A Perception Based Phonological Awareness Training Program for Preschoolers with Articulation Disorders

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Abstract

Remediation of phonological awareness (PA) deficits in preschool age children is essential to the prevention of delayed acquisition of reading abilities. The purpose of this research was to develop and assess the efficacy of a program to teach PA to preschool-aged children with delayed PA. Ten preschoolers with articulation disorders participated in 8 training sessions focusing on phonological awareness (PA) and phonemic perception. These children made significant improvements in their PA abilities such that their post-treatment PA test performance was not significantly poorer than that of normally developing children, but was significantly better than that of children with an articulation disorder who did not receive the PA training program. The clinical and theoretical implications of the results are discussed. Future research directions are proposed to confirm these results using an experimental design and to isolate the impact of phonemic perception on PA.

Résumé

Le traitement des déficits d'habiletés métaphonologiques (HM) des enfants d'âge préscolaire est essentiel afin de prévenir les troubles d'apprentissage de la lecture. Le but de ce projet de recherche était de développer et d'évaluer l'efficacité d'une intervention pour enseigner les HM aux enfants d'âge préscolaire qui ont des retards d'HM. Dix enfants d'âge préscolaire ayant des troubles d'articulation ont participé à 8 séances d'entraînement où l'emphase a été mise sur la métaphonologie et la perception phonémique. Ces enfants ont amélioré significativement leurs HM de sorte que leurs tests post-traitement ont démontré qu'ils avaient des HM qui n'étaient pas significativement inférieures par rapport à celles des enfants ayant un développement normal. Par contre, leurs HM étaient significativement supérieures par rapport à celles des enfants ayant des troubles d'articulation qui n'ont pas eu d'entraînement. Les implications cliniques et théoriques de ces résultats sont discutées. D'autres avenues de recherche sont proposées pour confirmer ces résultats de façon expérimentale et pour isoler l'effet de la perception phonémique sur les HM.

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Introduction

Phonological awareness has been shown to be important in the development of decoding and reading skills (Bradley, & Bryant, 1983). Children with poor phonological awareness tend to have poor reading skills, while children with good phonological awareness tend to have good reading skills. The emergence of phonological awareness skills is influenced by other aspects of phonological development such as phonemic perception and articulation abilities. It is also influenced by language development, family socio-economic status (SES), and home literacy experiences. Phonological awareness is present and can be measured in preschoolers (Chaney, 1992), thereby allowing for the possibility of identifying these difficulties early and possibly preventing successive decoding and reading delays.

The following section outlines the development of phonological awareness and explores the variables contributing to phonological awareness and the relationships between these variables.

Normal Phonological Development

Normal phonological development is characterised by the acquisition of three distinct but related skills. The first skill, phonemic perception, is the ability to perceive the difference between contrasting speech sound categories in one's native language. Phonemic perception is typically assessed by asking children to point to pictures that represent words that differ by a single speech sound. For example, "Point to seat." versus

"Point to sheet." The second skill, articulation, is the ability to produce speech sounds accurately. Articulation skills are assessed by asking children to name pictures of words that collectively contain all of the consonant sounds in the language. The third skill, phonological awareness, is the explicit knowledge that spoken words can be segmented into abstract units that represent individual speech sounds. Phonological awareness at the school-age level is tested with a variety of procedures that involve the mental manipulation of speech sounds. For example, the child might be asked to "Say *dog* without the *d*." When testing preschoolers, simpler procedures are employed. For example, the child might be asked to point to pictures to represent words that rhyme, or to a series of pictures that represent words that start with the same sound. Phonological awareness has been linked to the acquisition of reading skills.

Phonological awareness can be measured in different ways by targeting different breakdowns of the syllable. For example, phonological awareness can be assessed in terms of phonemes or onset and rimes. Phonemes are the smallest units of sound which contrast meaning in a language (i.e., *cat* is made up of three phonemes, /k/, /æ/, /t/). Onsets and rimes are the middle-sized phonological unit between smaller phonemes and larger syllables. Together an onset and a rime compose a syllable. Onsets are made up of the first consonant or consonant cluster in a syllable (i.e., /k/ in *cat* or /st/ in *stop*). The final part of the syllable is made up of the nucleus, which is a vowel (i.e., /æ/ in *cat*), and the coda, which is the final consonant sound (i.e., /t/ in *cat*). Together the nucleus and the coda make up the rime (i.e., /æt/ in *cat*). Words rhyme when they share a common rime and differ only in word onset (i.e., *chunky* and *monkey*).

The literature demonstrating the associations between phonological awareness, phonemic perception, and articulation were all taken into account in the development of the training program implemented in this study in which phonemic perception and phonological awareness are directly targeted in preschoolers with articulation disorders.

Phonological Awareness in Preschoolers

Many studies have shown that preschoolers have some phonological awareness skills. Burt, Holm, and Dodd (1999) demonstrated that 4-year-olds without articulation disorders have consistent phonological representations based on their speech production, are able to imitate words and non-words, can segment words into syllables, and can demonstrate an awareness of rime and onset, but not phonemes. To do this, they assessed each child's phonological representations through their spoken phonology, and short-term phonological memory along with their phonological awareness skills. The spoken phonology task included an assessment of each child's ability to articulate the names of items consistently and a phonological sample compared articulation across contexts. The phonological awareness tasks included a syllable segmentation task to assess syllabic awareness, Bradley and Bryant's (1983) odd-one-out task to assess rime and onset awareness, Fox and Routh's (1974) word identification task to assess onset awareness, and a phoneme segmentation task (Burt, et al., 1999).

Chaney (1992) discovered that 3-year-olds are able to make metalinguistic judgments including phonological and word judgment tasks, and that this ability improves with age. For instance, compared to 3-year-olds, 7-year-old children are better able to judge whether or not words rhyme. In addition to tests of metalinguistic awareness, language development, articulation, auditory discrimination, word knowledge and sentence structure were also assessed. Phonological awareness, word awareness, structural awareness, and print awareness were each assessed with a number of different tasks. The phonological awareness tasks included judging and correcting phonemes, judging initial sounds and rhymes, phonological play which involved purposely mispronouncing words, and phoneme synthesis. The word awareness tasks included a word segmentation task, a word play/substitution task, judging real versus nonsense words, a word renaming task, and a novel-item naming task. The structural awareness tasks included an assessment of morphemic and syntactic knowledge. The print awareness tasks included alphabet labelling and sorting tasks and answering questions related to books, such as "Show me the front of the book." and "Which way do I go when I read the story." (Chaney, 1992, p.496). These studies show that preschoolers as young as three years old have a variety of phonological awareness abilities at many levels, from phonemes to words.

The Connection between Phonological Awareness and Reading

The process by which preschool aged children acquire these phonological awareness skills is not well understood. A better understanding of the way in which phonological awareness is acquired is very important because research has shown that phonological awareness skills are correlated with decoding skills and early reading ability. Bradley and Bryant (1983) were the first to establish the causal relationship between phonological awareness and reading. They did this by testing the phonological awareness skills of 4- and 5-year-old non-readers and then testing their reading and spelling during the next four years. The initial testing consisted of the Schonell reading test, detecting the word with the odd onset, a memory task, and the Wechsler Intelligence Scale for Children-Revised (WISC-R). They found high correlations between the children's initial phonological awareness abilities and their later performance on the reading and spelling tests.

Chaney (1998) performed a longitudinal study which measured, among other things, the phonological awareness of 3-year-olds. She found that phonological awareness at three years of age predicted reading ability at seven years of age. Phonological awareness at age seven was measured using a phoneme segmentation task and a phoneme deletion task, while phonological awareness at age three was determined by asking the children to judge and correct phonemes, initial sounds and rhymes, phonological play, and phoneme synthesis. Reading ability at age seven was determined by assessing sound-symbol knowledge, word identification, and comprehension.

Stanovich, Cunningham, and Cramer (1984) had kindergarten children perform various phonological awareness tasks to determine the relationship between the tasks. They found that tasks involving matching initial and final consonants, removing and substituting initial consonants, determining which initial and final consonants are different and naming the missing consonant were correlated and were moderately predictive of reading ability one year later. They found these tasks to be better predictors of reading ability than global cognitive measures and a reading readiness task. Children scored close to ceiling on the rhyming activities, which may explain the limited correlation between rhyming and other phonological awareness tasks and ability to predict future reading skill.

Mann (1993) compared the ability of kindergarten phonological awareness and visual-motor abilities to predict grade one reading level. She found that phoneme segmentation and inventive spelling abilities were the strongest predictors of reading in grade one. Other researchers also show that phonological awareness is more predictive of future reading ability than other factors such as intelligence scores, age, and SES (e.g., Burt, et al., 1999).

Phonological Awareness Training

The causal nature of the relationship between phonological awareness and reading abilities has been confirmed in experimental treatment studies. Normally developing preschoolers do benefit from training programs that teach early phonological awareness skills. Bradley and Bryant (1983) taught phonological awareness skills to 4- and 5-year-old prereaders who had relatively low scores on phonological awareness tasks and subsequently found that these children demonstrated superior reading and spelling performance in comparison with the non-experimental comparison group. There were three training groups which focused on sound categorization, sound categorization with letters of the alphabet, and conceptual categorization. The sound categorization with letter support group made the most gains in phonological awareness, followed by the sound categorization only group.

Lundberg, Frost, and Petersen (1988) taught phonological awareness skills, including listening and rhyming skills, as well as sentence, syllable, and phoneme segmentation to 6-year-old prereaders. They found that this training positively affected their reading and spelling acquisition for up to two years after, compared to an untrained control group.

Although phonological awareness training has been shown to be beneficial for normally developing children, those children who are most at-risk for delayed acquisition of reading skills do not always benefit from these interventions. For example, Torgesen, Morgan, and Davis (1992) trained segmenting and blending in kindergarten children with low phonological awareness skills and found that approximately one-third of the children were unresponsive to the segmentation component of the training program. Differences in behaviour or attendance patterns did not distinguish responsive from unresponsive children, nor did participation in special classes, since children who demonstrated these characteristics were omitted from the participant pool. The assessment battery in their study included measures of phonological awareness, alphabetic reading, and the vocabulary subtest from the Stanford-Binet Intelligence Scale-Fourth Edition, in which the children were required to give verbal definitions of words. Other factors, not measured by the researchers, may have distinguished the responsive and unresponsive children, for example, articulation, other language abilities, and phonemic perception. The authors noted that the unresponsive children may have benefited further from more extensive training. Similarly, phonological awareness training programs have not been shown to be successful for dyslexic children.

Other researchers have found that dyslexic children who succeed in learning phonological awareness skills may not show concomitant gains in decoding and reading comprehension abilities (Olson, Wise, Ring, & Johnson, 1997; Torgesen, Wagner, & Rashotte, 1997). These researchers also suggested that unresponsive children may have benefited from more intensive or explicit training. Perhaps phonological awareness skills would transfer better to decoding and reading if the connection between phonological awareness and reading was made more explicit. For example, Hatcher (2000) demonstrated that children trained in both phonological awareness and reading made greater improvement in reading than those trained in phonological awareness alone. It is also possible that once children are diagnosed with reading disabilities or dyslexia they have developed ineffective reading strategies that hinder their ability to benefit from phonological awareness training (Greaney, Tunmer, & Chapman, 1997).

Contributors to the Development of Phonological Awareness

Given the strong relationship between phonological awareness and literacy skills, it is important to understand the variables that contribute to the acquisition of phonological abilities during the preschool period. Variables such as oral language skills, SES, and IQ can have an influence. Chaney (1998) found that overall language ability at age 3, in addition to metalinguistic skills and print awareness, contributed to the prediction of reading achievement at age 7. Other researchers have found a reciprocal relationship between language exposure and reading ability. For example, Blachman (1994) found that poor decoders enjoyed reading less than better decoders and read less often, thus having fewer opportunities for vocabulary growth and exposure to new concepts and ideas. Sénéchal, LeFevre, Thomas, & Daley (1998) found that home storybook reading was related to oral vocabulary development in kindergarten.

Chaney (1994) observed that family literacy experiences, maternal education, and SES independently influence knowledge of print concepts, and would thus have an influence on future reading ability. She also suggested that variable performance on phonological awareness tasks by children of different SES is attributed to differences in the language learning environments (Chaney, 1994). Burt et al. (1999) found that children from lower SES homes tend to have less exposure to written materials and perform more poorly on tests of phonological awareness than children from families of higher SES.

IQ, by itself, is not a reliable predictor of reading ability for children who have reading difficulties and IQ within normal limits. Bradley and Bryant (1978) compared children who made two or more errors on their test of phonological awareness to children who made one or no errors. For children with reading difficulties, the only difference found between the groups was spelling ability, when age, IQ, and reading level were also considered. Siegel (1989) found a dissociation between IQ and phonological skills. IQ was not correlated with reading and spelling skills of children with reading disabilities, as children with different IQ levels did not have different scores on reading comprehension tests (Siegel, 1989). For example, poor readers have a range of IQ scores, as do better readers.

Phonological Awareness and Articulation

The development of articulation skills is related to the development of phonological awareness skills. Studies that have examined the relationships between these variables are discussed below.

In a study of normally developing 3-year-olds, Thomas and Sénéchal (1998) explored the relationship between phonological awareness and articulation. They established the level of phoneme awareness for the target phonemes /r/ and /l/ and a control phoneme. Phonological awareness was measured through a phoneme recognition task which required children to label words contrasted with minimal pairs, a phoneme identification task which required children to identify words beginning with the same phoneme as another word, a phoneme judgment task which required children to identify misarticulated phonemes, and an auditory discrimination task. They divided the children into two groups based on articulatory accuracy. The high articulatory accuracy group consistently produced the target phoneme, while the low articulatory accuracy produced no correct articulations of the target phoneme. When phonological awareness was compared for these two groups, it was found that children who were able to properly articulate /r/ and /l/ had good phonological awareness for these sounds.

