationship between children's speech-language deficits and academic difficulties. A summary of tasks involved in reading is then presented. The review also focuses upon the relationship between phonological awareness and literacy skills. Recent studies have demonstrated that auditory and speech perception difficulties may be a common underlying factor in both language and reading impairments (Bird, Bishop & Freeman, 1995; Catts & Kamhi, 1986). Researchers have attempted to develop perceptual training techniques to ameliorate these basic processing problems (Merzenich, et al., 1996; Tallal, Miller, et al., 1996). Because a specific goal of this study was to evaluate the Fast ForWord program, the remainder of the chapter reviews studies that report the effects of training with this program (Tallal, Saunders, et al., 1996; Miller, et al.,1996; Tallal & Merzenich, 1997).

Speech Language Deficits and Academic Difficulties

Approximately 8% of children with normal development in hearing, motor abilities, and nonverbal intelligence fail to develop speech and language at or near the expected age (Tomblin, 1996). Numerous researchers have emphasized that language development represents the major learning task during the early education years which develops the foundation for later academic achievement (Aram & Hall, 1989). Deficits in language comprehension or expression may interfere with successful academic learning. An estimated 40-75% or more of children who present with speech and language disorders during the preschool years continue to demonstrate language and/or learning limitations in later academic settings (Aram & Hall, 1989).

Hall and Tomblin (1978) investigated 36 subjects with either articulation or language impairments. Language-impaired children exhibited more academic difficulties when compared to articulation-impaired children in the area of reading, but also in mathematics, language, and vocational skills. In a follow-up parent survey 13 to 20 years later of their adult children's abilities, 50% of language-impaired children's parents reported that their child continued to demonstrate some type of communication difficulty; however, only one parent of a child with past articulation problems reported continued difficulty. All subjects completed high school; however, significantly fewer language-impaired subjects than articulation-impaired subjects pursued higher education.

Catts (1993) reported on the relationship between speech-language impairments and reading disabilities of 56 children with articulation or language difficulties and 30 normally developing children. Several standardized speech-language measures were used to evaluate the children in kindergarten. Initial results indicated that, as a group, children with speech-language deficits performed lower than their peers. Subjects' reading abilities were also analyzed in first and second grade. Results revealed language-impaired children's reading skills were significantly more deficient than the normally developing children's and articulation-impaired children's reading skills. The articulation-impaired subjects scored within normal limits on the Gray Oral Reading Test-Revised and on the Word Identification and Word Attack subtests from the Woodcock Reading Mastery Tests-Revised, and did not differ significantly from the normally developing children's reading scores.

Additional research studies have suggested that articulation ability was not related to reading achievement. A study by Stackhouse (1982) found that children with organic speech disorders, such as dysarthria or cleft palate, did not evidence significant difficulties in reading acquisition. Similarly, research by Levi, Capozzi, Fabrizi, and Sechi (1982) demonstrated no significant difficulties in reading achievement for children with functional articulation delays.

Silva, Williams, and McGee (1987) studied language delayed children initially tested in preschool with retesting at ages 7, 9, and 11. The children with either expressive or receptive language delays exhibited reading scores which were 2 years delayed at age 11. Subjects with both receptive and expressive deficits demonstrated a 2 ½ year delay in reading scores. Therefore, children with both receptive and expressive language impairments were impacted the most in academic areas such as reading and vocabulary.

Levi, et al. (1982) supported the idea that language difficulties play a critical role in children's reading disabilities. In a study involving 32 children, 16 with phonological impairments and 16 with both phonological and language difficulties, the researchers found the presence of reading difficulties to be related to the perseverance, quality, and intensity of the language disorder. Children with phonological and language deficits performed below their counterparts on literacy measures.

Stark, et al. (1984) examined a group of language-impaired children initially identified at 4 to 8 years of age. This study was conducted to assess language and reading skills when the children were 8 to 12 years of age. Twenty-nine language-impaired children and 14 normally developing children participated in the study. All subjects scored within a normal range for nonverbal intelligence. All language-impaired children had been receiving therapy prior to the study. The language-impaired children's overall language age was at least 12 months below chronological or mental age. A comprehensive assessment including intelligence, receptive language, expressive language, speech articulation, and reading tests was administered. The Gates McGinitie Reading Test results indicated that 23 of 29 language-impaired subjects demonstrated a reading deficit of at least two grade levels, while normally developing children exhibited reading scores at or above chronological age level. Of the language-impaired subjects, 90% demonstrated some degree of reading impairment at follow-up 3 to 4 years later, with most requiring remedial instruction.

Menyuk, et al. (1991) conducted a 3 year study with the goal of predicting reading problems in at-risk children. Subjects included 130 children between the ages of 53 to 77 months and consisted of 23 children with specific language impairments (SLI), 32 children who were prematurely born, and 87 children in an at-risk group. The criteria for the SLI group was defined by at least 6 months delay in receptive language age, coupled with an expressive language deficit of at least 12 months below chronological age. Reading test results from the Wide Range Achievement Test noted more SLI children (50%) exhibited reading problems than the other two groups (at-risk 33% & premature 31%). The authors hypothesized that the differences among these groups of children might lie in the development of their processing skills which affect both oral language processing and reading ability. Findings from analyzing all test results indicated that semantic processing, the ability to retrieve lexical items rapidly, and perception of phonological sequences in words, were significant precursors to successfully learning to read.

Reading

Learning to read is a complex task. Reading requires the decoding of unknown words, as well as the comprehension of those words. Specific problem areas for children who have difficulty acquiring decoding skills may include deficits in phonological awareness, auditory perception, attention, knowledge of morphological rules, sequential memory, and visual perceptual ability. Descriptions and components of these decoding skills are described in Table 1.

Phonological Awareness and Literacy Skills

Phonological awareness is one of the fundamental skills cited by Ratner and Harris (1994) for decoding novel printed words when reading. Phonological awareness has been defined as the ability to reflect on and manipulate the sound structure of an utterance as distinct from its meaning (Stackhouse, 1997). Catts (1993) stated that phonological awareness is the explicit awareness of the sound structure of language which includes the knowledge that words are composed of syllables and phonemes and that words can rhyme or begin/end with the same sound segment. Several researchers have investigated the relationship between phonological awareness and reading achievement.

Table 1

Skills Required to Decode Unknown Printed Words

Skill	Description
Phonological Awareness Skills	Awareness of differences and similarities between phonemes Knowledge of phonological rules of the language Ability to blend individual phonemes into a meaningful word Knowledge of sound-letter association Ability to combine sounds into larger units
Auditory Perceptual Skills	Ability to isolate a sound within a word in initial, medial, and final position Ability to perceive relationships between words that rhyme (i.e., to perceive the sounds of parts of two or more words that sound the same Ability to perceive the double sound of consonant blends in words, such as *play* and *table* (e.g., *bl, br, cl, cr, dr, dw, fl, tr, gr, pl, gl, pr, sc, sk, sl, sm, sp, st, ng)* Ability to perceive the consonant combinations that represent one sound (*sh, th, wh, ch, ph, ng, gh*) Ability to perceive differences between the sounds of short vowels in words, such as *fan, fin, fun, tan, tin, and ten.* Ability to perceive the sounds of vowel combinations (e.g., *ie, ea, oo, oi, oa, ai*)
Attentional Skills	Ability to focus attention on a specific sound or task Ability to sustain attention for the length of time it requires to complete a specific task
Knowledge of Morphological Rules	Ability to divide perceived words into their smallest grammatical units, or morphemes (e.g., *unanswerable* contains *un*, *answer*, and *able*)
Sequential Memory	Rapid recognition and retrieval of the letters and words Ability to remember the order of phonemes that when combined comprise a word Ability to recall the sounds within a word and words within a phrase or sentence Ability to recall from memory the syntactical, phonological, and morphological rules that govern the arrangement of words in a phrase or sentence
Visual Perceptual Ability	Ability to distinguish different letter shapes and sizes Ability to perceive the differences between the amount of space separating letters within words and that which separates words in a phrase or sentence Ability to distinguish the direction and orientation of different letters

Note. From Understanding language disorders: The impact on learning (pp. 197-198), by V. L. Ratner and L. R. Harris, 1994, Eau Claire, WI: Thinking Publications.

The metalinguistic knowledge of words, syllables, and sounds was measured in 15 language-impaired children between the ages 3 to 6 to identify discrepancies in their phonological awareness skills as compared to normally developing children (Kamhi, Lee, & Nelson, 1985). Assessment procedures consisted of children dividing sentences and words into smaller units. The authors found that more than half of the language-impaired children could not divide monosyllabic words into smaller sound units when compared to their peers. Language-impaired children were also significantly delayed in their word awareness skills, such as the knowledge of what words were and their ability to answer questions about different words. Since the language-disordered children exhibited delays when compared with normal children, they were identified as at-risk for future academic problems, especially learning to read.

Research by Magnusson and Naucler (1990) analyzed several linguistic and metalinguistic tasks to determine which skills were most related to reading achievement. Thirty-seven matched pairs of language-learning impaired children and normally developing children participated in this study. Data was collected one year prior to and following first grade from numerous standardized tests. The investigators reported language-learning impaired children were deficient in language comprehension, syntactic/morphological production, and phonological awareness as compared to normally developing children. Language-learning impaired children experienced more difficulty than normally developing children on reading and spelling tasks. Syntactic production and language comprehension were found to be highly correlated with reading and spelling abilities. Measures of phonological awareness, however, were the best predictor of reading achievement.

Similarly, a longitudinal study conducted by Bird, Bishop, and Freeman (1995) evaluated the phonological awareness skills of a group of 31 males ages 5.0-7.4 at initial assessment. These children were reassessed at ages 79 and 91 months using measures of phonological awareness and literacy skills. Nineteen children exhibited only expressive phonological impairments and 12 exhibited phonological disorders and additional language difficulties. Normally developing boys served as a control group and were individually matched with children exhibiting phonological deficits. Phonological awareness tasks included rhyme matching, onset matching (same initial consonant), and onset segmentation and matching. Literacy measures included identification of letter names and sounds, nonword reading, and nonword spelling. Children who exhibited phonological impairments, regardless of whether additional language problems existed, performed lower on phonological awareness and literacy tasks than normally developing children. Tasks requiring segmentation and matching of onset and rhymes were consistently difficult for speech-language impaired children. The data suggest that children with expressive phonological impairments have difficulty identifying sounds within syllables. This deficit analyzing speech input may contribute to difficulties in both speech production and the acquisition of reading skills.