Bird, Bishop, and Freeman (1995) compared the phonological awareness of children with articulation impairments to children with normally developing articulation skills, matched for age and nonverbal intelligence. The phonological awareness test, consisted of three components; rime matching, onset matching, and onset segmentation and matching. Children with articulation deficits performed more poorly than children with normally developing articulation skills on phonological awareness and reading tasks throughout the course of this longitudinal study.

Webster and Plante (1992b) compared the phonological awareness of 3-year-olds with normally developing and delayed articulation skills and found that the children with good articulation skills performed significantly better on rhyme detection tasks. The phonological awareness tasks tested rhyme and onset awareness by asking the children to choose the word that does not sound the same as the others. Based on this study, and a previous study (Webster & Plante, 1992a), the authors state "productive phonological impairment...is significantly associated with deficits in phonological awareness" (Webster & Plante, 1992b, p.1202).

Rvachew, Ohberg, Grawburg, & Heyding (2003) used an adapted version of the phonological awareness test developed by Bird, et al. (1995) to compare 4-year-old children with normal articulation and delayed articulation. When matched for receptive vocabulary, age, SES, and pre-literacy skills, the children with normal articulation obtained significantly higher scores on the phonological awareness test than children with delayed articulation.

Preschool children with articulation disorders not only have low phonological awareness, but also low grade one reading skills. Larrivee and Catts (1999) measured the articulation, phonological awareness, and language ability of kindergarten children with and without articulation disorders, then measured their reading ability in grade one. As a group, the children with articulation disorders performed more poorly than controls on the reading and word recognition measures. When they divided the children with articulation disorders into groups of good and poor readers, they found that the poor readers had more severely delayed phonological awareness and language abilities than the good readers, as well as inferior ability to imitate multisyllabic nonwords. This study demonstrates the relationship between articulation skills, phonological awareness, and prospective reading ability as well as the limitations of this relationship, since articulation skills alone do not predict severity of phonological awareness or reading delay.

Phonological awareness training can successfully improve the phonological awareness of children with articulation disorders. Gillon (2000) compared a phonological awareness training program with a traditional articulation therapy program for 5- to 7-year-olds with articulation disorders. The phonological awareness intervention targeted rhyme, phoneme manipulation, phoneme identity, letter-sound correspondences, and phoneme segmentation and blending. The phonological awareness trained group made the most gains in phonemic skills and decoding, as phonemic skills were increased near the level of the normally articulating group. Therefore, phonological awareness training and not articulation training, increases the phonological awareness of children with articulation disorders, demonstrating that phonological awareness and articulation skills are not causally related to one another.

Phonological Awareness and Phonemic Perception

Phonemic perception is another variable that has been shown to influence phonological awareness. Children's ability to identify different tokens of speech sounds as belonging to one speech sound category (e.g., "s") or another (e.g., "sh") improves with age as children learn to attend to and integrate the acoustic features that are the most reliable cues to category identity. These developmental changes in phonemic perception performance occur as a function of the child's experience with their native language. Nittrouer (1996) found that children with less linguistic experience, due to less exposure in the home or to ear infections or both, have less mature phonemic perception abilities than age-matched children who come from middle class homes and do not experience ear infections. Furthermore, children who have relatively poor phonemic perception skills have greater relative difficulty with phonological awareness tasks.

Serniclaes, Sprenger-Charolles, Carré, and Demonet (2001) found that children with dyslexia have more difficulty with categorical perception of speech than do children who are learning to read at the typical rate. Specifically, they found that children with dyslexia have an increased ability to discriminate within category differences for speech sounds making it more difficult for them to distinguish actual differences between categories. Children with dyslexia seem to have difficulty constructing phonemic categories in the same way that aged matched and reading level matched controls do.

Phonemic Perception and Articulation

Phonemic perception abilities have been found to be causally related to articulation abilities. At least some children with an articulation delay have considerable difficulty with categorical perception of speech sound contrasts that reflect their articulation errors. Broen, Strange, Doyle, and Heller (1983) found that 3-year-old children with delayed articulation skills had variable perception of the /w/-/r/, /w/-/l/, and /r/-/l/ contrasts if they were unable to produce them. Hoffman, Daniloff, Bengoa, and Schuckers (1985) found that 6-year-old children with articulation disorders are less precise at identifying and discriminating /r/ and /w/ than normally articulating children. They suggest that, "[r]-misarticulating children may not base their perceptual categorizations upon the same stimulus dimensions that are crucial to the adult listener" (Hoffman, et al., 1985, p. 52). Rvachew and Jamieson (1989) presented synthesized words that contrasted speech errors, showing that some children with articulation disorders have speech perception errors that lead to their production errors. Rvachew, et al. (2003) demonstrated that 4-year-old children with normal articulation are better able to perceive phonemic contrasts than children with articulation disorders.

These studies demonstrate a relationship between perception and production, since the children with good production skills tend to show good perception skills, while the children with poor perception skills had more difficulty with production tasks. Further, it has been demonstrated that a treatment program that focuses on phonemic perception skills leads to significant improvements in articulatory ability. This effect was observed when articulation was not directly targeted (Jamieson & Rvachew, 1992), when articulation was targeted concurrently with phonemic perception (Rvachew, 1994), and when phonemic perception training preceded a phonological process intervention (Rvachew, Rafaat, & Martin, 1999). For example, Rvachew, Rafaat, and Martin (1999) used the Speech Assessment and Interactive Learning System (SAILS; AVVAZ Innovations, 1994) to treat the speech perception difficulties of children with articulation disorders and the children learned to produce sounds for which they were previously unstimulable. Thus, phonemic perception skills have a direct impact on articulation skills, demonstrating a causal relationship between these two variables.

Relationships between Articulation, Phonemic Perception, and Phonological Awareness

These studies demonstrate that phonemic perception is causally related to articulation. Phonological awareness and articulation are correlated, however, they are not causally related. In fact, the relationship between these two variables seems to be mediated through phonemic perception. There is also a demonstrated relationship between phonemic perception and phonological awareness, however, the direction and causality of the relationship has not yet been shown through experimental treatment studies showing that improvements in phonemic perception lead to improved phonological awareness.

Rvachew, Nowak, and Cloutier (under review) conducted a training program for preschoolers with articulation disorders incorporating traditional articulation therapy, phonemic perception training, and phonological awareness training. Despite significant gains in articulation and phonemic perception skills, participants did not make significant improvements in phonological awareness. Given the demonstrated interrelationship between phonemic perception, articulation, and phonological awareness, this result is somewhat unexpected. This result may be influenced by the fact that the phonological awareness component of the training program was lacking some characteristics of an effective phonological awareness training program as outlined by Ehri, et al. (2001). Ehri et al. (2001) suggest that effective phonological awareness training programs should include between 5 to 18 hours of total training time, while focusing on only 1 or 2 specific phonological awareness skills. Rvachew et al. (under review) attempted to target too many phonological awareness skills in too short of a time period. The training program included approximately 14 total hours of training, however, less than 4 hours of training time was devoted to both phonological awareness and phonemic perception training combined, resulting in much less than the recommended minimum of 5 hours for phonological awareness training. Within that time, onset and rime matching, letter name knowledge and sound-symbol association were all targeted, this is greater than the optimal 1 or 2 phonological awareness tasks, and perhaps proved to be even more detrimental to the success of the program given the small amount of time designated for this component of the training sessions.

Summary

To summarize, the literature to date indicates that phonological awareness skills are an important precursor to the acquisition of reading ability. The development of phonological awareness skills during the preschool period is related to the normal development of oral language skills, articulation skills, and speech perception skills. Preschool age children who have difficulty with the perception and articulation of speech sounds often demonstrate delayed development of phonological awareness skills and thus are at risk for subsequent deficits in reading ability. Previous studies have shown that a treatment program that focuses on phonemic perception skills has a profound effect on the rate at which articulation disordered children normalize their articulation skills. Training programs have also been successfully developed to increase the phonological awareness skills of children. However, none of these studies have successfully combined phonemic perception and phonological awareness training to increase the phonological awareness skills of preschoolers with articulation disorders. Like the study by Rvachew et al. (under review), the present study aimed to incorporate phonemic perception training into phonological awareness training. However, the phonological awareness component of the training program was modified in order to provide more training time while reducing the number of phonological awareness skills targeted. The purpose of this research was to determine the effectiveness of such a training program for 4- and 5-year-old preschoolers with articulation disorders.

Objectives & Hypotheses

The objective of this study was to further examine the demonstrated relationships among speech perception, speech production, and phonological awareness skills in preschool-aged children with articulation disorders. In order to explore the influence of a combination phonemic perception and phonological awareness training program on the phonological awareness of young children, an intensive training program incorporating extensive phonological awareness training and phonemic perception training was developed and implemented with 10 preschoolers with articulation disorders.

The hypothesis was that children who received the perception based phonological awareness training program would show superior gains in phonological awareness skills compared to children who received no training. Upon completion of the training program, it was anticipated that the trained experimental group would show gains in phonological awareness, both compared to their own initial phonological awareness skills and in comparison to an untrained comparison group made up of children with articulation disorders. A group of children with normally developing articulation served as a second control group to determine the phonological awareness abilities of the experimental group relative to children with normally developing phonological skills. It was hypothesized that the experimental group would increase their phonological awareness skills to reach the mean of the comparison group of children with normally developing articulation skills.

Method

Participants

In order to determine the effectiveness of the phonemic perception based phonological awareness training program, the group of trained preschool children was compared to two untrained comparison groups. The experimental group consisted of children with articulation disorders who participated in the phonemic perception based phonological awareness training program. The normally developing comparison group consisted of children with normally developing articulation skills. The articulation disordered comparison group consisted of children with articulation disorders who did not participate in the phonemic perception based phonological awareness training program. Hereafter, these groups will be referred to as the trained articulation disordered group (TA), the untrained normally developing group (ND), and the untrained articulation disordered group (UA). The children in the TA group and the UA group were referred by speech-language pathologists working at two large children's hospitals. The ND group was recruited from suburban preschool programs. All of the children spoke English as their first language. Hospital records indicated that all children had normal hearing and oral-motor structure and function and no other known concomitant delays or disabilities.

Each group was composed of 10 preschool children. The TA group included 3 girls and 7 boys, the UA group had 4 girls and 6 boys, and the ND group consisted of 5 girls and 5 boys. Speech-language therapy taking place prior to or concurrently with the study treatment program did not impact on children's eligibility to participate. Eight children in the TA group had received at least one block of articulation therapy prior to enrolment in the present study, while the other two children were participating in therapy blocks that overlapped somewhat with the experimental treatment sessions. Seven children in the UA group had received articulation therapy prior to their assessment.

Table 1 displays the pre-treatment test scores and participant characteristics by group. At the time of initial assessment, the children in the TA group ranged in age from 51 to 62 months with a mean of 56.7 months, the children in the UA ranged in age from 53 to 63 months with a mean age of 57.6 months, and the children in the ND group ranged in age between 50 and 62 months with a mean age of 56.7 months.

SES was calculated using the occupation and education level of each child's mother to yield a Blishen score (Blishen, Carroll, & Moore, 1987). The mean Blishen score for the TA group was 51.3 with scores ranging between 38 to 60, while the mean Blishen score for the UA group was 50.80 with scores ranging from 40 to 62, and the mean Blishen score for the ND group was 58.2 with scores ranging from 34 to 76.

All the children demonstrated average or above average receptive vocabulary scores as measured by the Peabody Picture Vocabulary Test-Third edition (PPVT-III; Dunn & Dunn, 1997). The TA group had a mean standard score of 109 and scores ranging from 91 to 131, the UA group had a mean standard score of 103 and scores ranging from 87 to 122, while the ND group had a mean score of 108 and scores ranging from 91 to 124.

Table 1

Mean (and standard deviation) and Analysis of Variance of Pre-treatment Participant Characteristics and Test Scores by Group

Participant Characteristics	*TA Group*	*UA Group*	*ND Group*	*F*
SES	51.3(7.06)	50.80(8.48)	58.2(11.35)	2.048
Age	56.7(3.3)	57.6(3.1)	56.7(4.19)	.213
PPVT	109.1(11.66)	103.2(9.39)	107.9(10.25)	.887
GFTA	5.4(4.74)	6.4(4.27)	41.6(18.96)	31.870**
PA	12.8(3.12)	13.00(3.02)	18.8(4.78)	8.357**
SAILS	69.9(11.4)	63.4(13.5)	76.1(10.3)	2.887
PCC	71.63(10)	-	92.26(5.34)	-
MLU	5.18(1.87)	-	5.21(1.32)	-
Literacy	11.9(4.75)	13.2(2.66)	13.1(5.04)	.285

Note. Dashes indicate that MLU and PCC data were unavailable for the UA group, due to missing language samples. SES = Socio-economic status (Blishen Score); Age is in months; GFTA-2 = Goldman-Fristoe Test of Articulation-Second Edition, percentile rank; PA = Phonological Awareness Test; PPVT = Peabody Picture Vocabulary Test-Third Edition, standard score; PCC = percentage of consonants correct; MLU = mean length of utterance; Literacy = Early Literacy Assessment.

**The mean difference is significant at the .01 level.

The mean percentile rank on the Goldman-Fristoe Test of Articulation-Revised Edition (GFTA-2; Goldman, & Fristoe, 2000) for the ND group was 42 and ranged from 22 to 78, demonstrating the normally developing articulation skills of this group. Children from both articulation disordered groups had mild to severe articulation disorders. The GFTA percentile ranks for the TA and UA group were 5.4 and 6.4, respectively, with both groups having scores ranging from below 1 to 15.

Percentage of consonants correct (PCC; Shriberg & Kwiatkowski, 1982) is a measure of articulatory accuracy. To obtain the PCC, the speech sample is first transcribed phonetically, then the number of consonants pronounced correctly is divided by the total number of consonants attempted. PCC was calculated with scores for the TA group ranging from 51.3% to 84.9% with a mean of 71.63% and scores for the ND group ranging from 83.3% to 97.2%, with a mean of 92.26%. PCC measurements were not available for the UA group as language samples were missing .

Frequency matching was used to ensure that the three groups of children were similar with respect to age, SES, and PPVT score. Furthermore, the TA and UA groups were equated for severity of their articulation deficit, as measured by the GFTA. As shown in Table 1, an ANOVA revealed that the matching procedure was successful with no significant between group differences in these variables, except for GFTA scores. The TA and UA groups were not significantly different with respect to GFTA percentiles, but both of these groups achieved a significantly lower mean GFTA percentile than the ND group.

Design

There were three phases of the study. The TA group participated in all three phases, while the two comparison groups, the UA and ND groups, participated in only the first phase. Phase 1 took place during the spring or early summer before each child's kindergarten year. During phase 1, the children underwent a thorough assessment to determine their baseline speech, language, perception, and phonological awareness abilities. The tests involved in the initial assessment included the phonological awareness test, the SAILS test of phonemic perception, the GFTA, the PPVT, the Early Literacy Assessment, and the recording of a spontaneous speech and language sample. Children in the TA group also completed an articulation probe, which acted as an adjunct to the GFTA, since the GFTA lacks the sensitivity to detect change when administered twice in less than three months. Phase 2 took place immediately following phase 1 in the early summer before the child's pre-kindergarten or kindergarten year. In phase 2, the children participated in eight phonemic perception based phonological awareness training sessions over the course of eight weeks. Phase 3 took place immediately following phase 2. During phase 3, the phonological awareness test, the articulation probe, and SAILS were readministered in order to determine post-treatment phonological awareness, articulation ability, and phonemic perception and to measure any changes occurring between the pre-treatment and post-treatment measures.

Procedure

Assessment

At the beginning and end of the study, children in the TA group received an assessment of their phonological awareness, speech perception, and articulation. In addition to the assessment of these skills, the initial assessment also included measures to assess receptive vocabulary, expressive language, and beginning literacy development. The initial assessments took approximately 60 to 90 minutes and included the following procedures.

Phonological Awareness Assessment. Phonological awareness was assessed using a test based on Bird, et al.'s (1995) phonological awareness test. The three components of this test include a rime matching section, an onset matching section, and an onset segmentation section. See appendix A for a list of the training and testing items from each section.

In the rime matching section, the examiner held up a puppet, for example, named "Dan," and said, "This animal's name is Dan. Dan likes things that sound like his name. Listen, which one of these things does Dan like?" The examiner then pointed to and named four pictures, which were situated in front of the child. For example, "House, boat, car, or van." The child was then expected to point to the picture that rhymed with the puppet's name (e.g., van).

In the onset matching section, the examiner held up a puppet and said, "This animal likes everything he owns to begin with the same sound. The sound he likes is e.g., /f/. Which one of these will he want?" The examiner then pointed to and named the four pictures that faced the child. The child was then expected to point to the picture that had the onset that the puppet preferred (e.g., fan).

In the onset segmentation section, the examiner held up the puppet, for example, "Marg," and said, "This animal's name is Marg. Marg likes things that start with the same sound as her name. Which one of these things will Marg want?" This section was more difficult than the onset matching section because the child was required to first segment the onset from the rime in the puppet's name, and then match it to the onset of the correct word, as in the onset matching section.

Each section included several training items, during which corrective feedback was given when necessary, followed by the test items, during which there was no corrective feedback given. There were 14 rime test items, 10 onset test items, and 10 onset-segmentation items for a total of 34 test items. Given that many of the children in the study had an articulation disorder, it was important that the child point to each answer, instead of requiring a verbal response, to ensure that there was no misunderstanding about the child's choice due to an error in articulation. Split-half reliability for this test has been determined to be 0.9772 (using and odd-even split) based on 87 prior administrations in which total scores ranged from 0 to 100 percent correct.

Standardized Articulation Assessment. Articulation was assessed using the GFTA. Each child was asked to name pictures of various items that collectively contained most of the consonant sounds in the English language. The child's score was then compared to the normative information that is included with the test to determine the child's level of articulation, in the form of percentile rank, compared to other children of the same chronological age.

Articulation Probe. The articulation probe was administered to children in the TA group at the time of initial assessment, or in some cases, before the commencement of the first training session. The articulation probe targeted the sounds /k/, /l/, /r/, /s/, /f/, /θ/. These sounds were targeted in word initial position in spontaneous speech by asking the child to name a picture. They were also targeted in all word positions in connected speech by asking the child to repeat a sentence after it was stated by the experimenter. The total number of correct articulations of each sound was tallied and a grand total out of 64 was calculated.

Phonemic Perception Assessment. The SAILS computer program was used to assess phonemic perception. The test stimuli contrasted correct and incorrect articulations of the sounds /l/, /k/, /r/, and /s/ in the word initial position. For example, half of the stimuli from each block were articulated correctly, i.e., cat → [kæt], while the other half were articulated incorrectly, i.e., cat → [tæt]. The stimuli were recorded from both child and adult speakers. The following instructions were given to the child. "You will hear some people say the word e.g., *lake*. Sometimes the person will say the word *lake* correctly. Sometimes they will make a mistake and say the word *lake* wrong. When you hear the word *lake* point to the *lake*. If the word is not *lake*, point to the X. If the person says the wrong word, point to the X." On the computer screen, in front of the child, was a picture representing the word (e.g., a picture of a lake) and a picture of an X, as well as a blank area for the reinforcing cartoon. After each response, the child was given reinforcement in the form of an on-screen cartoon, regardless of accuracy of the response.

Each test block was composed of 10 trials and there were one to three blocks per phoneme.

Receptive Vocabulary Assessment. Receptive vocabulary was assessed using the PPVT. For this test, four pictures were placed in front of the child and the child was asked to point to the picture that represented the word stated by the examiner. This test did not require any verbal participation of the children. The child's score was then compared to the normative data, in the form of standard score, which was included with the test to determine the child's receptive vocabulary compared to children of the same age.

Early Literacy Assessment. The children's early literacy and prereading skills were assessed using the Early Literacy Assessment, adapted from Jerry L. Johns (1997). The test was composed of three subtests. The first subtest, alphabet knowledge, involved asking the child to name uppercase and lowercase letters presented to them. In the second subtest, literacy knowledge, the child was shown a book and asked functional reading questions (i.e., "Where do you start reading?") and book structure questions (i.e., "Where is the title?"). The third subtest, basic word knowledge, involved asking the child to read sight words (i.e., a, the). The total number of correct responses was tallied to yield a final score out of 32.

Spontaneous Speech and Language Sample. Speech and language samples were recorded from all participants using a picture book (*Good Dog, Carl;* Day, 1986 or *Carl Goes Shopping*; Day, 1989). The children were asked to tell the examiner the story or to explain what was happening in the pictures. The examiner often asked opened-ended questions, such as "What are they doing now?" or took turns with the child in telling the story in order to give the child a guide as to the types of responses expected. The mean length of utterance (MLU) in morphemes was calculated using Systematic Analysis of Language Transcripts (SALT; Miller, & Chapman, 1996). The PCC was obtained by phonetically transcribing each sample. Ten percent of the samples were randomly selected for recoding by a second observer. Morpheme by morpheme reliability for the SALT transcriptions was 88.8%. Point by point reliability for the PCCs was 83.36%.

Training

Each child in the TA group participated in eight weekly phonological awareness training sessions. Each session was composed of four parts; (1) rime matching, (2) phonemic perception training, (3) onset matching, and (4) homework and review.

Onset and rimes have been targeted since words are more naturally divided into onsets and rimes than into phonemes (Kirtley, Bryant, MacLean, & Bradley, 1989) and preschoolers have demonstrated the ability to divide words at the level of onset and rime (Byrne, 1998).

The nature of the activities and the organization of each session remained consistent from week to week in order to help the children become familiar and comfortable with the routine, which allowed them to focus on learning the specific targets of each session. The target items for each week progressed from least difficult to most difficult, encompassing both the level of difficulty of articulation of the sound, and the contrasts presented each week. For example, the first onset targeted was /m/ which is early developing and rarely misarticulated while the remaining onset targets, /s/ and /k/, are more commonly misarticulated by young children, but represent features that are established in the speech of normally developing children at this age. During the first session /m/ was contrasted with /t/, which differs from /m/ in place, manner, and voicing.

During the second session, /m/ was contrasted with /p/, which it only differs from /m/ on manner of articulation only, making this distinction more difficult than the first. The progression of the training targets is outlined in Table 2. All onset and rime training stimuli is listed in Appendix B.

The phonological awareness training differed from the phonological awareness assessment measure in a few important ways. The training involved asking the children to select one of two options with the support from the experimenter, while the test required that the child make a choice from four response alternatives with no support from the examiner, with the exception of the training items. Therefore, the goal of training was to achieve a firm understanding of onset and rime in order to transfer this knowledge to a different task. Some stimuli targeted in training were also test items, however, the focus of the training was to establish an understanding of the concepts of onset and rime and not knowledge of specific onset and rime, per se.

Table 2

Progression of Treatment Targets

Session	Rime	SAILS	Onset
1	/æn/ /ɔl/	mitt	/m/ /t/
2	/æn/ /ɛn/	mitt	/m/ /p/
3	/æt/ /ɪg/	sue	/s/ /b/
4	/æt/ /ɪt/	sue	/s/ /w/
5	/ʌg/ /ɪŋ/	sue	/s/ /f/
6	/ʌg/ /æg/	cat	/k/ /p/
7	/æp/ /æd/	cat	/k/ /s/
8	/æp/ /æm/	cat	/k/ /t/

Rime Matching. The goal of the rime matching component was to teach the child to attend to the rime of words, notice similarities and differences between rimes and identify when words ended with the same rime or different rimes. This task required the child to use listening, discrimination, identification, and matching skills. Each session involved sorting picture cards into objects that ended in the same rime. At the beginning of each session the names of the two sorting objects were introduced and the picture cards were mixed up. The child was instructed to choose a card, say its name, decide which object it sounded the same as or which item it rhymed with, and then to put it into that object. For instance, during week 2, the picture cards were sorted into either a garbage can or a hen. The child was expected to sort pictures of *fan* and *ran* into the *can* and pictures of *men* and *ten* into the *hen*. The children were encouraged to say the name of the pictured item and the names of the sorting objects. The experimenter also stated the name of the picture and the objects, as necessary, initially stating the words as they would normally be pronounced, but often playing with the sounds of the words to make the different components more salient. The experimenter also commonly used other words to further illustrate the concept of common rimes. For example, listing all the previously sorted items "pen, ten, men, when, hen, den." The experimenter also repeatedly pointed out why the appropriate items belonged together, stating, "They have the same sound at the end." and "Those words both end with *en*." The number of trials varied from session to session, from 6 to 8 per rime target, depending on the number of existing words with the common rime. The target rimes became increasingly similar from session to session, making the contrast more difficult and increasing the level of attention to detail required to discriminate the sounds and to make the correct sorting decision.

Phoneme Perception Training. Each phoneme perception training component targeted the same word initial sound as the onset matching activity for the week. The sound /m/ was targeted first for two sessions, followed by /s/ and /k/ for three consecutive sessions each. The perceptual training involved the use of the SAILS program. This was the same computer program that was used to assess phonemic perception. Children were presented with a recording of a word and then asked to identify the word that they heard by pointing to the appropriate picture on the computer screen. The words that the children heard contrasted correct and incorrect articulations of the sounds listed above (i.e., *mitt* for /m/, *Sue* for /s/, and *cat* for /k/). The training proceeded in a similar way to that of the assessment as described earlier, however corrective feedback was provided to the child regarding the sound and word differences. For instance, in the case of mitt, the examiner might say, "No, that word did not sound like *mitt*. Listen again." When a mistake was made, the word was replayed and the child was given another chance to respond. The children completed 30 trials or three blocks during each training session.

Onset Matching. The goal of the onset matching component was to teach the child to attend to the initial sounds of words, noticing similarities and differences between the onsets of different words and identifying when words began with the same sound or different sounds. The onsets targeted were the same as those targeted for the phonemic perception training. Like the rime matching component, this task required the child to use listening, discrimination, identification, and matching skills. The onset tasks were primarily sorting and matching activities. For sessions 1, 3, 4, 6, and 8 children sorted picture cards, based on word onsets, into 'letter-munchers.' Letter-munchers were tissue boxes decorated with faces and labelled with their preferred onset. The children were instructed that letter munchers would only eat words beginning with that particular onset. For sessions 2, 5, and 7, children glued pictures onto letters of the matching onset, and then covered each picture with a piece of construction paper labelled with the onset, creating a lift-the-flap game. In addition to the activities listed above, sessions 5 and 8 also contrasted the target onsets while playing a board game. Progression through the game occurred by matching the target onset on the die, rolled at the beginning of each turn, with the next matching onset of a picture on the board. Use of the board game allowed review and reinforcement of the sounds targeted up to that point. For instance, in session 5 the onsets /m/ and /s/ were contrasted and in session 8 onsets /m/, /s/, and /k/ were contrasted. In session 7, the children played onset memory as another form of review, which involved matching words with their corresponding onset and contrasting all the onsets targeted up to that point. Another review activity, used in session 8 was onset bingo, during which children drew a sound and located all the words on their card with the matching onset. Like in rime training, the children were encouraged to say the names and sounds of the training items. Whenever necessary, the experimenter also stated the name of the picture, the objects, and the sounds, both in a usual way of speaking and with emphasis on the sounds and different parts of the words in order to further highlight their different components. The experimenter also commonly used other words from the same treatment session to further underscore the idea of matching onsets. For example, the experimenter may have listed all the previously sorted items "mitt, mop, man, moon, milk." The experimenter also repeatedly pointed out why the appropriate items belonged together, stating, "He likes to eat things that begin with the sound /m/. Mmmop begins with /m/ so he likes to eat the mop." and "Listen, mmmop has the /m/ sound at the beginning." Each week the target sound was contrasted with a sound with increasingly similar characteristics, making the distinction more difficult from week to week.