Auditory and Speech Perception Difficulties

Catts & Kamhi (1986) have suggested that phonological processing deficits may underlie many language and reading disabilities. These researchers proposed that some "low-level perceptual deficits identifying and discriminating phonemes and difficulty forming accurate representations of linguistic (or linguistic-like) information" (p. 344) were a causal factor for both language and reading difficulties. Auditory perceptual dysfunction has been suggested by numerous researchers as the primary underlying factor in reading disabilities and language impairment for many children (Haggerty & Stamm, 1978; Katz & Wilde, 1985; McCroskey & Kidder, 1980; Pinheiro, 1977; Rees, 1973, 1981; Willeford, 1977).

Reading Difficulties

Some researchers have suggested that dyslexia has an underlying auditory basis (Galaburda & Kemper, 1979; Haggerty & Stamm, 1978; Katz & Wilde, 1985; McCroskey & Kidder, 1980; Pinheiro, 1977; Rees, 1973, 1981; Willeford, 1977). Defining what constitutes dyslexia has proven to be no easy task (Hynd & Cohen, 1983). Wheeler and Watkins (1979) define dyslexia as children who have adequate intelligence, but experience a general language deficit which is a specific manifestation of a wider limitation in processing all forms of information in short-term memory, whether visually or auditorally presented.

A large body of evidence suggests that poor reading ability is due to deficits in underlying phonological processing skills (Blachman, 1994; Brady & Shankweiler, 1991), and that dyslexia is linguistically based (Vellutino & Scanlon, 1987). It has been proposed that difficulties experienced by poor readers on auditory processing tasks are specific to speech encoding, not a general auditory processing problem (Vellutino & Scanlon, 1989). Studdert-Kennedy and Mody (1995) argue that the phonological awareness deficit encountered by poor readers is a problem with rapid perception specific to linguistic stimuli. Similarly, Mody, Studdert-Kennedy, and Brady (1997) documented that poor readers who exhibited problems discriminating rapidly presented synthetic /ba/ and /da/ syllables, did not have coinciding difficulty with equally rapid non-speech stimuli presentations. Tobey and Cullen (1984) measured temporal integration for tone and tone-sweep stimuli and discovered no difference in the temporal processing ability between children with auditory memory and reading problems versus age-matched normally developing children.

An alternate theory proposed by investigators is that children with poor reading skills have difficulty with rapid-temporal processing tasks (Eden, Stein, Wood, & Wood, 1995; Tallal, Miller, & Fitch, 1993). Reed (1989) stated that children with reading problems may also struggle in discriminating brief auditory cues. Tallal and colleagues (1993) have suggested that dyslexic children have a general language problem characterized as phonemic dysfunction, which is based on temporal-processing deficits in multiple sensory modalities. In a review of literature, Farmer and Klein (1995) examined the evidence for a temporal-processing deficit related to reading problems. The authors noted consistent evidence for a multi-sensory temporal-processing deficit of both auditory and visual tasks requiring sequential processing of two or more stimuli.

Language Impairment

Lubert (1981) reviewed previous research which suggested that children with specific language impairment have difficulty processing rapid sequences of brief sounds. Specific language impairment (SLI) is used to describe disorders of children who demonstrate deficits in language performance, without additional deficiencies in other domains. In a study by Wright et al. (1997) children with language impairment evidenced significant problems perceiving short-duration tones. Numerous researchers have found children with SLI evidenced difficulties in a range of domains such as auditory, visual, tactile and phonetic perception, as well as motor tasks (Bishop, 1990; Haynes & Naidoo 1991; Hughes & Sussman, 1983; Johnson, Stark, Mellitis, & Tallal, 1981; Powell & Bishop, 1992). Due to these deficits, Locke (1994, 1997) theorized that language-impaired children have a generalized neuromaturational delay. Other research has suggested that the primary deficit is neurally processing rapid events, concluding that these children can be distinguished by an inability to process quickly changing multi-sensory stimuli (Anderson, Brown, & Tallal, 1993).

Stark and Heinz (1996) examined phoneme perception skills of children with receptive language impairments only, and children with both receptive and expressive language deficits. A serial-ordering task incorporated by the authors required the children to replicate a sequence of /ba-da/ phonemes with a panel-press procedure. This task involved the ability to create motor sequences in response to auditory stimuli. Only the children in the receptive and expressive language disorder group had difficulty discriminating /ba-da/ syllables. Both groups of children performed poorly on the serial-ordering task. The authors hypothesized that a perceptual deficit accounted for the poor performance by the children with both receptive and expressive problems, although a motor-sequencing deficit could explain the results as well.

Computer Training Utilizing Altered Speech

Longitudinal studies have demonstrated persistent delays in the development of language, as well as slower progression, despite conventional therapeutic intervention with language-learning impaired children (Rissman, Curtiss, Tallal, 1990; Curtiss, Katz, Tallal, 1992). Recently, researchers have attempted to develop perceptual training techniques for ameliorating basic auditory processing problems suggested to be the basis for language impairment (Merzenich, et al., 1996; Tallal, Miller, et al., 1996). The first of these was developed by Paula Tallal, Michael Merzenich, and their colleagues. The techniques consisted of two computer games one that utilized temporally modified speech and nonspeech temporal integration training (identifying rapidly successive tones) and the second incorporated phoneme identification. One-on-one training with clinicians in speech and language exercises occurred in addition to the training with computer games, presented via headphones, that adaptively trained temporal processing and phoneme identification.

Subjects were seven children between the ages of 5 and 9 years. All subjects had a nonverbal IQ of 80 or above on the Wechsler Intelligence Scale for Children. The authors reported all subjects scored at least one standard deviation below the mean in receptive and expressive language skills as measured by the Token Test for Children, the Goldman-Fristoe-Woodcock Auditory Discrimination Test, Curtiss and Yamada Comprehensive Language Evaluation-Receptive, the Goldman-Fristoe Test of Articulation, and the Tallal Repetition Test. All subjects initially demonstrated severe auditory processing deficits, specifically two-tone sequencing ability, on the Tallal Repetition Test. The investigators hypothesized that through alteration of fluent speech and modification of the acoustic process children might learn to recognize consonants not previously perceived.

The two computer games used in this study included the Circus Sequence game and the Phoneme Identification game. Both games began with stimuli easy to perceive. The games included long nonverbal stimuli (60 ms) or consonant transition (65-70 ms) durations, presented with long interstimulus intervals (ISIs) (500 ms) and with increased amplification of consonants. These training variables were altered progressively to approximate normal speech characteristics in both games. Children received feedback in both games by audio and visual reinforcements for correct responses. The children earned points on a point accumulator for correct but not incorrect responses.

One of the computer games, Circus Sequence, was a perceptual identification task which consisted of four stimulus sets of 60 ms-duration tone sweeps with starting or ending frequencies of 500, 1000, 2000, and 4000 Hertz (Hz). The second computer game, entitled the Phoneme Identification game, required children to identify stop consonants presented with brief formant transitions. The stimuli used were /be/, /de/, and /ge/ targets and foils.

Speech and language exercises with a speech-language pathologist (SLP) were included to maintain the children's attention and provide motivation. In general, the speech and language exercises consisted of acting out commands in a Simon Says format with props, pointing to pictures or blocks in response to commands, repeating syllables, nonsense words, actual words or sentences verbatim, and pointing to pictures corresponding to spoken words. Commands of increasing complexity and length were used throughout training with the SLP. Immediate feedback models were given by the

SLP in listening games if the child answered incorrectly, giving the child a second opportunity to process the information accurately.

Intensive training occurred with subject participation 3 hours a day, 5 days a week at the laboratory and as homework for 2 hours per day, 7 days a week during a 20-day period. Circus Sequence temporal training exercises were conducted for 19 to 28 of the sessions for 20 minutes each over the 4-week training period. Phoneme identification task specific training time was not clearly specified.

The Tallal Repetition Test was used to determine improvements in temporal event recognition and sequencing abilities for tones. Posttrainingresults indicated a significant difference in the children's ability to sequence two-tones, discriminate between tones with shorter ISIs and tone duration. The Goldman-Fristoe-Woodcock Diagnostic Auditory Discrimination Test revealed 6 of 7 subjects made significant improvements in phoneme discrimination. The gain was approximately 2 years in age equivalency for discriminating speech sounds. The Token Test also revealed an average gain of 2 years in age equivalency for following auditory commands of increasing length and grammatical complexity. The investigators measured change in grammatical comprehension using the Curtiss and Yamada Comprehensive Language Evaluation-Revised (CYCLE-R). The average age equivalency gain was 1 ½ years. A strong correlation was found between the children's ability to sequence and segment successive rapidly presented auditory sweep tones correctly and their posttrainingreceptive language scores.

The two games were modified following the first study in an attempt to increase performance consistency and better maintain attention. The second version of the Circus Sequence game was altered so that tone variations in each set were extended to 135 Hz. Tones with durations of 60, 40, and 20 ms were included, as opposed to only 60 ms as in the first trial. An animated performance barometer was included to further indicate progress. To encourage better attention, five misses in a row resulted in a decrease of difficulty level, and subjects were not allowed to increase the difficulty until a certain number of correct responses were obtained. The Phoneme Identification game was revised to include progressively adaptive tasks. The stimuli used were five consonant-vowel (CV) pairs which included /ba/ vs. /da/, /be/ vs. /de/, /fa/ vs. /va/, /aba/ vs. /ada/, and /ba / vs. /da /. As criteria were met, task difficulty increased by reducing the length of the consonant elements, differential intensification of fast consonant elements was progressively faded, and the ISIs for consecutive CV's were progressively reduced. A performance barometer was also added to the Phoneme Identification game.

Additional games were also included for the second study. The two new games were designed to facilitate generalization from the first two games to encompass a wider range of temporal sequence events and phonemic contexts that occur in natural speech. Old McDonald's Flying Farm was designed to further increase the subject's identification of phonemes. The main variables included the duration of a wider range of simulated consonants and the ISIs between the repeated consonants. Phonic Match targeted sound matching in which subjects were required to identify identical sounds in a matching format. The main variables consisted of the temporal structure of the phonemes and the phoneme sequences in individual consonant-vowel-consonant (CVC) words.

Subjects were 22 children between the ages of 5.2 to 10.0, with a mean nonverbal IQ of 96.4 as measured by the Wechsler Intelligence Scale for Children. Assessment procedures of the first study were replicated for the second. Initially, all subjects exhibited a severe delay in expressive and receptive language development, marked temporal processing deficits, and reading problems. Subjects were divided into two groups, modified speech training and natural speech training. The two matched groups were determined according to pretraining test measures of nonverbal IQ, receptive language abilities, gender, and age.

Training exercises were similar to the format of the first study. The modified speech training group received computer games that adaptively trained temporal processing and language exercises that utilized acoustically modified speech. The natural speech training group received essentially the same treatment; however, computer games were not temporally adaptive and natural speech was used for the language exercises. Subjects participated in these games for 3 ½ half hours per day, 5 days a week at the laboratory with supplemental homework for 2 hours per day, 7 days a week during a 20-day period. The additional homework was presented entirely in the form of recorded children's stories on tape with children receiving acoustically modified versions or natural speech versions, depending on the training they received.

Posttraining assessment procedures were similar to those used in the first study. Improvement made by the children receiving modified speech was significantly greater [$F(1,20) = 5.44$, $p= .0015$] than that of the children receiving natural speech as measured by the Goldman-Fristoe-Woodcock Auditory Discrimination Test, the Tallal Repetition

Test, and the Token Test for Children. The Tallal Repetition Test was used to determine improvements in the temporal event recognition and sequencing abilities for tones. The children who received modified speech training scores on the Tallal Repetition Test increased; however, the children who received natural speech training showed no significant improvement following the 4-week training period. The group that received modified speech training increased by 1.25 standard deviations. The Goldman-Fristoe-Woodcock Diagnostic Auditory Discrimination Test noted a larger increase in phoneme discrimination in the group that received modified speech training than the group that received natural speech training. A gain of almost one standard deviation was noted in the group that received modified speech training, whereas the group that received natural speech training demonstrated only a .5 standard deviation increase in scores.

The Token Test measured the children's ability to follow auditory commands of increasing length and grammatical complexity. Children in the modified speech training group demonstrated a .5 standard deviation increase on the Token Test, while a .2 standard deviation gain was noted by children in the natural speech training group.

The investigators measured change in grammatical comprehension using the CYCLE-R. Children in the modified speech training group increased pretest scores by .8 standard deviation, whereas the natural speech training group improved scores by .5 standard deviation.

Longitudinal follow-up data was taken 6 weeks and 6 months after completed training in the second study (Tallal, Miller, et al., 1996; & Tallal & Merzernich, 1997). Children that received modified speech training and children that received natural speech training participated in the study. At 6 weeks posttraining, the modified speech training group demonstrated a .4 standard deviation increase in scores when compared to scores gathered immediately following training completion. The children in the natural speech training group increased their scores .3 standard deviations at 6 weeks posttraining. Six months after training was completed, the children in both groups demonstrated a .1 standard deviation increase in scores taken at 6 weeks posttraining. Data indicated continued improvement in both groups; however, the children that received the modified speech training achieved significantly higher scores than the children that received the natural speech training. These results indicate the benefits gained through modified speech training were maintained and increased over time.

The results of the first and second study (Tallal, Miller, et al., 1996; & Merzenich, et al., 1996) indicate that providing language-learning impaired children with an acoustically modified signal that can be adequately processed, while reducing the existing temporal processing deficit achieved through adaptive training, greatly enhanced language-learning impaired children's ability to process naturally occurring speech.

In an attempt to combat early language impairment and subsequent academic disorders such as reading, a collaboration between Dr. Paula Tallal, Dr. Steven Miller, Dr. Michael Merzenich, and Dr. William Jenkins produced Fast ForWord (FFW). Fast ForWord consists of seven adaptive training exercises in computer game formats created to enhance auditory processing, phonological awareness, and language processing skills in language learning impaired children. Fast ForWord uses artificial speech, digitized human speech, tones, and sounds. Speech characteristics and sounds, primarily consonants, are modified as the child advances through the program. Initially, the speech sounds are separated by a longer duration (250 ms), but as the child's auditory processing skills improve, the length of separation is shortened to 20 ms.

Seven adaptive training exercises comprise Fast ForWord, which include three sound and four word tasks. The three sound training exercises used are entitled Circus Sequence (process and sequence tonal skills), Old MacDonald's Flying Farm (distinguish phonemic sound changes), and Phoneme Identification (identify specific phonemes). In the sound exercises, complex auditory stimuli are presented in a tone format using different frequencies, time durations, and phonemes. An ongoing performance evaluation is used for monitoring task difficulty level to insure that each child is correctly responding 80% of the time. The four word exercises are Phonic Match (memory and reasoning skills using simple word structures), Phonic Word (phoneme and word recognition skills for complex words), Block Commander (listening comprehension and syntactic rules), and Language Comprehension Builder (increasingly complex sentence to develop higher-level language). The word exercises consist of words presented either in isolation or within sentences with distinct linguistic complexity levels. Acoustically modified speech is used to enhance the phonetic components of natural speech. Speech processing difficulty levels for these exercises are arranged in a hierarchy, from an easier Level One to a more complex Level Five. Level 5 presents the child with natural, unmodified speech. All seven training exercises incorporate animations to maintain the child's interest and to reward correct responses.

Research supports the notion that intense perceptual training with Fast ForWord improves language skills. Miller, et al. (1996) conducted a study using 106 children with attentional deficit disorder (ADD) and language learning impairment (LLI). The primary focus of the research was to determine if differences exist between ADD and LLI children in their ability to improve auditory speech reception skills. The Token Test for Children and the Clinical Evaluation of Language Fundamentals (CELF) were administered before and after training. Dramatic improvement in language comprehension was evidenced, with 82.5% of the children increasing their scores on the Token Test for Children. Similarly, children's scores rose from the moderate-mild deficit range to within normal limits on the CELF. The researchers reported that both groups of children benefitted tremendously in language comprehension from the computer-guided training and no significant differences existed between the groups.

In a large national field test study (Tallal & Merzenich, 1997), 533 children (377 male, 153 female) participated in Fast ForWord training exercises. Subjects participated in computerized training sessions an average of 1 hour and 40 minutes per day, 5 days per week. Children participated in the program until the criterion of 90% accuracy was achieved on five of seven games at the most difficult level incorporating natural speech. Duration of participation was generally between 6 to 8 weeks, with no subject's program extending longer than 50 days. Training exercises were administered either in a home setting (approximately 200 children) or in clinics, special education settings, or elementary schools (approximately 300 children) throughout the United States. Subjects exhibited a wide range of diagnostic labels, some of which included central auditory processing disorder, pervasive developmental disorder, attention deficit disorder, and language-impaired.

Results gathered from a variety of assessment measures indicated significant gains in the subjects' receptive and expressive language abilities and discrimination abilities. The GFW demonstrated subjects' abilities to be approximately 1.5 standard deviations below the mean on pretest measures. Following Fast ForWord training, the children's scores on the GFW were near the mean in quiet conditions and slightly above the mean in the noise conditions.

The Token Test for Children was administered to 329 subjects. Pretest scores were approximately 2 standard deviations below the mean, while posttest scores improved by more than one standard deviation. Forty-five percent of the children scored at or above the mean following FFW training.

Two standardized test batteries were used to assess a portion of the subjects' receptive and expressive language abilities. The Clinical Evaluation of Language Fundamentals (CELF) was administered to 148 children. Pretest results on the CELF demonstrated mean receptive and expressive language scores more thanone standard deviation below the mean. Following training, receptive and expressive test scores entered the range which the test described as within normal limits. The Test of Language Development Primary (TOLD-P) was administered to 77 subjects and the TOLD-Intermediate was administered to 50 subjects. Pretest results on both tests showed scores approximately one standard deviation below the mean on the composite language quotient. Posttrainingresults showed significant gains across all subtest quotients, with scores approaching or exceeding the mean.

Training focused specifically on adaptive temporal discrimination tasks has been found to increase the language abilities of children with language impairment (Merzenich, et al., 1996; Tallal, Miller, et al., 1996; Tallal & Merzenich, 1997). As reported by Brady, Scarborough, and Shankweiler (1996), however, the posttraining gains documented by Merzenich et al. (1996) and Tallal, Miller, et al. (1996) are difficult to interpret for many reasons. These include the following: a) not enough information was provided about the exact nature of the linguistic strengths and weaknesses of the language impaired children; b) little is known about one of the testing instruments used (CYCLE-R, an unpublished test); and c) clarification is needed about which aspects of the versatile intervention program were essential.

The authors of Fast ForWord have not documented improvement of reading skills following the training program in any research study. Nevertheless, accounts of the research in the popular press have made unsubstantiated statements that such training might help dyslexics. Although it appears logical that Fast ForWord training may improve several of the skills necessary to decode words when reading, research is needed to substantiate this hypothesis. Therefore, more research is needed to establish the effect of Fast ForWord on reading problems.

Summary and Statement of Objectives

Researchers estimate that more than half of preschool children with speech and language disorders will continue to demonstrate language and/or learning difficulties in later academics (Aram & Hall 1989). The academic area most commonly effected was reading (Silva, Williams, & McGee, 1987; Stark et al., 1984). Investigators have suggested that children with language impairments frequently exhibit poor phonological awareness skills. Phonological awareness skills have also been found to be highly related to reading achievement (Magnusson & Naucler, 1990).

Auditory perceptual dysfunction has been suggested as an underlying factor in language impairment as well as reading disabilities (Haggerty & Stamm, 1978; Katz & Wilde, 1985; McCroskey & Kidder, 1980; Pinheiro, 1977; Rees, 1973, 1981; Willeford, 1977). Research has suggested that language-impaired children have difficulty processing rapid sequences of brief sounds (Anderson, Brown, Tallal, 1993; Lubert, 1981; Wright et al., 1997). Similarly, others have proposed that children with poor reading skills have difficulty with rapid-temporal processing tasks (Eden, Stein, Wood, & Wood, 1995; Reed, 1989; Tallal, Miller, & Fitch, 1993). A general language problem characterized as phonemic dysfunction, which is based on temporal-processing deficits in multiple sensory modalities, is one hypothesis for children's reading difficulties (Farmer & Klein, 1995; Tallal, Miller, & Fitch, 1993). Poor readers have been found to exhibit difficulties perceiving rapidly presented linguistic stimuli, which many contribute to reading problems (Mody, Studdert-Kennedy, & Brady, 1997; Studdert-Kennedy & Mody, 1995; Vellutino & Scanlon, 1989).

Researchers have developed perceptual training techniques to improve auditory processing skills (Merzenich, et al., 1996; Tallal, Miller, et al., 1996). In an attempt to combat early language impairment and subsequent academic disorders, a collaboration between Dr. Paula Tallal, Dr. Steven Miller, Dr. Michael Merzenich, and Dr. William Jenkins has produced Fast ForWord. The Fast ForWord program consists of seven adaptive training exercises in computer game formats created to enhance auditory processing, phonological awareness, and language processing skills in language-learning impaired children.