Homework and Review. The homework given after each session reviewed both the target onset and rime for each week. The rime review activity was a sorting activity. Items were cut out and pasted onto a picture of an item with the matching rime. The rimes and words were the same as those targeted in the weekly session. For example, in session 6, the sorting choices were *mug* and *bag* and the pictures to be glued were *rug, wag, zag, dug, hug, rag, gag,* and *mug.* The onset review activity involved collecting a couple of small items in a paper "surprise bag" to bring to the next training session to share with the experimenter. In addition to these review tasks, children were also given onset booklets. After session 3 and the introduction of the /s/ onset, the children were given an /s/ onset book, with examples of /s/ initial words presented in a rhyming story. A similar book was given to the children in session 6 for the /k/ onset. Children were encouraged to bring their completed rime homework and onset surprise bag to each session. This allowed the targets from the previous week to be reviewed and motivated the child to complete their homework each week.

All onset and rime judgements were made based on pictures and the production of the target word by both the child and the experimenter. It was not expected that preschool children were able to read, however each picture card did have the word written below it. Previous research has shown that although children are not expected to be able to read at 4-years-old, they benefit from exposure to print and print exposure may facilitate reading and spelling abilities (Blachman, 1989; Stackhouse, Wells, Phil, Pascoe, & Rees, 2002). Children who did happen to learn to recognize any of the letters or words through the course of the training program may benefit from this additional knowledge and may be able to use it for future reading tasks. In fact, it seemed that many children did not pay any attention to the printed word at all, instead focusing their attention on the sounds of the word and the picture on the card. There was one child, however, who preferred to use the visual information from the printed word to make his matching decision. In order to force this child to use his speech perception and discrimination skills when making his matching decision, the printed word on the picture cards were covered up. Once the printed word was covered he experienced some difficulty adjusting to using the auditory information to make his decision. This was interesting because he seemed to be keenly aware of which component he needed to examine visually to determine the onset or rime match, but was unable, at first, to transfer this knowledge to the auditory domain.

Reassessment

Only children in the TA group underwent reassessment. Reassessment took place during phase 3, following the completion of the phonemic perception based phonological awareness training program. The reassessment included three measures from the initial assessment; the phonological awareness test, the articulation probe, and the SAILS test of phonemic perception. These measures served as the outcome measures for the study.

Results

Pre-Treatment Analyses

Table 1 displays the results of a one-way ANOVA used to assess between group differences in participant characteristics for the initial assessment. The three groups did not differ significantly in their age, SES, SAILS, PPVT, or early literacy. An alpha level of .05 was used when conducting all statistical analyses to reduce the likelihood of committing a type I error.

Articulation. The results of the ANOVA indicated that there was a significant difference in GFTA percentile rank scores between the three groups, $F(2, 27) = 31.87$, $p < .000$. Table 3 displays the results of Tukey's post-hoc analyses which indicated that the ND group performed significantly better than both groups of children with articulation disorders. The TA group and the UA group did not differ significantly from one another on this measure. PCC was compared for the TA and ND groups using an independent samples t-test which indicated that the groups were significantly different on this measure, $t\ (18) = -5.748$, $p < 000$. PCC measurements were not available for the UA group due to missing language samples.

Phonological Awareness. The ANOVA indicated that there were also significant differences between the three groups on the phonological awareness test $F(2, 27) = 8.357$, $p < .001$. Tukey's post-hoc comparisons indicated that the ND group performed significantly better on the test of phonological awareness than either of the articulation disordered groups with a mean score of 18.8 and scores ranging from 10 to 24. The TA group and the UA group had mean scores of 12.8 and 13.0, with scores ranging from 8 to

19 and 8 to 18, respectively. The TA group and the UA group did not differ significantly on their level of phonological awareness.

Phonemic Perception. The results of the ANOVA indicated that there were no significant differences between the three groups on the SAILS test of phonemic perception. The TA group had a mean SAILS score of 69.9% with scores ranging between 53% and 86%, the UA group had a mean SAILS score of 63.4% with scores ranging from 47% to 84%, and the ND group had a mean SAILS score of 76.1% with scores ranging from 56% to 88%.

Expressive Language. An independent samples t-test indicated that the TA and ND groups did not differ significantly on MLU, $t\ (18) = -0.36, p < .972$. The mean MLU for the TA group was 5.18, ranging from 1.78 to 9.02, while the mean MLU for the ND group was 5.21, with scores ranging from 2.85 to 7.35. MLU measurements were not available for the UA group.

Early Literacy. The ANOVA indicated that there were no significant differences between groups on the Early Literacy Assessment. The mean score for the TA group was 11.9 with scores ranging from 1 to 17, the mean score for the UA group was 13.2 with scores ranging from 9 to 17, and the mean score for the ND group was 13.1 with scores ranging from 6 to 19.

Table 3

Tukey's Post Hoc Analysis Results for Between Group Differences of Pre-treatment Participant Characteristics and Test Scores

	Groups Compared	Mean Score Difference	*Standard Error*
GFTA	TA & ND	-36.20*	5.16
	TA & UA	-1.00	5.16
	ND & UA	35.20*	5.16
PA	TA & ND	-6.00*	1.67
	TA & UA	-.20	1.67
	ND & UA	5.80*	1.67
PCC	TA & ND	-20.6300	9.2033
	TA & UA	-	-
	ND & UA	-	-

Note. GFTA-2 = Goldman-Fristoe Test of Articulation-Second Edition, percentile rank; PA = Phonological Awareness Test; PCC = percentage of consonants correct.

*The mean difference is significant at the .05 level.

Post-Treatment Analyses

The key question explored in this study was whether or not the phonemic perception based phonological awareness training program was effective in improving the phonological awareness skills of the TA group. The pre-treatment and post-treatment test statistics for the TA group are displayed in Table 4. A paired samples t-test was used to determine that the experimental group's mean change in phonological awareness test score from 12.8 to 18.7 was statistically significant, $t(9) = -3.93, p < .003$.

Phonemic perception and articulation were also reassessed following participation in the treatment program. The mean scores on the SAILS test of phonemic perception increased from 69.9% to 80.3%, $t(9) = p < .011$. The mean scores on the articulation probe made a nonsignificant increase from 21.6 to 25.9. Figure 1 displays the mean group changes in phonological awareness, phonemic perception, and articulation. These results indicate that the training program was successful in making a significant improvement in both skills targeted, phonological awareness and phonemic perception, compared to the pre-treatment levels.

Table 4

Mean (and standard deviation), Range, and t-test Results for the TA Group on Pre-treatment and Post-treatment Tests of Phonological Awareness, SAILS, and the Articulation Probe

	Pre-Test		Post-Test			
	M (SD)	*Range*	*M (SD)*	*Range*	*df*	*t*
PA	12.8 (3.12)	8 - 19	18.7 (5.77)	9 - 26	9	-3.93**
SAILS	69.9 (11.41)	53 - 80	80.3 (8.88)	59 - 90	9	-3.16*
Articulation Probe	21.6 (11.53)	1 - 38	25.9 (13.59)	5 - 44	9	- 2.09

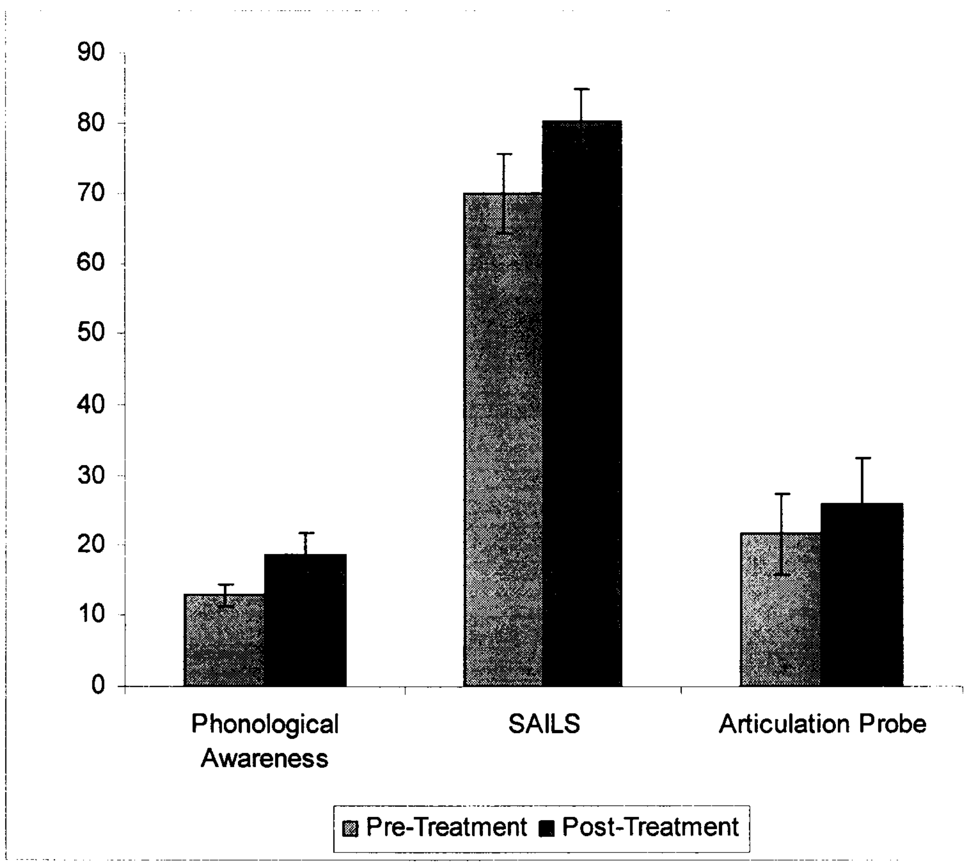
Note. PA = Phonological Awareness Test.

**The mean difference is significant at the .01 level.

*The mean difference is significant at the .05 level.

Figure 1

Mean pre-treatment and post-treatment scores for the TA group



Note. The change in phonological awareness is significant at $p < .01$. The change in SAILS is significant at $p < .05$. The change in the articulation probe score is not significant.

Post-Treatment Comparisons

Due to the non-experimental nature of this study (i.e., the UA and ND comparison groups participated in only the initial assessments and not the post-treatment measures), post-treatment scores from the TA group were compared to initial assessment scores from both comparison groups. Table 5 displays the results of a one-way ANOVA used to assess differences between the TA group's post-treatment scores and the UA and ND groups' assessment scores on the phonological awareness test and SAILS.

Figure 2 displays the TA group's mean pre-treatment and post-treatment phonological awareness test scores, in addition to the mean initial assessment phonological awareness score of the UA and ND comparison groups, visually demonstrating the TA group's mean significant increase in phonological awareness, both compared to their own initial phonological awareness skill and compared to the levels of the two comparison groups. The ANOVA confirmed that there were significant differences between the groups on the phonological awareness test, $F(2, 27) = 5.064$, $p < .014$. Table 6 displays the results of Tukey's post-hoc analysis which indicated that the TA group performed significantly better on the post-test of phonological awareness than the UA group, while the difference in test scores between the TA group and the ND group were not statistically significant. The TA group began with a low phonological awareness score, not statistically different from that of the UA group, but significantly lower than that of the ND group, and ended up with a phonological awareness test score significantly higher than the that of the UA group, but not statistically different from that of the ND group at the completion of the training program.