Previous research of Fast ForWord indicated that children who participated in this training program demonstrated significant gains in receptive and expressive language abilities and discrimination abilities (Tallal & Merzenich, 1997; Tallal, Saunders, et al., 1996). Children's test scores on a variety of assessment procedures, including the Goldman-Fristoe-Woodcock Auditory Discrimination Test, the Token Test, The Clinical Evaluation of Language Fundamentals, and the Test of Language Development-Primary, all revealed significant gains when comparing pre- and posttest scores following FFW training.

The recent advances made by Tallal, Merzenich, and colleagues in perceptual training for remediation of language learning impairments have led to dramatic improvements in speech reception skills. Recent accounts of the research in the popular press have made unsubstantiated statements that such training might help individuals with reading impairments. However, the producers have only reported group mean gains in the program for large numbers of children. They have not presented detailed descriptions of individual children's language skills before and after training. The authors of Fast ForWord also have not documented its effect on phonological awareness skills or reading ability. Therefore, the purpose of this study is to examine the effect that Fast ForWord has on children's phonological awareness and reading skills.

The specific primary research questions asked in the study are:

1. Do individual children who receive Fast ForWord training evidence a significant gain of greater than one standard deviation on The Phonological Awareness Test?

2. Do individual children who receive Fast ForWord training evidence a significant gain of greater than one standard deviation on the Test of Early Reading Ability-2?

Additional secondary research questions are as follows:

1. Do individual children who receive Fast ForWord training evidence a significant gain of greater than one standard deviation in their general language skills?

    a. Do individual children who receive Fast ForWord training evidence a significant gain of greater than one standard deviation in their expressive language skills, as measured by the Language Processing Test-Revised and the Test of Language Development-Primary?

    b. Do individual children who receive Fast ForWord training evidence a significant gain of greater than one standard deviation in their auditory perceptual skills, as measured by the Screening Test for Auditory Processing?

Chapter III

Method

Overview

The purpose of this study was to determine the effects of Fast ForWord training on children's phonological awareness and reading skills. Five language-impaired children received Fast ForWord (FFW) training for approximately 2 hours per day, 5 days a week, for 6 to 8 weeks. Three language-impaired children served as a comparison control group. The Phonological Awareness Test (PAT) and The Test of Early Reading Ability-2 (TERA-2) were administered pre- and posttest to evaluate the effects of the FFW program on phonological awareness and reading skills. In addition, the Language Processing Test-Revised (LPT-R), the Test of Language Development-Primary (TOLD-P:2), and the Screening Test for Auditory Processing Disorders (SCAN) were used to identify other skills impacted by Fast ForWord. These measures also facilitated a more thorough description of the subjects' strengths, weaknesses, and progress.

Subject Selection

Experimental subjects were 5 children between the ages of 6:0 and 8:6 at the initial time of assessment who were enrolled in the Fast ForWord program. The experimental subjects scored one standard deviation below the mean on The Phonological Awareness Test and the Test of Early Reading Ability-2. Subjects' initial performance might also have been below the mean on other testing measures which included the Language Processing Test-Revised, the Test of Language Development-Primary:2, and the Screening Test for Auditory Processing Disorders. However, the scores on the LPT-

R, TOLD-P:2, and SCAN, did not have to be below the mean to qualify for the study. Two subjects, Subjects 3 and 4, did not score a minimum of one standard deviation below the mean on the TERA-2. However, these subjects were included in the study as the PAT standard scores were at least one standard deviation below the mean and the subjects were within the target age range.

Several of the experimental subjects had received speech and language services previously. Subject 1 received speech and language services during the educational year through the Eastern Illinois University Speech-Language-Hearing Clinic twice per week for 50 minutes to improve expressive and receptive language skills. Subject 2 did not receive speech and language services during the school year, however, this subject had been identified as having reading difficulties by the parents and classroom teacher. Subject 2 was born with neurofibromatosis and had been diagnosed with attention deficit hyperactivity disorder (ADHD) and learning disabled (LD). Subjects 3 did not receive speech and language services during the school year, however, this subject had been identified as having reading difficulties by the classroom teacher. Subject 4 received speech and language services throughout the school year four times per week for 60 minute sessions targeting language processing deficits. Subject 5 received speech and language services throughout the educational year twice per week for 60 minutes to improve phonological processing skills.

The 5 experimental subjects' pretest standard score results for five assessment measures are presented in Table 2.

Table 2

Five Experimental Subjects' Pretest Standard Scores for Five Assessment Measures.

Measure	Subjects				
	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5
PAT	< 71	65	74	86	78
TERA-2	58	69	88	104	82
TOLD-P:2	72	78	77	77	88
LPT-R	67	68	93	88	89
SCAN	74	69	117	101	105

Note. All five assessment measures standard scores are based on a mean of 100 with a standard deviation of 15.

Control subjects were 3 language-impaired children between the ages of 6:0 and 8:6 at the initial time of assessment. These subjects also scored one standard deviation below the mean on the PAT and the TERA-2. Subjects might also have scored below the mean on other testing measures (the LPT-R, TOLD-P:2, and the SCAN). Like the experimental group, these scores did not have to be below the mean on these measures to qualify for the study. Two subjects in the control group, Subjects 2 and 3, did not score a minimum of one standard deviation below the mean on the TERA-2. However, these subjects were included in the study as the PAT standard scores were at least one standard deviation below the mean and the subjects were within the target age range. The 3 control subjects were not identified at the time pretest measures were administered to the 5 experimental subjects. However, the length of time between pre- and posttest of control subjects corresponded to the length of time between assessments of experimental subjects. The 3 control subjects' pretest standard score results are presented in Table 3.

The 3 subjects in the control group did not participate in the Fast ForWord program. They also did not receive speech-language therapy or other special services to improve reading skills during the time which the experimental subjects were participating in Fast ForWord. All 3 control subjects were identified by their parents as having reading difficulties.

Table 3

Three Control Subjects' Pretest Standard Scores for Five Assessment Measures.

Measure	Subjects		
	Control Subject 1	Control Subject 2	Control Subject 3
PAT	64	69	85
TERA-2	69	98	92
TOLD-P:2	67	83	96
LPT-R	54	79	60
SCAN	80	164	146

Note. All five assessment measures standard scores are based on a mean of 100 with a standard deviation of 15.

Experimental and control subjects did not exhibit any documented deficits in other developmental areas including physical, visual, auditory, and cognitive development.

Assessment

Pre- and posttest assessments were conducted using the following battery of standardized tests: The Phonological Awareness Test, the Test of Early Reading Ability-

2, the Language Processing Test-Revised, the Test of Language Development-Primary:2, and the Screening Test for Auditory Processing Disorders.

The Phonological Awareness Test (Robertson & Salter, 1997) is designed to highlight difficulties in phonological processing and phoneme-grapheme correspondence for children ages 5:0 to 9:0 years. Children's rhyming, segmentation, isolation, deletion, substitution, blending, grapheme, and decoding skills are assessed in a developmental sequence. Rhyming skills are evaluated through discrimination and production. Segmentation tasks include segmenting sentences, syllables, and phonemes. Identification of the initial, medial, and final sounds in a word is assessed in the isolation subtest. Deletion skills are evaluated in compound words and syllables. Substitution of one phoneme for another phoneme is assessed in words with and without manipulatives. Blending skills are evaluated in words at the syllable (e.g. /win-dow/) and phoneme (/m-i-l-k/) level. The grapheme section assesses sound-letter knowledge. Decoding skills are evaluated through reading of nonsense syllables.

The Test of Early Reading Achievement (TERA-2) (Reid, Hresko, & Hammil, 1991) analyzes the reading ability of young children ages 3:0 through 9:11 years. The test is designed to measure children's ability to attribute meaning to printed symbols, their knowledge of the alphabet and its functions, and their understanding of the conventions of print. The contextual meaning subtest measures a child's abilities from three types of print which include awareness of print in environmental contexts, knowledge of relations among vocabulary items, and awareness of print in connected discourse. The subtest of knowledge of the alphabet and its functions measures letter and numeral naming, alphabet recitation, and oral reading. Three aspects of a child's familiarity with and ability to respond to the conventions of print, are assessed through the conventions of written language subtest. These three aspects include book handling, response to other print conventions, and proof reading.

The Language Processing Test-Revised (Richard & Hanner, 1995) is designed to evaluate the ability of children ages 5:0 through 11:11 years to attach meaning to language and effectively formulate a response. The first six subtests of the LPT-R are arranged in a hierarchical order from the least to most difficult. The LPT-R has two pretests, Labeling and Stating Functions, which represent preschool prerequisite language processing skills. Subtests of the LPT-R include Association, Categorization, Similarities, Differences, Multiple Meanings, and Attributes. Labeling skills, the simplest task of language processing, are evaluated naming pictures with a one-word response. The ability to state functions is assessed through stating a verb which describes the function of a noun. Associations requires naming items that are typically associated with specific nouns presented. Categorization skills are assessed through naming three objects which share similar features when verbally presented with a specific category. The ability to recognize similarities is assessed by stating how two objects are alike. In the differences subtest, the task requires an explanation of how to differentiate between two objects. The multiple meaning task requires appropriate definition of words used in varying contexts. The attributes subtest is a composite task which evaluates the ability to spontaneously express specific attributes (i.e. function, components, color, accessories/necessities, size/shape, category, composition, and location/origin).

The Test of Language Development-Primary:2 (Newcomer & Hammill, 1988) includes seven subtests which evaluate specific strengths and weaknesses in receptive and expressive language skills of children ages 4:0 through 8:11 years. Subtests include Picture Vocabulary, Oral Vocabulary, Grammatic Understanding, Sentence Imitation, Grammatic Completion, Word Discrimination, and Word Articulation. Picture vocabulary is assessed through pointing to one of four pictures which best represents the meaning of a stimulus word. Oral vocabulary is evaluated by verbal definition of common words. Identification of appropriate syntax is assessed in the grammatic understanding subtest . Sentence imitation skills are evaluated through an imitation task with sentences verbally presented by the examiner. Grammatic completion includes the ability to recognize, understand, and use common morphological forms. Word discrimination requires recognition of phonemic differences using minimal pairs. Word articulation ability is assessed through spontaneous utterances of speech sounds in response to picture stimuli.

The SCAN (Keith, 1986) analyzes the auditory processing skills of children between the ages of 3:0 to 11:0 years. The three SCAN subtests include Filtered Words, Auditory Figure Ground, and Competing Words. These subtests are recorded on an audiocassette and presented through headphones. For the filtered words subtest, 20 words are presented to the right ear, followed by 20 words presented to the left ear with the child immediately repeating each word. A response is correct only if the word is repeated accurately. In the auditory figure ground subtest, speech noise is presented simultaneously to the same ear in which words are presented. As in the first subtest, 20 words are presented to each ear, first the right and then the left. The child must repeat each word accurately for a response to be correct. The final subtest, competing words, presents semantically unrelated monosyllabic word pairs simultaneously to both ears. For the first 25 word pairs, the child repeats both words, starting with the word heard in the right ear first. The next 25 word pairs requires the child to repeat both words starting with the word heard in the left ear first. Credit is given for each word accurately repeated, even if only one word of the pair is repeated correctly or if the words are repeated in reverse order.

Pretest measures were conducted primarily by the graduate student involved in the research study, but also by two certified SLPs employed by the Shiloh School District, an additional training site. The graduate student administered The Phonological Awareness Test and the Test of Early Reading Ability-2 subjects to ensure consistent testing measures for the primary research questions.

Posttraining measures were conducted similarly to the pretesting procedures. The graduate student once again administered all primary test measures (PAT and TERA-2). Two other certified professionals on site also assisted with posttesting on other assessments. Experimental subjects were posttested within one week after completing the FFW program.

<u>Reliability</u>

A graduate student attending Eastern Illinois University, along with the two previously mentioned SLPs, administered the test battery. The PAT and TERA-2 testing measures were audiotaped. Twenty percent of the primary pre- and posttesting procedures were re-scored by another graduate student to determine the reliability of the primary graduate student administrator. Intrajudge reliability, a comparison of results by the same individual, was .95 for The Phonological Awareness Test and .97 for the Test of Early Reading Ability-2. Similarly, interjudge reliability, a comparison of results by different individuals, was .90 for The Phonological Awareness Test and .99 for the Test of Early Reading Ability-2.

Training Procedures

The 5 experimental subjects participated in the Fast ForWord training program. Two subjects participated in the program at the Eastern Illinois University Speech-Language-Hearing Clinic and 3 subjects at the Shiloh School District.

The Fast ForWord training program is a CD-ROM and Internet-based program that consists of seven computerized training games (Scientific Learning Corporation, 1997). These games are designed to target temporal processing and phoneme identification. The training program includes the following training features: rate of processing, individualized adaptive training, modified speech, and performance review. The seven computerized training games are as follows: Circus Sequence, Old MacDonald's Flying Farm, Phoneme Identification, Phonic Match, Phonic Word, Block Commander, and Language Comprehension Builder. The FFW program is recommended for children ages 4 to 13 years.

Circus Sequence is designed to train processing of non-verbal sounds more promptly and accurately. The featured skills include rate of processing speed, short term memory, and serial order processing. Circus Sequence requires replication of a two-sound sequence by clicking on two buttons, each of which corresponds to a specific sound. The time interval separating the two-sound sequence decreases as the child's performance increases. This allows the child to better distinguish rapidly presented sounds. Three stimulus categories of frequency sweep tones are used: 1) 500 Hz, 2) 1 kHz, 3) 2 kHz. A total of 1260 adaptive training levels are required for 100 percent completion of Circus Sequence.

Old MacDonald's Flying Farm addresses the ability to detect temporal acoustic differences between phonemes. The five stimulus categories include contrasts of /gi-ki/, /chu-shu/, /si-sti/, /ge-ke/, and /do-to/. The task increases in difficulty as the interval between the contrasts is shortened. The featured skills in Old MacDonald's Flying Farm include rate of processing speed, short term memory, phoneme discrimination, and sustained and focused attention. To reach 100 percent completion of Old MacDonald's Flying Farm, Level 18 must be completed. This level challenges the child to distinguish between phonemes that differ by only one temporal acoustic cue or rates of acoustic change found in normal speech.

Phoneme Identification enhances the ability to identify a single phoneme. A target phoneme is presented. Then the child must correctly identify the same phoneme out of a stimulus set of two. The five syllable pairs used in this task are: /aba-ada/, /ba-da/, /be-de/, /bi-di/, and /ba-fa/. The featured skills are rate of processing speed, short term memory, and phoneme identification. The total number of levels in this game is 26 for 100 percent completion.

Phonic Words targets the ability to distinguish minimal pairs, words that differ only by an initial phoneme (tack vs. pack) or by the final phoneme (pat vs. pack). The featured skills are rate of processing speech and word recognition. The carrier phrase "Point to..." is used to elicit the child's selection between two pictures. During the progression of this game, the degree of acoustically modified speech used decreases. The highest level, Level 5, uses natural unmodified speech.

Phonic Match consists of a grid of 4 to 16 animated tiles containing animal characters. The featured skills are rate of processing, short term memory, and word recognition. Once a tile is selected by the child, a single word is given which represents the tile. The child must match tiles containing the same target words. The tiles disappear once the child identifies the match. The words within the grid may vary either in initial or final phonemes. During the progression of this game, the degree of acoustically modified speech used decreases. As in the Phonic Words game, Level 5 progresses to natural unmodified speech.

Block Commander is a three-dimensional board exercise that targets increasing listening comprehension and attention skills. Focus is achieved by asking the child to follow a series of simple or complex commands. As the game becomes more challenging, longer sentences and/or increased syntactic difficulty are incorporated. The amount of modified speech used decreases as criterion are reached. Level 5, the highest level, uses natural unmodified speech. The featured skills are rate of processing speed, short term memory, listening comprehension, and syntax.

Language Comprehension Builder focuses on building phonological, morphological, and grammatical comprehension skills through pictures illustrating actions and complex relational themes. The child chooses the correct answer out of a four picture stimulus set, in which the remaining choices are foils. The featured skills are processing speed, listening comprehension, syntax, morphology, and grammar. These skills are trained using receptive language skills typically mastered between the ages of two and eight years. The child must progress through the hierarchy of skills. As in the previously mentioned games, Level 5 uses natural unmodified speech.

Each of the exercises began with a teaching phase which demonstrated to the child how an exercise was to be completed. Once the exercise appeared to be understood, adaptive training began. Each exercise established the most appropriate stimulus level based on responses. Modified speech was used as stimuli to facilitate comprehension for children who had difficulty perceiving the rapidly changing sounds. The modified speech was adjusted to be just beyond the child's capacity to easily identify it, thus constantly challenging their auditory processing ability.

The children's progress was recorded via the Internet with the Scientific Learning Corporation, the corporation that produces Fast ForWord. The certified Fast ForWord supervisor and the graduate student involved in the research had access to the graphs and tables indicating the subjects' daily progress at the Eastern Illinois University site. Progress was checked minimally twice a week to closely monitor subjects' performances. A certified Fast ForWord professional at the additional site monitored the subjects' progress and provided the graduate student with the subjects' graphs and tables at the completion of Fast ForWord.

Subjects were gradually introduced to the Fast ForWord program. The amount of training time increased progressively during the first week of the program. Exercises listed for the first week of training must be played each day, but not in any particular order (See Table 4). After day 5, the schedule remained constant at 20 minutes per exercise, 5 exercises per day, and 5 days per week. The order of the training exercises was determined by the computer and could not be altered. Training for the day was complete when signaled by the "End of Schedule" bus that appeared across the computer screen or when the exercises for the day began to repeat. After the training for the day was completed, the child automatically went though the "End of Schedule" routine to acquire extra bonus points. The optimum training period for each child varied depending on their rate of progress. Fast ForWord training was completed when the subject reached at least 90 percent completion on at least five of the seven training exercises or when 9 weeks of FFW training had occurred.

Throughout the Fast ForWord program reinforcement was provided for the children. Daily point totals were recorded with stickers awarded for every 100 points accumulated. When each child completed one row on the sticker chart, a trip to the small prize basket was allowed. Upon completion of the FFW program, a Beanie Baby was given to the child. These reinforcement procedures were followed at both FFW training sites.

Table 4

Fast ForWord Training Progression.

Training Days	Exercises Available for Play
Days 1-3 1 hour	Circus Sequence Phonic Match Block Commander
Days 4 & 5 1 hour 20 min.	Circus Sequence Phoneme Identification Phonic Match Block Commander
From Day 6 1 hour 40 min.	Circus Sequence Old MacDonald's Flying Farm Phoneme Identification Phonic Match Phonic Word Block Commander Language Comprehension

Chapter IV

Results

The study investigated the effects of the Fast ForWord computer training program on children's phonological awareness and reading skills. The primary research questions asked of study were: 1) Do individual children who receive Fast ForWord training evidence a significant gain of greater than one standard deviation on The Phonological Awareness Test? 2) Do individual children who receive Fast ForWord training evidence a significant gain of greater than one standard deviation on the Test of Early Reading Ability-2? Additional secondary research questions were: 1) Do individual children who receive Fast ForWord training evidence a significant gain of greater than one standard deviation in their general language skills as measured by the Language Processing Test-Revised and the Test of Language Development-Primary? 2) Do individual children who receive Fast ForWord training evidence a significant gain of greater than one standard deviation in their auditory perceptual skills as measured by the Screening Test for Auditory Processing?

Results were obtained by comparing the difference between pre- and posttest standard scores. The initial and final Fast ForWord game completion percentages for each individual subject were also analyzed. Each assessment measure was assessed to determine any increases in reading and/or language skills. Group means for all assessment measures were also calculated. The results collected for the experimental subjects are presented in the following tables.

Subject 1

Subject 1, 6 years 10 months, did not achieve the completion criteria (90%) for any of the seven games. Table 5 details the progress made on the Fast ForWord games. The highest completion level obtained was 50% on Block Commander (which targeted listening comprehension and attention skills). A 47% increase was evidenced on this game. The next highest completion level was 25% on Phonic Match (which featured rate of processing, short term memory, and word recognition skills). A 15% increase was observed on this game. The subject remained at 0% accuracy with no gain on Circus Sequence. Subject 1 participated in FFW training for 8 weeks with 98% attendance (39/40 sessions).

Table 5

Game Completion Data of Fast ForWord Games for Subject 1.

FFW Game	Initial %	Final %	% Gain
Circus Sequence	0%	0%	0%
MacDonald's Flying Farm	6%	9%	3%
Phoneme Identification	12%	7%	-5%
Phonic Match	10%	25%	15%
Phonic Word	14%	16%	2%
Language Comprehension	5%	15%	10%
Block Commander	3%	50%	47%

Initial language test scores for Subject 1 suggested overall low language skills. Results from testing measures revealed standard scores ranging between 2 to 3 standard deviations below the mean. Table 6 displays Subject 1's raw scores and standard scores for the assessment measures. The largest strength was oral vocabulary as measured by the TOLD-P:2 (this skill was at the 50th percentile). Weaknesses included phonological awareness skills, knowledge of the alphabet and writing conventions, receptive and expressive language skills such as picture vocabulary, grammatical understanding and grammatical completion, and language processing skills.