Table 5

Mean (and standard deviation) and Results of Analysis of Variance of TA Group's Post-Treatment Test Scores versus the ND and UA Comparison Groups' Initial Assessment Test Scores

	TA Group	*UA Group*	*ND Group*	*F*
PA	18.7(5.77)	13.0(3.02)	18.8(4.78)	5.064*
SAILS	80.3(8.88)	63.4(13.53)	76.1(10.3)	6.313**

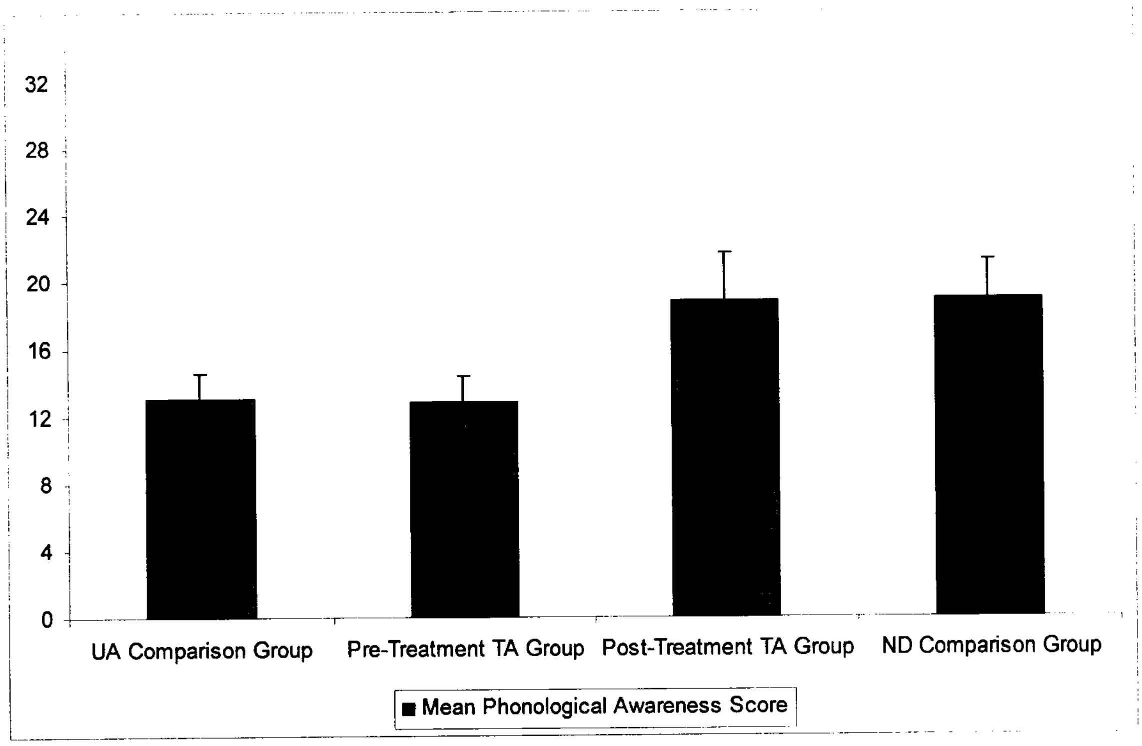
Note. PA = Phonological Awareness Test.

**The mean difference is significant at the .01 level.

*The mean difference is significant at the .05 level.

Figure 2

Mean phonological awareness test scores by group



Note. There are no significant differences between the UA group and the pre-treatment TA group, or between the post-treatment TA group and the ND group on mean phonological awareness test scores. The UA group and the pre-treatment TA group are significantly different from the post-treatment TA group and the ND group.

Table 6

Tukey's Post Hoc Analysis Results for Between Group Differences in TA Group's Post-Treatment Test Scores versus the ND and UA Comparison Groups' Initial Assessment Test Scores

	Groups Compared	Mean Score Difference	*Standard Error*
PA	TA & ND	-.10	2.09
	TA & UA	5.7*	2.09
	ND & UA	5.8*	2.09
SAILS	TA & ND	4.2	4.95
	TA & UA	16.9**	4.95
	ND & UA	12.7*	4.95

Note. PA = Phonological Awareness Test.

**The mean difference is significant at the .01 level.

*The mean difference is significant at the .05 level.

Therefore, after completion of the training program, the phonological awareness skills of the TA group surpassed those of the UA group and were found to be in the normal range, as compared with the ND group.

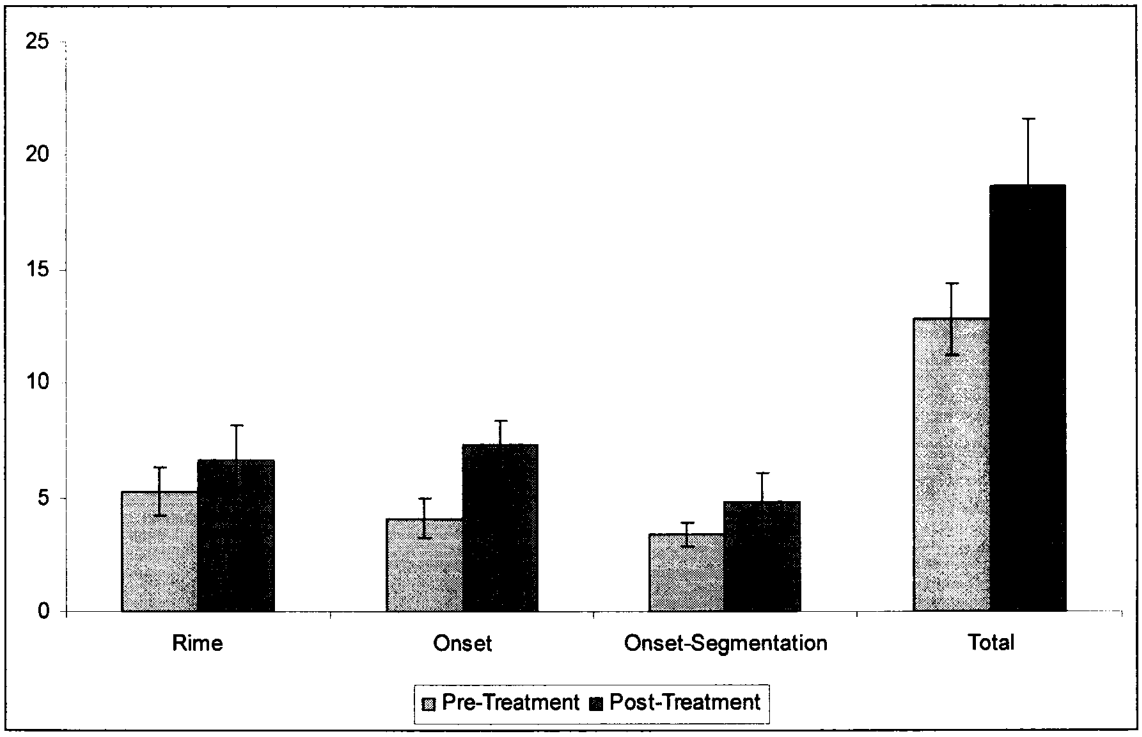
The ANOVA also indicated that there were significant post-treatment differences between groups on the SAILS test of phonemic perception, $F(2, 27) = 6.313, p < .006$. A Tukey's post-hoc analysis indicated that the TA and ND group had significantly higher phonemic perception scores than the UA group. As in the pre-treatment assessment, phonemic perception scores between the TA and ND groups were not significant. The results of this post-hoc analysis are also displayed in Table 6.

Changes in Individual Subtests

It is of interest to determine which, if any, of the subtests accounted for the majority of the change in phonological awareness from pre-test to post-test. Figure 3 displays the mean phonological awareness total and subtest scores. Of the three subtests, the change in onset score was the greatest with a mean increase in score of 3.2 out of a possible 10 test items. The mean change in the onset-segmentation score was 1.4 out of 10 test items, while the mean change in rime score was the smallest at 1.3 out of 14 test items. This means that the increase in overall phonological awareness score was most influenced by the increase in onset awareness. In fact, the only subtest score with a significant difference between pre-treatment and post-treatment assessments was the onset subtest, $t\ (9) = -1.871, p < .000$.

Figure 3

Pre-treatment and post-treatment phonological awareness subtests scores with standard error bars



Note. The change in onset was significant, t (9) = -1.871, p <.000, and the total phonological awareness change was significant, t (9) = -3.93, p < .003.

Individual progress

Individual changes in phonological awareness test scores are displayed in figure 4. Only one of the children in the experimental group failed to show an improved phonological awareness score after participating in the training program. All of the other children in the program increased their level of phonological awareness, while this child's score dropped from 12 to 9 out of 34. This child was the youngest in the TA group. He had a short attention span and difficulty staying on task. It was difficult to ascertain whether his difficulty participating in the training program was related to a lack of comprehension, a lack of ability, or a lack of motivation. His MLU, PCC, and post-treatment SAILS scores were lower than those of the other children.

The mean post-treatment phonological awareness score of the TA group was not significantly different from the ND group. However, half of the children participating in the study were not successful in increasing their phonological awareness scores to this level. The characteristics that differentiated children with scores above the mean and scores below the mean included pre-treatment phonological and rime awareness, SES, and overall change in phonological awareness, specifically the change in onset awareness between pre-treatment and post-treatment. The characteristics of these two groups are displayed in Table 7.

Figure 4

Individual change in phonological awareness between pre-treatment and post-treatment measurements

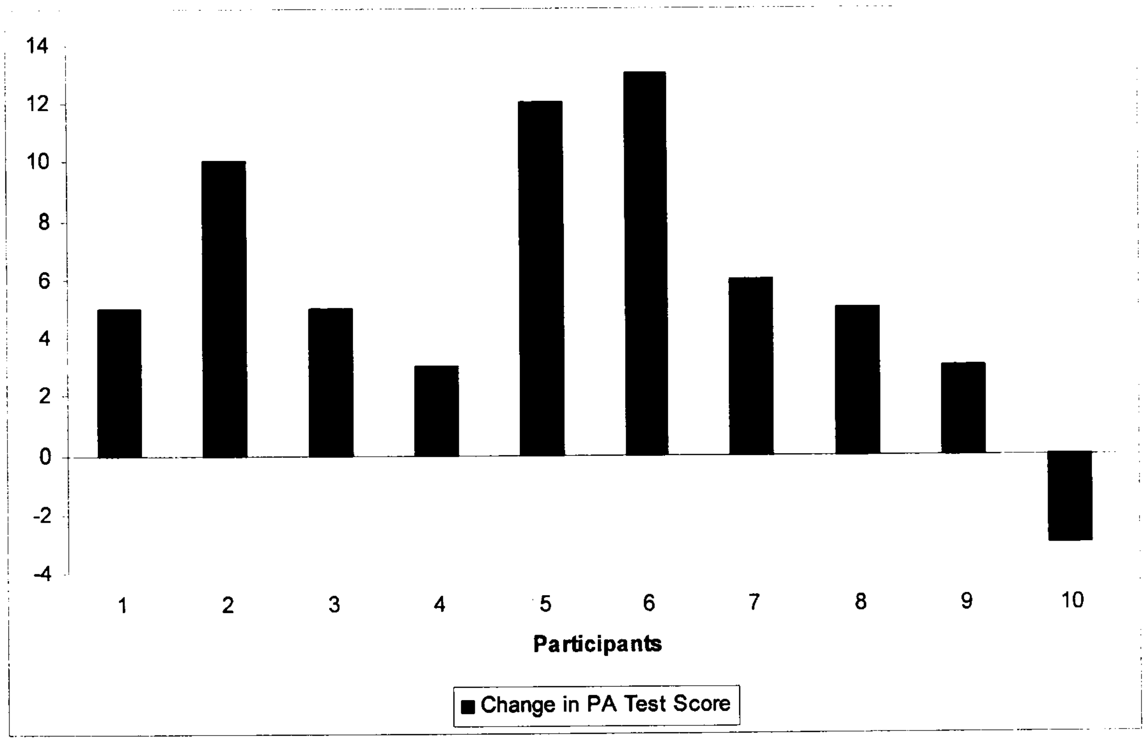


Table 7

Variables Differentiating Between Children in the TA Group with Post-treatment Phonological Awareness Test Scores Above and Below the Mean

	Low PA	*High PA*		
	Mean (SD)	*Mean (SD)*	*df*	*t*
SES	47 (6.89)	55.6 (4.28	8	-2.371*
PPVT	103.8 (2.28)	114.4 (1518)	8	-1.545
GFTA	4.20 (3.11)	6.6 (6.11)	8	-.783
Pre-Treatment PA	10.8 (2.17)	14.8 (2.68)	8	-2.593*
Pre-Treatment Rime	4 (1)	6.6 (2.19)	8	-2.414*
Pre-Treatment Onset	3.6 (2.07)	4.6 (1.34)	8	-.905
Pre-Treatment Onset-Seg.	3.2 (1.3)	3.60 (0.89)	8	-.566
SAILS	65.8 (11.08)	74 (11.31)	8	-1.158
PCC	70.86 (11.76)	72.4 (9.25)	8	-.230
MLU	4.56 (1.81)	5.82 (1.91)	8	-1.072
ELA	10.80 (6.65)	13 (1.87)	8	-.712
Change in Rime	1 (1.6)	1 (4.72)	8	-.278
Change in Onset	2 (1.58)	4.4 (1.14)	8	-2.753*
Change in Onset-Seg.	0 (2.12)	2.80 (1.79)	8	-2.256
Change in PA	3 (3.46)	8.80 (4.21)	8	-2.380*

Note. SES = Socio-economic status (Blishen Score); GFTA = Goldman-Fristoe Test of Articulation, Second Edition, percentile rank; PA = Phonological Awareness Test; PPVT

= Peabody Picture Vocabulary Test-Third Edition, standard score; PCC = percentage of consonants correct; MLU = mean length of utterance; Literacy = Early Literacy Assessment; Onset-Seg. = Onset Segmentation subtest of the phonological awareness test.

*The mean difference is significant at the .05 level.

Discussion

The Success of the Training Program

In this study, 10 children with articulation disorders participated in a phonemic perception based phonological awareness training program. The mean phonological awareness level of the trained group was increased significantly from the level of other children with articulation disorders, to the level of normally developing children. Therefore, the training program was successful. The hypothesis that children participating in phonemic perception based phonological awareness training would increase their phonological awareness scores over an untrained comparison group was supported. This program demonstrates that preschoolers with articulation disorders can benefit from appropriate phonological awareness training.

Many other researchers have developed successful phonological awareness training programs for children. Table 8 displays eight other phonological awareness training programs implemented with normally developing children or children with articulation disorders, in various stages of reading development. These training programs ranged in training time between 7 and 40 hours, with a mean time of 21hours. This is considerably more time than the 6 to 8 hours of phonological awareness training in the present study. As in the present study, the studies by Gillon (2000), Hesketh, Adams, Nightingale, & Hall (2000), Roth, Troia, Worthington, & Dow (2002), and van Kleeck, Gillam, & McFadden (1998) targeted prereaders with articulation disorders.

Table 8

Comparable Phonological Awareness Training Programs

Treatment program	Participant age(s)	Training targets	Training type	Total treatment time
Gillon (2000)	5- to 7-year-olds with articulation disorders	- phonological awareness - articulation	- individual	- 20 hours
Hesketh, et al. (2000)	Preschoolers with articulation disorders	- metaphonological awareness - articulation	- individual	- 10 hours
Lundberg, et al. (1988)	Kindergarteners (Prereaders)	- listening - phonological awareness - phoneme awareness	- groups of 15-20	- 43 to 57 hours
Qi, & O'Connor (2000)	Kindergarteners	- segmenting and blending - onset identification and rhyming	- small groups	- 7 to 10 hours

Roth, et al. (2002)	4- to 6-year olds with language or speech delay	- rhyming	- individual	- 9 to 12 hours
Rvachew, et al. (under review)	Preschoolers with articulation disorders	- phonemic perception -onset and rime matching, letter names and sound-symbol association - articulation	- individual	- approximately 14 hours
Van Kleeck, et al. (1998)	Preschoolers with speech or language disorders	- Rhyming - phoneme awareness	- groups of 3-4	- 12 hours
Wise, et al. (1999)	2^{nd} to 5^{th} graders	- phonological awareness - articulation - sound manipulation	- groups of 3 - individual on computer	- 40 hours

Note. This is not an exhaustive list of phonological awareness training programs, only those that have implications for the present study have been included.

These studies demonstrate that phonological awareness training can be successful for young children with articulation disorders, however, the average amount of training time required for these training programs was 13 hours. Again, the children in the present training program were able to make significant gains in phonological awareness, increasing their phonological awareness abilities to the level of normally articulating comparison children, in substantially less time. Bus and Ijzendoorn (1999) found that the duration of training was not related to the effect size, thus encouraging researchers to continue to determine how much training is enough to normalize phonological awareness skill, while conserving valuable time and resources. Thus, this study is important in demonstrating that these gains are possible in as little as 6 hours of training.

Program Design

Many researchers have developed and implemented phonological awareness training programs with a wide range of participants, treatment styles, and treatment goals. As the meta-analyses of Bus and Ijzendoorn (1999) and Ehri et al. (2001) demonstrate, phonological awareness training programs differ in intensity and duration of treatment, level of phonological awareness targeted, age of participants, pre-treatment abilities and risk-factors of participants, and contributing variables taken into account in the program design. The present study is unique in its combination of characteristics including targeting preschool children with articulation disorders, teaching phonological awareness through rime and onset training, and the incorporation of phonemic perception training.

The Inclusion of Phonemic Perception Training. Other researchers have successfully improved phonological awareness skills in the absence of phonemic perception training, even for children with articulation disorders (e.g., Gillon, 2000; Roth, et al., 2002). However, phonemic perception training was included in the present study due to the demonstrated connection between phonological awareness and phonemic perception. Children with phonological awareness delays are likely to have speech perception difficulties (Manis, et al., 1997; Rvachew, et al., 2003). It is probable that poor phonological awareness skills are the result of poor perception skills. For example, McBride-Chang (1995b) found that speech perception ability contributed unique variance to the phonological awareness of third and fourth grade children and Nittrouer (1996) found that children with speech perception difficulties were more likely to experience difficulty on phonemic awareness tasks. Since phonemic perception skills have been shown to be related to phonological awareness, it was hypothesized that the inclusion of phonemic perception training would improve the ability of the children in this study to benefit from phonological awareness training. However, the design of the study did not permit the isolation of the impact of phonemic perception training on phonological awareness training.

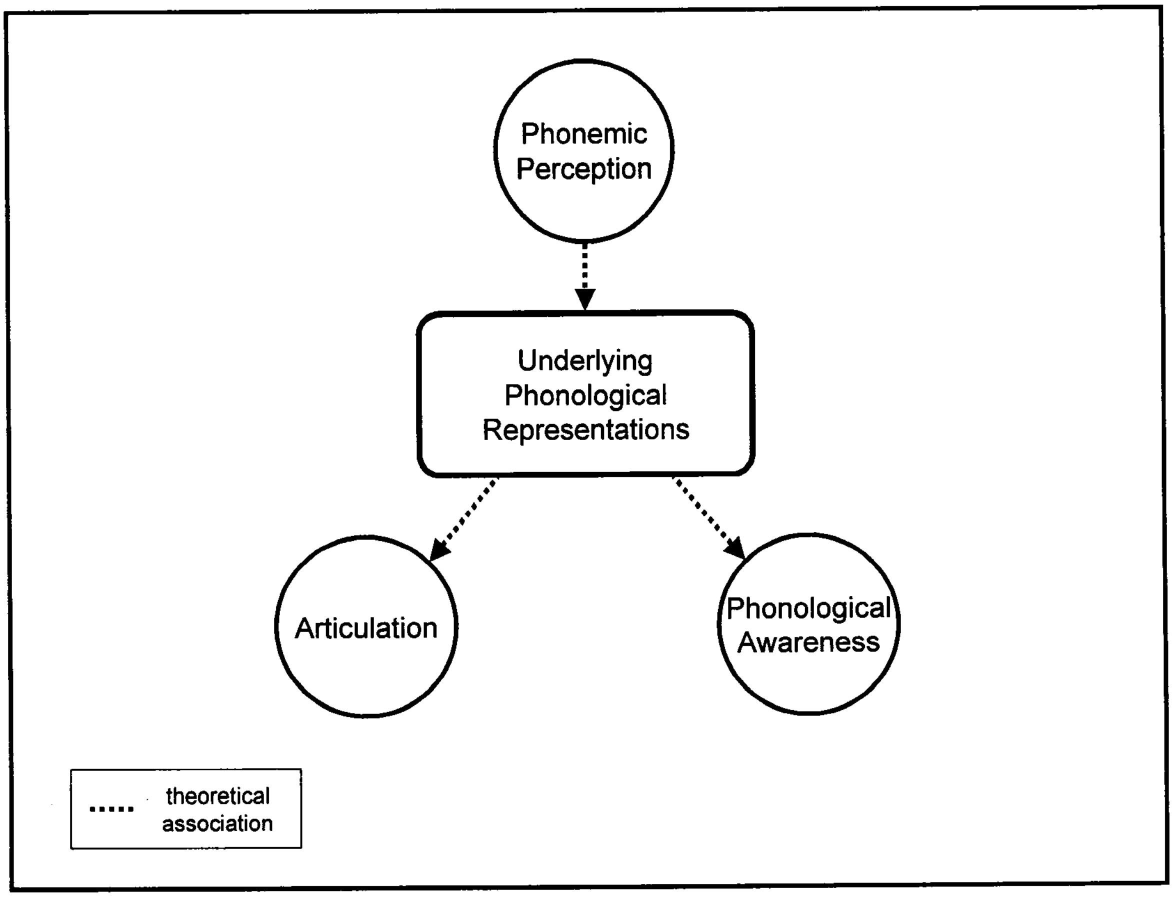
The Combination of Phonemic Perception and Phonological Awareness Training. However, phonemic perception training, by itself, does not result in improved phonological awareness, therefore, it was necessary to include phonological awareness training, in addition to phonemic perception training. Though it is clear that phonemic perception and phonological awareness are related, the relationship does not seem to be direct. Good phonemic perception seems to be a prerequisite for, but not a guarantee of, good phonological awareness (Rvachew, 2003), and phonological awareness is not always affected by phonemic perception training. For example, Rvachew, et al. (under review) incorporated traditional articulation therapy, phonemic perception training, and some phonological awareness training. Speech-language pathologists treated each child's articulation disorder using traditional therapy techniques. In addition, children in a randomized control group read and discussed computerized books, while children in the experimental group participated in SAILS and some phonological awareness training. The phonological awareness training included letter-recognition, letter-sound association, and onset-rime matching, although this aspect of the program was extremely limited, amounting to less than 2 hours of total phonological awareness training provided over a 16 week period. Although the experimental group made significantly greater gains in articulation and phonemic perception skills compared to the control group, the control and experimental groups did not differ significantly on their gains in phonological awareness, demonstrating that phonemic perception training, even with the inclusion of minimal phonological awareness training, is insufficient to elicit changes in phonological awareness. Despite the demonstrated relationship between these abilities, this study demonstrates that phonological awareness requires direct training in order to yield improvements, even in the presence of phonemic perception training. Thus, it was important to include both phonemic perception training and phonological awareness training in the present study.

The Role of Articulation Training. Many studies have demonstrated that children with articulation delays also have delays in phonological awareness (e.g., Bird, et al., 1995; Larrivee, & Catts, 1999; Nittrouer, 1996; Rvachew, et al., 2003; Webster, & Plante, 1992a, 1992b). Some researchers have suggested a direct relationship between articulation and phonological awareness (e.g., Thomas & Sénéchal, 1998). However, it is not a simple linear relationship, as the severity of the articulation disorder does not predict the degree of phonological awareness difficulty (Hesketh, et al., 2000; Rvachew, 2003). In addition, articulation training does not result in improvements in phonological awareness. For example, Wise, Ring, and Olson (1999) trained children with low reading ability between grades two and five. All children received small group phonics training and individual practice using a computer reading program. In addition to this training, children either participated in sound manipulation training, articulation training, or a combination. All three trained groups increased their reading and phonological awareness skills over classroom-trained controls. The sound manipulation group had the best performance on the phonological awareness tasks, while articulation training did not have a significant impact on phonological awareness skills. Gillon (2000) found similar results with 5- to 7-year-olds trained in either phonological awareness or traditional articulation therapy. Children participating in phonological awareness training made significantly greater gains in phonological awareness than children receiving traditional articulation therapy. Rvachew et al. (under review) also found that children participating in traditional articulation therapy did not make significant increases in phonological awareness skills. Due to the negligible ability of articulation training to affect any improvement in phonological awareness, it was not included in the present study.

Underlying Phonological Representations. The relationship between phonemic perception, articulation, and phonological awareness may not be direct and may, in fact, exist only in relation to a fourth variable, underlying phonological representations. Figure 5 demonstrates how phonemic perception impacts upon underlying phonological representations, which in turn, influence phonological awareness and articulation skills.

Figure 5

Model of the theoretical relationship between phonemic perception, phonological awareness, and articulation skills



Other researchers have also noted the theoretical role of underlying phonological representations. Metsala and Walley (1998) proposed the lexical restructuring model which suggests that underlying phonological representations are gradually restructured from a holist form to a form that is segmented at the phonemic level as spoken vocabulary grows, thus increasing access to smaller phonological units. Over the course of development, this restructuring process is dependent upon the child's ability to encode words with increasing precision. In addition to restructuring the form of the phonological representations for individual words, the child also gradually reorganizes the structure of the lexicon itself to reflect growing knowledge of the relationships between words based on similarities and differences at the level of increasingly smaller units. This theory has been supported by word recognition studies conducted with typically developing and dyslexic children and adults (e.g., Metsala, 1997a; Metsala, 1997b). Further support is provided by Werker, Fennell, Corcoran, and Stager (2002) who found that the vocabulary size of 14-month-old infants predicted their ability to learn phonetically similar words. These researchers acknowledge that it is impossible to know whether the infant's ability to attend to the fine phonetic details enhances word learning, or whether a rapidly increasing lexicon enhances the children's ability to attend to the fine phonetic details of spoken words. Edwards, Fox, and Rogers (2002) reported a similar finding for preschool aged children, specifically that receptive vocabulary size was significantly correlated with speech perception performance in a task involving the identification of words gated to remove some of the cues to word final consonant identity.

Although the children who participated in the present study had receptive vocabulary skills that were within the average range one cannot assume that their underlying representations were encoded with sufficient detail or organized in a segmental manner. Some children may be able to develop large vocabularies despite poorly encoded underlying representations, in a manner similar to bright dyslexic children who can develop large repertoires of orthographic representations using a sight word reading strategy, despite poor phonological encoding. The poor performance on the SAILS word identification task demonstrated by most children with an articulation disorder indicates that these children are likely to have poorly specified underlying phonological representations. Furthermore, these children's difficulties with phonological awareness tasks indicates that they are making the transition from holistic to segmented underlying representations more slowly than typical children. Phonemic perception training improves the precision of the children's phonological representations for individual words which in turn supports improved articulation accuracy (Jamieson & Rvachew, 1992; Rvachew, 1994; Rvachew, Rafaat, & Martin, 1999). However, improved phonological awareness test performance requires that the child subsequently develop segmented underlying representations and a reorganized phonological lexicon. In order for this occur in children who have delayed development of the phonological system, it may be necessary to provide both phonemic perception and phonological awareness training.

The model in figure 5 illustrates that the development of these variables is likely to proceed in a particular order. Phonemic perception seems to play an important role in the development of underlying phonological representations. Phonological awareness and articulation ability then develop from underlying phonological representations as they become increasingly precise, segmented and organized. Thus the development of mature phonological awareness and articulation skills is dependent on adult-like phonemic perception and underlying phonological representations.