Table 6

Raw Scores, Standard Scores, and Test Gains for Five Standardized Test Measures for Subject 1

Measure	Pretest		Posttest		Test Gain	
	Raw	SS	Raw	SS	SS	1 s.d.
PAT	58	< 71	55	< 71	—	
TERA-2	12	58	18	78	+20	*
TOLD-P:2	51	72	60	72	0	
LPT-R	20	67	40	84	+17	*
SCAN	87	74	100	79	+5	

Note. All assessment measures had a mean of 100 with a standard deviation of 15; * indicates a standard score increase of one standard deviation or greater.

Posttest data was obtained 9 weeks later following participation in the Fast ForWord (FFW) language program. Subject 1 evidenced greater than one standard deviation increase on two assessment measures, the TERA-2 and LPT-R. On the TERA-2, the standard score improved by 20 points, a gain of slightly over one standard deviation. Another large increase in standard score was observed on the LPT-R. The standard score on this measure improved 17 points, which was also slightly more than one standard deviation. The increase was attributed to minimal gains on the subtests of categories and associations. Standard scores for the PAT and TOLD-P:2 remained unchanged at approximately 2 standard deviations below the mean. Results of the SCAN indicated standard scores increased five points. Posttest scores may not accurately reflect language skills due to non-compliant testing behavior by this subject.

Subject 2

Subject 2, 8 years 2 months, did not achieve the completion criteria (90%) for any of the seven games. Table 7 represents the FFW game data for Subject 2. The highest completion rate was 88% on Phonic Word (which focused on distinguishing words by a single phoneme either in the initial or final position). The increase on this game was 77%. The second highest completion occurred on Old MacDonald's Flying Farm with 68% completion, a 64% increase. Old MacDonald's Flying Farm concentrated on detecting temporal acoustic differences between phonemes. Subject 2 participated in FFW training for 8 weeks with 98% attendance (39/40 sessions).

Pretest data revealed Subject 2 performed two standard deviations below the mean on the PAT, TERA-2, LPT-R, and SCAN, as well as one standard deviation below the mean on the TOLD-P:2. Table 8 outlines the testing scores for Subject 2. Strengths on the testing measures included word articulation (the 37th percentile). Specific weaknesses consisted of phonological awareness skills, knowledge of the alphabet and writing conventions, receptive and expressive language, and language processing skills.

Table 7

Game Completion Data of Fast ForWord Games for Subject 2.

FFW Game	Initial %	Final %	% Gain
Circus Sequence	0%	9%	9%
MacDonald's Flying Farm	4%	68%	64%
Phoneme Identification	17%	36%	19%
Phonic Match	10%	31%	21%
Phonic Word	11%	88%	77%
Language Comprehension	6%	55%	49%
Block Commander	6%	52%	46%

Table 8

Raw Scores, Standard Scores, and Test Gains for Five Standardized Test Measures for Subject 2

Measure	Pretest		Posttest		Test Gain	
	Raw	SS	Raw	SS	SS	1 s.d.
PAT	128	65	137	69	+4	
TERA-2	26	69	28	75	+6	
TOLD-P:2	85	78	98	77	-1	
LPT-R	32	68	50	81	+13	
SCAN	100	69	122	79	+10	

Note. All assessment measures had a mean of 100 with a standard deviation of 15; * indicates a standard score increase of one standard deviation or greater.

Following 8 weeks of FFW training, posttest measures indicated gains on four assessment measures. No tests evidenced gains of greater than one standard deviation.

The LPT-R evidenced the largest standard score increase of 13 points, a gain of nearly one standard deviation. The subtests of similarities, differences, and multiple meanings demonstrated the most improvement with scores improving to within normal limits. The SCAN documented a standard score increase of 10 points. The TOLD-P:2 results indicated a decrease of one standard score point from pre- to posttest. Despite a raw score increase, standard score decreased which was attributed to the change in the subject's chronological age (7:11 pretest; 8:2 posttest). Results from the PAT evidenced a standard score increase of four points.

Subject 3

Subject 3, 7 years 9 months, achieved the completion criteria (90%) on four of the seven computer games. Table 9 details game completion levels. The completed games included Circus Sequence (90%) which focused on processing of tone sweeps, Phonic Match (94%), Phonic Word (97%), and Language Comprehension Builder (96%) which targeted phonological, morphological, and grammatical comprehension skills. Subject 3 participated in FFW for 7 weeks with 89% attendance (31/35 sessions).

Pretest data for Subject 3 indicated performance nearly 2 standard deviations below the mean on the PAT and 1.5 standard deviations below the mean on the TOLD-P:2. Other testing measures were within one standard deviation of the mean. Table 10 provides the testing results for Subject 3. Strengths observed included language processing skills. Specific weaknesses involved phonological awareness skills and receptive and expressive language skills.

Table 9

Game Completion Data of Fast ForWord Games for Subject 3.

FFW Game	Initial %	Final %	% Gain
Circus Sequence	1%	90%	89%
MacDonald's Flying Farm	8%	31%	23%
Phoneme Identification	19%	71%	52%
Phonic Match	12%	94%	82%
Phonic Word	17%	97%	80%
Language Comprehension	8%	96%	88%
Block Commander	13%	71%	58%

Table 10

Raw Scores, Standard Scores, and Test Gains for Five Standardized Test Measures for Subject 3

Measure	Pretest		Posttest		Test Gain	
	Raw	SS	Raw	SS	SS	1 s.d.
PAT	145	74	187	90	+16	*
TERA-2	35	88	33	85	-3	
TOLD-P	92	77	101	84	+7	
LPT-R	65	93	70	97	+4	
SCAN	153	117	160	123	+6	

Note. All assessment measures had a mean of 100 with a standard deviation of 15; * indicates a standard score increase of one standard deviation or greater.

Subject 3 demonstrated posttest gains of greater than one standard deviation on the PAT with increased standard scores on all subtest except graphemes. Standard score increases were observed on three assessment measures, the TOLD-P:2, LPT-R, and SCAN, but were not significant at the one standard deviation level. The TERA-2 results did not indicate a positive increase in standard score.

Subject 4

Subject 4, 7 years 6 months, achieved completion criteria (90%) on four of the seven games. Table 11 details the FFW game completion data. The four games completed included Old MacDonald's Flying Farm (98%), Phonic Match (93%), Phonic Word (98%), and Language Comprehension Builder (97%). Circus Sequence was completed at the 85% level. Subject 4 participated in the FFW training program for 7 weeks with 74% attendance (26/35 sessions).

Table 11

Game Completion Data of Fast ForWord Games for Subject 4.

FFW Game	Initial %	Final %	% Gain
Circus Sequence	1%	85%	84%
MacDonald's Flying Farm	6%	98%	92%
Phoneme Identification	16%	61%	45%
Phonic Match	12%	93%	81%
Phonic Word	14%	98%	84%
Language Comprehension	6%	97%	91%
Block Commander	10%	74%	64%

Table 12 presents testing scores for Subject 4. Weaknesses included receptive and expressive language skills on the TOLD-P:2 and the decoding subtest of the PAT. Testing strengths included the isolation, deletion, and graphemes subtests of the PAT and the association and categorizations subtest of the LPT-R.

Table 12

Raw Scores, Standard Scores, and Test Gains for Five Standardized Test Measures for Subject 4

Measure	Pretest		Posttest		Test Gain	
	Raw	SS	Raw	SS	SS	1 s.d.
PAT	147	86	150	76	-10	
TERA-2	34	104	33	85	-19	
TOLD-P	90	77	104	86	+9	
LPT-R	54	88	61	90	+2	
SCAN	141	101	134	88	-13	

Note. All assessment measures had a mean of 100 with a standard deviation of 15; * indicates a standard score increase of one standard deviation or greater.

Subject 4 did not evidence significant gains on posttest measures. A standard score increase of four points was noted on the TOLD-P:2. The LPT-R was the other measure which evidenced a minimal increase in standard score of two points. Subject 4 was not attentive during the posttest procedures and expressed displeasure in participating.

Subject 5

Subject 5, 8 years 0 months, achieved completion criteria (90%) for one game, Language Comprehension Builder at the 96% level. Table 13 represents FFW game completion percentages. Block Commander achieved a 71% completion followed by Phonic Word at 55% and Phonic Match at 50% completion. Subject 5 participated in the

FFW training program for 7 weeks with 80% attendance (28/35 sessions).

Table 13

Game Completion Data of Fast ForWord Games for Subject 5.

FFW Game	Initial %	Final %	% Gain
Circus Sequence	0%	0%	0%
MacDonald's Flying Farm	2%	34%	32%
Phoneme Identification	16%	37%	21%
Phonic Match	12%	50%	38%
Phonic Word	17%	55%	38%
Language Comprehension	8%	96%	88%
Block Commander	12%	71%	59%

Subject 5 initially performed within one standard deviation of the mean on the TOLD-P:2, LPT-R, and SCAN. The standard scores for the PAT and TERA-2 were below 1.5 standard deviations of the mean. Table 14 provides testing scores for Subject 5. Weaknesses for Subject 5 included the oral vocabulary, sentence imitation, grammatical completion, word discrimination and articulation subtests of the TOLD-P:2. Strengths included language and auditory processing skills.

Table 14

Raw Scores, Standard Scores, and Test Gains for Five Standardized Test Measures for Subject 5

Measure	Pretest		Posttest		Test Gain	
	Raw	SS	Raw	SS	SS	1 s.d.
PAT	155	78	174	83	+5	
TERA-2	31	82	35	87	+5	
TOLD-P	113	88	133	93	+5	
LPT-R	60	89	67	93	+4	
SCAN	145	105	138	91	-14	

Note. All assessment measures had a mean of 100 with a standard deviation of 15; * indicates a standard score increase of one standard deviation or greater.

Subject 5 achieved increased standard scores on four of the five testing measures, although none of the gains met the significance level of one standard deviation. The SCAN was the only assessment measure in which gains were not observed. A five point increase in standard score was evidenced on the PAT, TERA-2, and TOLD-P:2 while the LPT-R indicated a four point gain. The oral vocabulary, word discrimination, and word articulation subtests of the TOLD-P:2 accounted for the increase in standard score evidenced on this measure.

Summaries

A summary table of all subjects' individual game completion is presented in Table 15. The FFW dismissal criteria of 90% on five of the seven games was not attained by any of the 5 subjects.

Subjects 3 and 4 completed the most FFW games of the experimental subjects with four games reaching the 90% criterion level. These two subjects finished three of the same games which included Phonic Match, Phonic Word, and Language Comprehension Builder. Subject 3 also completed Circus Sequence while Subject 4 completed Old MacDonald's Flying Farm. Subject 5 completed one FFW game, Language Comprehension Builder whereas Subjects 1 and 2 did not meet completion criteria for any of the seven games.