The children participating in the training program of the present study illustrate this progression of skill development due to their pattern of performance on the variables measured. All but one of the children either had normal levels of phonemic perception at the time of initial assessment or achieved normal phonemic perception ability by the post-treatment assessment. Thus, by the end of the training program, most children had adult-like phonemic perception abilities for the target phonemes. However, none of the children participating in the training program had normally developing articulation skills and half of the children in the study had lower than average phonological awareness skills at the conclusion of the training program. Nittrouer, Studdert-Kennedy, and McGowan (1989) proposed that as vocabulary increases in size, words with similar acoustic patterns are clustered, facilitating the realization of phonetic segments. This segmentation and reorganization of words must occur before phonological awareness skills can benefit from detailed underlying phonological representations, illustrating why phonemic perception may not have an immediate impact on underlying phonological representations, phonological awareness, and articulation. Although these children demonstrated normal phonemic perception and receptive vocabulary perhaps their underlying phonological representations had not yet been organized in a way that allowed them to be utilized for normalization of articulation or phonological awareness.

Figure 5 also reflects the finding that articulation training does not lead to improvements in phonological awareness. In fact, the relationship between phonological awareness and articulation has been shown to be spurious. Any changes occurring concurrently in both phonological awareness and articulation are reflective of changes in underlying phonological representations which impact upon both abilities (Rvachew, 2003, November).

Summary. This study attempted to benefit from the theoretical relationships between these variables by targeting phonemic perception and phonological awareness in children with articulation disorders. The model in figure 5 illustrates how the combination of phonemic perception and phonological awareness training would more greatly impact upon phonological awareness skills than phonological awareness training alone, since phonemic perception training may impact on underlying phonological representations that are also linked to phonological awareness and articulation skills. However, the isolated impact of phonemic perception cannot be measured since this study lacked a comparison group trained in phonological awareness, but not phonemic perception. It is beyond the scope of this paper to draw further conclusions about the nature of the relationships between phonemic perception, phonological awareness, and articulation, however, this study demonstrates the importance of consideration of these variables in the design of other training programs.

Program Participants

Phonological awareness training has been shown to have a positive impact on phonological awareness and future decoding skills; however, it is vital that these training programs be implemented for at-risk prereaders early in development. Preschoolers with articulation disorders were targeted in the present study for two important reasons. First, Ehri et al. (2001) found that pre-kindergarten and kindergarten aged children made the most gains from phonological awareness training, compared to older children. Therefore, this program was designed for younger children who are most likely to benefit from phonological awareness training. Second, it has been shown that children with articulation disorders are at risk for delayed phonological awareness skills (e.g., Rvachew, et al., 2003) and future reading difficulties (e.g., Larrivee, & Catts, 1999). Ehri et al. (2001) found that children at risk for future reading difficulty were likely to benefit from phonological awareness training as much as normally developing children. Thus, by targeting preschoolers with articulation disorders, this training program was aimed at an at-risk population, with a strong potential to benefit from training.

Harm, McCandliss, and Seidenberg (2003) used a computational model to demonstrate how the stage of reading development, normally associated with developmental changes in underlying phonological representations, affect the success of phonological awareness training programs. They showed that phonological awareness training was more effective for prereaders than for children further along in reading development. They identified the root of decoding difficulty as a lack of appropriately segmented underlying phonological representations, meaning that words are read in a more holistic way and are not associated or identified based on smaller components such as onset and rime or phonemes. Thus, normal phonological development encompasses the formation of increasingly segmental underlying phonological representations. However, phonological awareness training was only shown to increase the segmental nature of these underlying phonological representations for prereaders, since children in later stages of reading development have had to resort to using nonsegmental strategies to learn and organize new words. This research demonstrates that it is not age, per se, but stage of reading development, which contributes to the success of phonological awareness intervention.

As demonstrated by Harm, et al. (2003), when children are prereaders, phonological awareness training contributes to the development of increasingly segmented underlying phonological representations. However, for older children, who are further along in reading development and are likely to have been exposed to more words, training which focuses on the letter-sound associations are necessary to break up their holistic item-specific representations into more segmental ones. Thus, if phonological awareness training is to be effective, it must be implemented with children early in their process of developing reading skills.

Other researchers have identified another important reason for early intervention. Stanovich (1992) noted that "small achievement differences early can cause larger differences later on" (p. 330), illustrating that the discrepancy between children with reading disabilities and normally developing children grows over time, especially as children move from the beginning stages of decoding and reading to reading to learn. Children not receiving remediation may also develop bad habits and begin to rely on ineffective reading strategies, contributing to further difficulty (Greaney, et al., 1997).

It is important to develop phonological awareness training programs for children with articulation disorders, since it is likely that they will experience delayed phonological awareness (e.g., Bird, Bishop, & Freeman, 1995; Larrivee, & Catts, 1999; Nittrouer, 1996; Webster, & Plante, 1992a, 1992b). Specific phonological awareness training has been shown to be successful for preschoolers with articulation disorders. For example, Hesketh et al. (2000) successfully improved the phonological awareness of preschoolers with articulation disorders using activities that targeted syllables, rimes, initial and final sounds, and phonemes. Roth et al. (2002) improved the rhyme knowledge of 4- to 6-year-olds with articulation disorders or receptive and expressive language disorders, through a series of rime-based activities, from matching to elimination, to judgment and production. van Kleeck et al. (1998) demonstrated similar success training rhyming and phoneme awareness in small groups of preschool children with speech and/or language disorders. The rhyme activities were similar to those used by Roth et al. (2002), and included rhyme recognition, identification, judgment, and generation. The phoneme awareness tasks focused on beginning and ending sounds, with the addition of segmenting and analysis tasks. Children with articulation disorders in the present study were very receptive to phonological awareness training, increasing their level of phonological awareness to that of their normally developing peers.

Program Components

Size of the Phonological Unit Targeted in Training. In order to perform phonological awareness tasks, like those presented in this study, children must be able to segment their underlying representations of words. For example, someone with only whole word representations for words would not be able to successfully complete any phonological awareness activities since, by definition, phonological awareness is the knowledge that words can be broken up into smaller parts. It has been suggested that phonological awareness instruction should be given at a level corresponding to the child's literacy development (Ehri, et al., 2001). In the present study, onset and rime were deemed most developmentally appropriate.

Onset and rime are the middle unit size between syllables and phonemes, as syllables can be divided into onsets and rimes and onsets and rimes are made up of phonemes. Like phonemes, onset and rime can be used in decoding. Many phonological awareness training programs for young children involve onset and rime training. Previous research supports the notion that children develop an awareness for larger units earlier on (e.g., Byrne, 1998), although other research has presented evidence that children develop knowledge of smaller units first (e.g., Duncan, Seymour, & Hill, 2000).

Segmenting and blending skills have been shown to be good predictors of reading ability in older children (O'Connor, & Jenkins, 1999). Qi and O'Connor (2000) trained segmenting and blending skills or onset identification and rhyming in small groups of kindergarteners with low phonological awareness. They found that children in both training programs benefited equally in the skills trained, however, these children were older than the children in the present study and had normally developing articulation skills, so it is unclear if preschoolers with articulation disorders would benefit from similar training in segmentation and blending. However, for young children, it may not be appropriate or necessary to target grapheme-phoneme correspondences or segmenting and blending skills. Lundberg et al. (1988) showed that it is possible to positively influence the future reading and spelling abilities of prereading children without targeting grapheme-phoneme correspondences, despite the demonstrated importance of this skill by other researchers (e.g., Schneider, et al., 2000). Since the training program was implemented before formal reading instruction began, children had not yet begun to form representations for words and therefore, this type of instruction was successful in instigating appropriately segmental representations in the study participants (Harm, et al., 2003). In addition, Byrne (1998) found that 4-year-olds are likely to judge words based on larger units, and are not able to identify that particular graphemes represent particular phonemes in words. For example, Byrne (1998) taught children to identify the words "fat" and "bat" however, the children were unable to establish that the "f" stood for /f/ and "b" for /b/. In other words, they were unable to break up the printed word or the speech stream in order to identify which parts of the words or letters corresponded to which particular speech sounds.

As children learn to decode they learn that letters and letter sequences correspond to spoken sounds and words and learn to divide up the speech stream to match correlating aspects of the spoken and written words. Younger children, like those from Byrne's (1998) study were only able to transfer the sound-symbol correspondences when they were confined to morphemes. For example, they were able to segment the final /s/ from a word when it was the plural morpheme (e.g., the /s/ in cats), but not when it was the final phoneme of a word (e.g., the /s/ in mess).

The research in this area may remain inconclusive because even fluent readers do not utilize just one approach to reading. Byrne (1998, p. 23) said it best when he said, "...a given writing system may represent spoken language at more than one level... and learners may not discover all levels of representation even when they learn to use the orthography." It is possible that people learn to read by relying more heavily on one form of reading or another. For example, one could read by memorizing and recognizing whole words or by attempting to read through decoding every phoneme in each word they come across. Both methods are limited, the first due to its large memory requirements and restricted ability to allow the reader to learn new words, and the second due to its inability to yield accurate representations of irregular words. Therefore, neither method is likely to fully explain any one person's reading attack strategy, the exception being for children with reading disabilities and possibly deaf readers. Children with reading disabilities are often identified as relying excessively on one of the above strategies, which does not result in successful reading development (Kamhi, & Catts, 1989). Deaf readers who communicate solely through visual communication and do not have access to the auditory speech stream are likely to have non-phonological representations of written words and thus read by memory (Miller, 2002).

The use of onset and rime in reading fits somewhere in between these two extremes. Children can memorize various onset and rime sound-print correspondences, a somewhat less onerous task than memorizing all the words in the English language, and use these correspondences to read by analogy. For example, by knowing that "at" says /æt/ and "b" says /b/ one has the ability to attempt to decode words with /b/ onsets and /æt/ rimes by analogy. Rime knowledge may also be important for reading, since many "irregular" words are irregular only according to grapheme-phoneme correspondences and not grapheme-rime correspondences (i.e., words ending in –ight, -tion, -ought; Byrne, 1998).

In this study, children learned to identify words with common onsets and rimes. These skills are important for reading since they teach that words can be divided up into smaller parts and that words can have these smaller units in common. The ability to divide words up into smaller parts, either onsets and rimes, or phonemes, is essential for decoding. The notion that words can share these units is important for reducing memory load.

The Impact of Training on Onset, Rime, and Onset-Segmentation. Children in the TA group made significant gains in phonological awareness overall, however, the only subtest that demonstrated significant gains was onset awareness. The rime and onset-segmentation subtest scores both increased, but not significantly. There are several possible reasons for this unbalanced change in subtests scores.

Children in the TA group made the least amount of gains on the onset-segmentation subtest, compared to performance on the other two subtests. The mean score of the ND group on the onset-segmentation task was 3.8 ($SD = 1.81$), while the TA group's pre-treatment and post-treatment mean scores were 3.4 (SD = 1.07) and 4.8 ($SD = 2.66$), respectively. The TA group's pre-test and post-test measures of onset-segmentation ability did not differ significantly from the ND group's mean onset-segmentation score, demonstrating that even preschoolers with normally developing articulation skills do not have a good onset-segmentation skills. Rvachew et al. (2003) also found that normally developing preschoolers did not perform well on the onset-segmentation portion of the test. The mean change in the TA group's onset-segmentation score from 3.4 to 4.8 was nonsignificant, $t(9) = -1.871, p < .094$. Given that normally articulating children do not perform well on this subtest and this treatment program focused on rime and onset training and not onset-segmentation training, it seems reasonable, even predictable, that the TA group did not make significant gains in this area.

Like the onset-segmentation subtest, the mean change in score of the rime subtest was also statistically insignificant, increasing from 5.3 to 6.6, $t(9) = -1.271, p < .235$. However, the TA group's pre-treatment rime scores were significantly lower than the ND group's rime scores, $t(9) = -2.497$, $p < .026$. Some researchers have found that rime and rhyming are not as amenable to training as other phonological awareness tasks. For example, van Kleeck, et al. (1998) trained preschoolers with speech and language disorders in rhyming and phoneme awareness tasks. They found that changes in phonological awareness were attributable to training, while the changes in rhyming were not (van Kleeck, et al., 1998). Gillon (2000) found that children who did and did not participate in phonological awareness training made equivalent gains in rhyming, while children receiving phonological awareness training made significantly greater gains in phonemic awareness, demonstrating that rhyme awareness does not require specific intervention, as phoneme awareness did. The prereading children participating in Lundberg, et al.'s (1988) study performed only slightly better on rhyme measures after training, however these results may have been distorted by ceiling effects.

In the present study, there are many possible reasons that rime training may not have lead to the significant gains that onset training did. For example, rime was targeted less intensively than onset. Each training session consisted of only one rime training activity, while three sessions had one onset activity, four sessions had two onset activities, and one session had three onset activities. The result was that onset was targeted in 14 activities, compared to 8 in which rime was targeted. The onsets were also trained over a greater number of sessions. Four rimes were targeted for two sessions each, while only three onsets were targeted, one over two sessions and the other two over three sessions each. In addition, onset foils were reviewed more often than rime foils, resulting in further practice and reinforcement. There were eight different rime foils and four different rime targets, for a total of 12 targeted rimes, while there were only six different onset foils, and three different onset targets, one of which doubled as a foil, for a total of eight targeted onsets. This increased amount of onset repetition may have contributed to the increased level of onset awareness.

In addition, rime knowledge seems to be acquired in a more natural way, requiring more practice and more processing time to become a well-rooted concept (Goswami & Bryant, 1990). It is possible that some extraneous factor may have been responsible for low rime score in the pre-treatment assessment and this factor could have also been responsible for maintaining a low level of rime awareness, despite training.