Of the FFW games, Language Comprehension Builder had the highest completion rate with three of the five subjects finishing the game. Interestingly, none of the five subjects achieved the 90% level for Phoneme Identification or Block Commander.

Table 16 provides a summary of the subjects' standard score gain performance on the five assessment measures as well as an average gain for each measure. Subjects 1 and 3 increased standard scores by a minimum of one standard deviation on three assessment measures. The testing measures differed for each subject as Subject 1 improved standard scores by a minimum of one standard deviation on the TERA-2 and LPT-R while Subject 3 improved standard scores on the PAT. The remaining three subjects did not improve their standard scores by a minimum of one standard deviation on any of the assessment measures. As a group, the average standard score gains were highest for the LPT-R and TOLD-P:2, with increases reported at 8.00 and 4.00, respectively.

Table 15

Five Subjects' Fast ForWord Percentage (%) Gains for Each Game

FFW Game	Subjects				
	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5
Circus Sequence	0%	9%	90%*	85%	0%
Flying Farm	9%	68%	31%	98%*	34%
Phoneme Identification	7%	36%	71%	61%	37%
Phonic Match	25%	31%	94%*	93%*	50%
Phonic Word	16%	88%	97%*	98%*	55%
Language Comprehension	15%	55%	96%*	97%*	96%*
Block Commander	50%	52%	71%	74%	71%

Note. * indicates 90% completion criteria was achieved.

Table 16

Summary of Five Subjects' Test Gain Performance and Average Gain on Five Assessment Measures.

Measure	Subjects					
	Subject 1**	Subject 2	Subject 3	Subject 4**	Subject 5	Avg Gain
PAT	0	+4	+16 *	-10	+5	+3
TERA-2	+20 *	+6	-3	-19	+5	+1.8
TOLD-P:2	0	-1	+7	+9	+5	+11
LPT-R	+17 *	+13	+4	+2	+4	+8
SCAN	+5	+10	+6	-13	-14	-1.2

Note. All assessment measures had a mean of 100 with a standard deviation of 15; * one standard deviation increase; ** indicates subject was not cooperative during posttesting procedures.

Table 17 provides a summary of the control subjects' pre- and posttest standard scores and average gain on the five assessment measures. Control Subject 1 increased standard scores by a minimum of one standard deviation on two different assessment measures, the TERA-2 and SCAN. The other two control subjects did not improve standard scores by a minimum of one standard deviation on any of the five assessment measures. A large variability in standard score gains was noted on the SCAN with two control subjects, Subjects 2 and 3, significantly decreasing scores upon posttest.

Group means and standard deviations for both the experimental and control subjects on each assessment measure were calculated. Table 18 presents the group means and standard deviations for each group. As a group, the FFW subjects' largest standard score average increases were 8 points on the LPT-R and 4 points on the TOLD-P:2. These subjects' evidenced a minimal average gain of 3 standard score points on the PAT and approximately 2 points on the TERA. No positive average increase in standard score was observed on the SCAN.

The PAT results noted a larger mean increase in group means for the control group (8.00) than the experimental group (3.00). The standard deviation for the experimental subjects was large (9.38) with the standard deviation for the control subjects smaller (5.29). The TERA-2 results mirrored those found for the PAT. The control subjects demonstrated a larger mean standard score improvement (6.67) than the experimental subjects (1.80). The standard deviation was large for both groups. The TOLD-P:2 results were similar to the TERA-2 with the most gain evidenced for the control group. The control group mean was 10.33 and the experimental group mean was

Table 17

Summary of Three Control Subjects' Pre- and Posttest Standard Scores, Test Gain, and Average Gain on Five Assessment Measures.

Measure	Control Subject 1	Control Subject 2	Control Subject 3	Avg Gain
PAT				+8.0
Pre	64	69	85	
Post	66	81	95	
Test Gain	+2	+12	+10	
TERA				+6.67
Pre	69	98	92	
Post	87	94	98	
Test Gain	+18*	- 4	+6	
TOLD-P:2				+10.33
Pre	67	83	96	
Post	79	86	112	
Test Gain	+12	+3	+16*	
LPT-R				+2.67
Pre	54	79	60	
Post	66	75	61	
Test Gain	+12	- 4	-1	
SCAN				-32.6
Pre	80	164	146	
Post	97	100	95	
Test Gain	+17*	- 64	- 51	

Note. All assessment measures had a mean of 100 with a standard deviation of 15; * indicates a standard score increase of one standard deviation or greater.

4.00. Unlike the PAT and TERA-2, the standard deviation for the TOLD-P:2 was smallest for the experimental subjects (4.36). The LPT-R demonstrated the greatest increase for the experimental group (8.00) with a slightly larger standard deviation (6.60) than the TOLD-P:2. For the control group, the average improvement in standard score was less (2.67) although the standard deviation about the mean was very comparable to that of the experimental group (6.66). The SCAN was the only assessment measure for both groups where group mean gains were negative numbers. The experimental subjects evidenced a mean decrease in standard score (-1.20) with a large standard deviation (11.39). For the control subjects a much larger average decrease was observed (-32.67) with the standard deviation about the mean being extremely variable (43.50).

Table 18

Group Means and Standard Deviations for Testing Gains of Five Subjects.

Group	PAT	TERA-2	TOLD-P:2	LPT-R	SCAN
Experimental	3.00 (9.38)	1.80 (14.27)	4.00 (4.36)	8.00 (6.60)	-1.20 (11.39)
n = 5					
Control	8.00 (5.29)	6.67 (11.02)	10.33 (6.66)	2.67 (6.66)	-32.67 (43.50)
n = 3					

Note. Standard deviations reported in parentheses; all assessment measures had a mean of 100 with a standard deviation of 15.

Chapter V

Discussion

The primary purpose of the present study was to determine the impact of Fast ForWord on individual children's phonological awareness and reading skills. Another purpose was to determine the effect of Fast ForWord on children's overall language skills and auditory perceptual skills.

Examination of the Fast ForWord game completion data revealed several interesting findings. Of the seven FFW games, Language Comprehension Builder had the highest achievement rate as 3 subjects met completion criteria. Phoneme Identification and Block Commander were not completed by any of the 5 subjects. According to the FFW data obtained, none of the 5 subjects achieved the minimum of 90% completion on five of the seven exercises. However, two subjects, Subjects 3 and 4, completed four of the training exercises, whereas another two subjects, Subjects 1 and 2, did not meet completion criteria for any of the seven exercises.

When comparing subjects who completed four of the seven FFW exercises (Subjects 3 and 4) with those subjects who did not complete any of the seven games (Subjects 1 and 2), similarities were noted. Subjects 3 and 4, who had chronological ages of 7:9 and 7:6, which were similar to the chronological ages of Subjects 1 and 2, 6:10 and 8:2. Subjects 3 and 4's (who completed four FFW games) initial language ages, as measured by the TOLD-P:2, were similar at 5:9 and 5:6, while Subjects 1 and 2's initial language (who completed no games) ages differed at 4:6 and 6:1, respectively. Additionally, FFW average initial game percentages for Subjects 3 and 4's were 11.1% and 9.3%, which were slightly higher than Subjects 1 and 2's average initial game percentages at 7.1% and 7.7%, respectively .

Examination of the standardized test results also revealed several interesting findings. As a group, the experimental subjects evidenced the most gain on the Test of Language Development-Primary and the Language Processing Test-Revised; however, the increases were not significant at the one standard deviation level. Noticeable differences between the experimental and control subjects on posttest measures were not found. Posttest data indicated that two subjects, Subjects 1 and 3, increased standard scores on at least one assessment measure by one standard deviation or greater. Subject 1 increased standard scores on the TERA-2 and LPT-R while Subject 3 improved standard scores on the PAT. Interestingly, none of the other subjects increased standard scores by at least one standard deviation on any of the five measures.

No clear pattern was observed between subjects who increased standard scores on at least one assessment measure (Subjects 1 and 3) versus subjects who did not evidence a significant gain (Subjects 2, 4, and 5). Subjects 1 and 3's, chronological ages were 6:10 and 7:9 with language ages of 4:6 and 5:9, respectively. Subjects 2, 4, and 5's chronological ages were 8:2, 7:6, and 8:0 with language ages of 6:1, 5:6, and 6:9. Of the two subjects who demonstrated standard score gains (Subject 1) did not complete any of the seven FFW exercises, while Subject 3 met criteria on four of seven games. Of the three subjects who did not demonstrate significant standard scores gains, one subject, Subject 4, completed four of the seven exercises, Subject 5 completed one exercise, and Subject 2 did not complete any of the exercises.

Results from this study do not support the early Fast ForWord research that documented significant gains of 1 ½ to 2 years in language skills in 4 to 8 weeks following 100 minutes per day of training for 5 days per week (Tallal & Merzenich, 1997; Scientific Learning Corporation, 1997, 1998). Experimental subjects' largest mean increases in posttest standard scores were on the LPT-R, and TOLD-P:2. However, these standard score mean gains were eight and four points, respectively, much lower than the previously reported increases by the FFW developers. On the phonological awareness and reading assessment measures, the mean improvements for the experimental group were minimal at three and approximately two standard score points.

Upon completion of the FFW program and close analysis of the assessment results, specific clinical implications were evident. One implication demonstrated was that some children toward the lower to middle end of the recommended chronological ages (FFW is recommended for children ages 4 to 13) may not be appropriate for FFW training. Similarly, children may need to have certain prerequisite language skills to benefit from the training.

A specific strength of the study was the detailed information provided on individual subjects' performance rather than group measures which mask individual variation. The published FFW field test study (Tallal & Merzenich, 1997) presented large group results which did not detail individual subjects' FFW performance and assessment measure gains. The data presented by Tallal and Merzenich (1997) grouped children with a wide range of diagnostic labels preventing professionals from distinguishing the profile for children who achieved the most benefit from the training program. Interestingly, all 5 experimental subjects initially appeared to be good candidates for the FFW program.

However, none of the experimental subjects met FFW's completion criteria (90% on at least 5 of 7 training games) and only 2 subjects made significant gains on any of the five assessment measures. These findings demonstrate the need for the profiles of successful children to be delineated by Scientific Learning Corporation and shared with parents and professionals.

Another strength of this study was the new information provided about FFW's impact on phonological awareness and reading skills. The developers of FFW have stated that the program can aid children with specific phonological awareness skills which then facilitate successful reading skills (Scientific Learning Corporation, 1997, 1998). Authors also contend that all of the FFW exercises facilitate recognition of phonemes in different positions of a word; however, the exercises do not directly teach reading (Scientific Learning Corporation, 1997, 1998). At the time the present study was conducted, a major discrepancy in regard to this information was noticed. In the FFW developers' published studies on the program, measures of phonological awareness were not included in their test protocol although statements were made, and still are today, regarding the program's effectiveness in training phonological awareness skills.

The current study included phonological awareness and reading assessment measures and results, therefore, may provide insight into the effectiveness of Fast ForWord on those specific skills. Results demonstrated that, as a group, the children who participated in FFW did not increase their standard scores on either of the primary testing measures by a minimum of one standard deviation. Individually, Subject 3's PAT standard score increased by 16 points, while Subject 1's TERA-2 standard score improved by 20 points. It seems logical that FFW could impact these skills since three exercises (Phoneme Identification, Phonic Word, and Phonic Match) focus on specific phonological skills (phoneme identification in isolation, syllables, and words). Nevertheless, the data obtained in the current study did not demonstrate significant gains in these skills for the subjects as a group. Interestingly, the control subject group increased the PAT standard scores by an average of eight points and the TERA-2 standard score by nearly seven points. The control group's mean gain was higher than the experimental subjects which minimally improved the PAT standard score by three points and TERA-2 by approximately two points.

Several weaknesses existed with the subject pool for the present study. Only five children participated in the FFW program. It is difficult to draw definitive conclusions regarding the effectiveness of FFW due to the small number of experimental subjects. Two of the experimental subjects, Subjects 1 and 4, were non-compliant during posttest procedures. Subject 1 often declared, "I don't want to do this." Re-direction techniques were used with Subject 1 repeatedly throughout posttest assessment. Methods such as playing games and taking breaks were employed on several occasions during each test. Similar techniques were also used with Subject 4 but with less frequency than with Subject 1. Subject 4 demonstrated decreased posttest scores on three measures with minimal gain noted on the other two.

Second, the number of control subjects was not equal to the number of experimental subjects. Two of the three control subjects incorporated into the study were not posttested before the school year began due to late identification. Posttesting occurred within the first 5 weeks of the school year. Although the control subjects' increased posttest scores were not likely to be due to the short period of time enrolled in the educational curriculum, the fact exists as a weakness in the study.

Another weakness of the study was the use of the SCAN in the test protocol. The average gain on the SCAN for both the experimental and control subjects was negative with a large variation about the mean. In the development of the SCAN, Keith (1986) determined test-retest reliability data following a six month retest interval and determined that SCAN scores may be unreliable. Amos and Humes (1998) further researched the stability of SCAN outcomes using 47 children, ages 6 to 9 years, with a 6 to 7 week retest interval (Retest interval in the current study was 8 to 9 weeks). Results from the Amos and Humes (1998) study indicated that raw, standard, and composite scores significantly improved upon retest for two of the three subtests. Percentile ranks and age-equivalent outcomes were also noted to increase significantly. The investigators stated that it appeared a second administration of the SCAN could provide a better estimate of an individual child's best performance. The article's findings were not published at the time the present study was initiated and, therefore, did not impact test protocol selection.

Prior to the development of FFW, the authors hypothesized that the deficits underlying receptive difficulties in language-learning impaired children arose from a temporal processing deficit. The researchers defined this deficit as expressed by limited abilities at identifying some brief phonetic elements represented in specific speech contexts and by poor performances at identifying or sequencing short-duration acoustic stimuli (Merzenich, et al., 1996). The current FFW program was developed following two trial studies (Merzenich, et al., 1996; Tallal, Miller, et al., 1996) which indicated that implementation of an intense schedule of practice trials undertaken for a significant daily exercise period over a series of successive days could, in effect, "remodel" the brain so a child could effectively perceive speech stimuli. The premise was that, if language impaired children developed competent speech reception, other language skills would quickly improve as well (Scientific Learning Corporation, 1997). The results obtained in the present study suggest that perhaps changes in temporal processing ability, the proposed underlying difficulty for language impaired children, do not occur with all children who participate in the training program. Individual and group results from the on the SCAN from the current study did not support this concept. If temporal auditory processing ability was altered by Fast ForWord, SCAN results should have indicated gains in those skills. However, both the experimental and control subject group means for the SCAN did not indicate positive increased scores (-1.20 and -32.67, respectively). The results from this study demonstrated that, as a group, the experimental subjects' language processing skills improved more than their auditory processing skills, as measured by the LPT-R (8.00) and the SCAN (-1.20). Interestingly, as a group, the control subjects evidenced minimal increases in language processing skills, as measured by the LPT-R (2.67). These results may indicated that FFW modifies language processing ability rather than temporal auditory processing ability.

Susan Brady (1998), a professor of psychology at the University of Rhode Island, has studied speech perception and the phonological difficulties associated with reading disabilities. She questions the accuracy of the premise proposed by Tallal and her colleagues' in regard to an underlying temporal processing deficit in language impaired children. Brady emphasized that if the FFW producers' premise is the existence of a temporal processing deficit, then potential subjects should be identified as having those deficits before enrolling in the FFW program.

From the time this study began, Fast ForWord developers have been involved in further research and new program developments. Fast ForWord Two was introduced in the fall of 1998. This additional program has been reported to build upon and strengthen the language and reading skills that children acquire through Fast ForWord. The sequel program is composed of five exercises that are designed to accelerate the development of reading skills such as recognizing sound/letter correspondence, learning to decode words faster and easier, listening and reading comprehension, word finding, working memory and much more (Scientific Learning Corporation, 1998). Fast ForWord Two incorporates words, whereas Fast ForWord focuses on speech sounds.

The results obtained in this study highlight several areas for future research. Additional studies should be conducted to provide further insight into the impact Fast ForWord has on phonological awareness and reading skills, as well as in other areas. Brady (1998) emphasized the need for more research regarding the Fast ForWord training program. For example, are all FFW games appropriate for all age children? Results from the current study noted two games on which none of the five children met the completion criteria of 90%, Phoneme Identification and Block Commander. It could be that some children may not be neurologically ready or possess the necessary language age needed to succeed on these games. Another area within the FFW program that needs to be examined is the lack of control by the on-site professional. Currently, speech-language pathologists have no control over the training exercises determined for each day the exercises are pre-determined by SLC. If a child continually struggles with a specific game, despite one-on-one training, and motivation to play other FFW games is effected, the SLP can not alter the program to omit the difficult game. In a sense, this lack of control violates good treatment principle. If children were seen in one-on-one therapy and were continually struggling with a task, would we not alter the treatment method or use stimuli at a lower level in order for the child to succeed?

The demand for comparative research with other programs that directly target language, phonological awareness, and reading skills improvement, is another area for future studies. It is also essential that studies be conducted with larger numbers of subjects to better determine the speech and language profile of children who can receive the most benefit from the program. Previous research studies conducted by the Fast ForWord developers have incorporated subjects who exhibited a wide range of diagnostic labels (e.g., attention deficit disorder, autism, language impairment, and central auditory processing disorder); however, specific results for each disability category have not been provided by the company (Tallal & Merzenich, 1997). The national field test study (Tallal & Merzenich, 1997) results did not provide specific speech and language characteristics for different disorder areas; rather, all children were grouped into a single category. Data indicated that significant mean gains were found in subjects' receptive and expressive language abilities and discrimination abilities, but identification of which children evidenced the most gains in those skill areas was not provided. Information about characteristics of individual children who did not benefit was also not included.

Conversation with a part-time employee of the Scientific Learning Corporation described studies presently being conducted to provide additional insight into the effectiveness of the program for children with specific impairments; however, this data has not been made available to consumers and professionals to date (A. Osterling, personal communication, February 19, 1999). Currently, an individual speech-language pathologist must justify the use of this training program based on limited available data. Considering the high cost of the program and the lack of research available to substantiate effectiveness in specific disorder areas, concerns have been raised among many practitioners. As of September 16, 1998, nearly 10,000 children have used Fast ForWord (Scientific Learning, 1998). Therefore, Scientific Learning Corporation could draw from a large database of individual children's results, which could then be analyzed to provide more specific details about successful and unsuccessful client's profiles. This would provide speech language pathologists with a more accurate idea of which language impaired children would be potential candidates for the FFW program.

In addition to investigation into the appropriate speech and language profile, future research should also address the language age of children who receive maximum benefit from FFW. The Scientific Learning Company has targeted a broad chronological age range of children (ages 4 to 13) for which the FFW program may be beneficial. The present study included children in the middle of the recommended chronological age range but toward the lower end of the language age range (ages 4:6 to 6:9). Throughout the progression of FFW, it was observed that Subject 1 (language age of 4:6) struggled with certain basic skills that may be necessary for program success (e.g., attention span, motivation, game skill understanding, basic language skills). Since Subject 1's language age was toward the lower limit of FFW's chronological age span, it is recommended that future research evaluate a successful child's language age.

A final implication for future research is related to functional gains made by a child after completion of the FFW program. Longitudinal studies would provide data to determine whether gains evidenced from FFW are generalized into the classroom and home environments. The inclusion of parent and teacher reports of a child's speech and language abilities both pre- and post participation would contribute valuable insight into FFW's impact on other skills. The published longitudinal data from the developers (Tallal, Miller, et al., 1996; Tallal & Merzenich, 1997) was obtained at six weeks and six months following FFW completion and reported only standardized test data. Data obtained six months or more following FFW training is critical to determine the long-term impact of the program.

As this study demonstrated, the need for future research evaluating the effectiveness of the training program is imperative. It will also be important to carefully evaluate Fast ForWord Two and its impact on phonological awareness and reading skills in future studies. Perhaps Brady (1998) provided the most appropriate statement, "We (speech-language pathologists) have the responsibility to offer the best resources to children who need help and to keep up with new developments. At the same time, we need to seek out the best scientific evidence to not falsely raise the hopes of worried parents and to not obligate vulnerable families to expensive interventions of questionable value."

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APPENDIX A

Research Participation Authorization

EASTERN
ESTABLISHED 1895
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Communication Disorders and Sciences
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RESEARCH PARTICIPATION AUTHORIZATION

Melissa Nulty, graduate student, and two assistant professors from Eastern Illinois University, Jean Smitley and Rebecca Throneburg, are conducting a research project assessing children's reading and phonological awareness skills. I authorize permission for ____________________ (child's name), ____________ (birthdate), who is my ____________ (relationship) to participate in this project. I give my permission for the researchers to use all data collected during the research, including audio recordings for teaching and publications. I understand that my child's name will not be used in any descriptions or reports of data.

______________________________ (parent signature)

____

______________________________ (address)

______________________________ (parent names)

______________________________ (city) (state) (zip)

______________________________ (phone)

______________________________ (date)