Why was onset awareness impacted more successfully through training than the other two subtests? There are several reasons that this may be the case. First, the phonemic perception training portion of the treatment program specifically targeted perceptual phonological knowledge of onsets. Furthermore, the phonemic perception training activity targeted the same onset phoneme that was targeted during the onset awareness training tasks during a given session. On the other hand, no phonemic perception training was provided for rimes units or coda consonants. It is possible that the phonemic perception training focus on onset could alter the underlying representations of these phonemes, particularly in the onset position, making onset judgments more salient and resulting in the significant increase in onset awareness score, as opposed to nonsignificant increases in other subtests, which did not receive the benefit of phonemic perception training. Since there was no phonemic perception training for rimes, sounds in this word position were not reviewed in the same way as onsets and changes in rime awareness or underlying representations related to the rime word positions were limited.

Second, onsets and alliteration tend to be targeted in training programs in schools more thoroughly and more often than rimes and rhyming (Byrne, 1998), whereas rhyme knowledge may be acquired in a more natural way with less overt teaching (MacLean, et al., 1987; Goswami, & Bryant, 1990). Classroom teaching methods further emphasize onsets through a strong focus on letter names and letter sounds (Duncan, et al., 2000). This preponderance of onset-focused training could impact the way parents interact with their children in supporting their reading acquisition. In this study, it may have impacted the type of support families gave their children when reviewing concepts and completing homework activities. If parents thought that onset awareness would be more influential in acquiring prereading skills they may have tutored their children in onsets and letters or focused more of their attention on the onset homework.

Third, the onsets targeted in this study were made up of only one phoneme, whereas the rimes targeted consisted of two phonemes. Print information about both onset and rime was available to the children through the labelled picture cards, but only the onset "letter-munchers" were labelled with the individual target and foil letters. Throughout the sorting activity the link between the grapheme and phoneme was made, both by the child and the experimenter, by frequently labelling the sound the letter-muncher preferred to eat. The goal of the activity was not necessarily to draw the child's attention to the letter or its corresponding sound, but was a natural consequence of labelling the sorting items with letters. The rime sorting objects were not labelled, but even if they were, it may have been more difficult for children to establish the connection between the specific letters and corresponding sounds, since there would have been more than one letter to decipher. Thus, in this study, onsets may have been more conducive to inadvertently teaching grapheme-phoneme correspondences. Grapheme-phoneme correspondences have been shown to increase the effectiveness of phonological awareness training (Ehri, et al., 2001), so if they were targeted through the nature of the onset sorting activity or through parental instruction, they are likely to have influenced the level of onset awareness in the positive direction.

A fourth possibility, suggested by van Kleeck et al. (1998), is that rime training may impact other realms of phonological awareness, by increasing sensitivity to the sound structure of words. Bryne (1998) also supports this notion, suggesting that rhyme awareness redirects children's focus from meaning to sound and allows them to develop the ability to further segment words. Therefore, the rime training component may increase the salience of the onset of words, while onset training may not have a reciprocal effect on rime awareness.

Implications for Future Reading and Decoding

The end goal of any phonological awareness training program is to improve phonological awareness skills for the purposes of normalizing future decoding and reading skills. This study demonstrated that phonemic perception based phonological awareness training can have an immediate impact on the phonological awareness skills of preschoolers with articulation disorders. However, it is not known for certain how phonemic perception training, phonological awareness training, or the combination, will transfer to future decoding and reading ability.

Other studies have demonstrated that phonological awareness training can improve future reading ability (e.g., Bradley, & Bryant, 1983), particularly when implemented early for at-risk children (Ehri, et al., 2001). Since this training program was successful in increasing phonological awareness, it may be reasonable to expect better decoding and reading skills in the future, particularly in comparison to untrained children with articulation disorders.

However, in order to apply phonological awareness skills to decoding and reading, children must be able to transfer these skills to other uses and contexts. Phonological awareness skills learned through training are not useful if children are unable to use this knowledge in decoding. Many studies have demonstrated that children experience transfer failure even when phonological awareness skills are successfully trained (Hatcher, 2000; Lovett, Warren-Chaplin, Ransby, & Borden, 1990; Olson, et al., 1997). Byrne (1997) reported that younger children show greater difficulty transferring their phonological awareness skills to other tasks, however, other researchers have found that the decoding skills of younger children benefit more from phonological awareness training than those of older children (e.g., Bus & Ijzendoorn, 1999). In the present study, phonological awareness was not trained in isolation, but with the addition of phonemic perception training, making it more difficult to predict the success of transferring phonological awareness to prospective decoding abilities.

The impact of phonemic perception training on decoding and reading ability is less well documented. The phonemic perception component of the training program may have improved the degree to which children benefited from phonological awareness training, thus contributing to further gains in decoding and reading. Phonemic perception training may also have contributed to the fine tuning of the underlying phonological representations, which would further impact phonological awareness, and potentially future decoding and reading. In addition, speech perception itself may exert an independent influence on word reading (see McBride-Change, 1995a).

Harm, et al. (2003) illustrated that phonological awareness training in the absence of instruction in letter-sound associations may not transfer to decoding ability for children who have already begun reading instruction. It is possible that the demonstrated increase in phonological awareness has occurred only on a superficial level and, although the measurement reflects a significant change in the nature of these discrete phonological awareness abilities (i.e., changes in rime and onset awareness and onset-segmentation skills), the change has not in fact improved the segmental nature of the underlying phonological representations and therefore, improvements may not be noted in future tests of decoding and reading comprehension. However, the children participating in this study had not yet begun formal instruction in reading and writing and therefore phonological awareness training retains the ability to increase the componential organization of their underlying phonological representations (Harm, et al., 2003).

These children may lack the ability to use their knowledge of words and parts of words as a stepping stone to learning to decode the printed word and thus lack the ability to apply their new-found knowledge to reading situations. This study did not include explicit instruction in the connection between reading and phonological awareness, a connection that has been shown to be beneficial when training phonological awareness in children (e.g., Cunningham, 1990), thereby potentially reducing the benefits of improvements in phonological awareness related to decoding and reading.

In short, it is not known for certain what impact this phonemic perception based phonological awareness training program will have on future reading and decoding abilities. However, there is support for the notion that this training program will have a positive influence on these abilities. This program was successful in increasing the phonological awareness of participants to the level of normally developing peers and other training programs have demonstrated that successful phonological awareness training programs can positively impact upon future reading skills. In addition, phonological awareness was targeted in younger children, before the onset of reading or formal reading instruction, which has been shown to improve the chance of the transfer of phonological awareness to decoding. The impact of phonemic perception training is not known, however, if successful, it likely acted to increase the segmental nature of the underlying phonological representations, a positive factor in future decoding and reading.

Limitations

Despite the significant improvement in phonological awareness skills achieved through the phonemic perception based phonological awareness training program, there are several limitations to the study. These limitations are related to the study design, including a small number of participants and threats to internal and external validity. In addition, the training program did not prove to be successful for all children.

Unresponsiveness to Training. Not all the children who participated in the phonological awareness training program were successful in increasing their phonological awareness to the level of normally developing children. In fact, one child did not make gains in phonological awareness at all. These cases demonstrate that phonological awareness training, despite being successful for most children, is not successful for all. Other successful phonological awareness training programs have also reported subsets of children for which phonological awareness training was not successful. Specific factors related to the development of speech, language, or reading abilities have been shown to distinguish between responsive and unresponsive children, in addition to other cognitive characteristics and developmental skills, as well as features of the child's environment.

Al Otaiba and Fuchs (2002) reviewed 23 early literacy intervention studies and found that children who did not benefit from phonological awareness training had characteristics of poor phonological awareness, poor sound discrimination ability, slower rapid naming, poor attention and behaviour. They also found that certain demographic variables correlated with unresponsiveness to training, including the child's age, parents' education and occupation, and child's level of English proficiency.

In this study, there was one child whose phonological awareness score failed to improve between pre-treatment and post-treatment assessments. This child was the youngest child in the group and demonstrated low MLU, PCC, and post-treatment SAILS compared to the other children. During the training sessions, he had difficulty attending, making it difficult to determine if his low level of performance was related to comprehension difficulties, motivational concerns, or if he lacked the ability to attend to within word phonological units, making participation in the training too difficult of a task for him. Al Otaiba and Fuchs (2002) also found that poor attention and behaviour were related to unresponsiveness to training.

Including this unresponsive child, half of the TA group was unsuccessful in raising their phonological awareness score to the mean level of the ND group. These children, though not exactly unresponsive to phonological awareness training, still demonstrated a delay in phonological awareness, even after participation in training.

Children in this not-as-responsive group demonstrated lower pre-treatment phonological awareness, pre-treatment rime awareness, SES, and less change in phonological awareness score, specifically the onset awareness subtest. Some of these findings are in accord with those of Al Otaiba and Fuchs (2002) including the finding that pre-treatment phonological awareness and SES were correlated with unresponsiveness to training.

van Kleeck et al. (1998) suggested that rime training may increase sensitivity to the sound structure of words, thereby impacting other areas of phonological awareness. Since exposure to nursery rhymes is related to preschool rime awareness (MacLean, Bradley, & Bryant, 1987), perhaps children with low pre-treatment rime awareness lacked these experiences and this lack of experience with nursery rhymes also influenced their ability to learn more about rimes. Some combination of these factors may also have contributed to the small gains in rime awareness. Perhaps eight training sessions is not enough exposure to teach this concept to children who have not already had some experience with it, due to the limited intensity of training and the lack of processing time to more naturally assimilate the information. Thus, children with low post-treatment phonological awareness were at a disadvantage due to their demonstrated low pre-treatment rime awareness. Roth et al. (2002) implemented pre-treatment lessons for children who had not reached a minimum level of rime awareness which ensures that all participants experience some exposure to the concept before direct training is begun. This may prove especially beneficial for preschoolers whose pre-treatment exposure to different aspects of phonological awareness may be minimal, or variable, increasing their chances of being unresponsive to training.

In the present study, children with low post-treatment phonological awareness demonstrated the least gains in phonological awareness overall, but also the least gains in the onset awareness. Improvements on the rime and onset-segmentation subtests were not statistically different from responsive children. Since these children started out with low phonological awareness and ended up with low phonological awareness, it is logical that they made the least overall gains in phonological awareness. However, it is interesting to note that the difference in phonological awareness gains resulted from the low post-treatment phonological awareness group making fewer improvements in onset awareness.

Number of participants. This study lacked power due to the small number of participants. In addition, due to the small sample size, the selected group is not likely to be representative of the larger population. In fact, this group differs from many children with articulation disorders in two important areas. First, although articulation disorders are not necessarily associated with low receptive vocabulary, children with articulation disorders are likely to have vocabulary levels in the normal range. The children in the present study actually demonstrated higher than average receptive vocabulary. The mean PPVT score for the TA group was 109, more than half a standard deviation above the test mean of 100. The mean SAILS score for these children was 69.9, just below the cut-off for normal phonemic perception of 70. This score was higher than expected since children with articulation disorders typically have even poorer phonemic perception skills. Since this sample is not representative of the population of children with articulation disorders, it is impossible to determine if this treatment program would have similar success for other samples of children with articulation disorders who typically have poorer perceptual abilities and smaller vocabulary sizes. It is not known what impact these relatively high phonemic perception and receptive vocabulary scores may have on phonological awareness or ability to benefit form phonological awareness training.

Threats to Internal and External Validity. Within the limitations of the study design, the results can be considered successful since the phonological awareness skills of the children with articulation disorders were increased to the level of the children with normally developing articulation skills. However, due to the quasi-experimental nature of the study, it is not clear that the encouraging results are due to the treatment program or some other factor. In designing this type of treatment program the interest lies in the cause and effect relationship between independent and dependent variables. In this case, does the training program result in an increased level of phonological awareness. However, this study lacked two of the necessary components of an experimental study design, which are required to be sure that findings are the result of a true relationship between the independent and dependent variables.

First, this study lacked the random assignment of the participants. The children were assigned to experimental and control groups, not randomly before the onset of the training program, but as a matter of convenience, based on the time and location of the assessment. Second, this study used non-equivalent control groups since neither control group participated in the reassessment procedure from which post-treatment measurements for the experimental group were derived. In effect, this meant using the control groups' initial assessment scores served as comparison for both the pre-treatment and post-treatment scores of the experimental group. The result is a serious threat to the internal validity of the results since any change in the dependent variable, the phonological awareness test score, could have been the result of some extraneous variable and not the independent variable, the phonemic perception based phonological awareness training program. This increases the probability that a type 1 error has occurred and in actuality, the likelihood that the training program did not bring about the changes that yielded the significant differences in the phonological awareness scores of the experimental group.

In order to prove the cause and effect relationship, the phonemic perception based phonological awareness training program needs to be redesigned in order to address the following potential extraneous variables and therefore, threats to internal validity.

In order to control for maturation and improved phonological awareness skills due to the effects of age and the passage of time, the children in the control groups must be given the same pre-treatment and post-treatment assessment batteries, at the same time intervals as the experimental group. However, participants in the training program by Rvachew et al. (under review) did not demonstrate gains in phonological awareness after 16 weeks. Therefore, maturation is not likely to have been an important contributor to the increase in phonological awareness score in this study since the elapsed time between pre-treatment and post-treatment assessments was less than 10 weeks.

The act of testing and retesting can produce practice effects. For example, phonological awareness test scores may be improved due to familiarity with the test and test items and not reflect a real change in phonological awareness ability. This can be addressed by administering the phonological awareness test to the control groups the same number of times and at approximately the same time as it is administered to the experimental group.

Statistical regression becomes a threat to internal validity when participants are selected for their low test scores, however, this is only the problematic when the test used to choose the sample is the same test that is used to track changes in that measurement (Zhang, & Tomblin, 2003). In this study, children were selected based on their low levels of articulation. Although children with low articulation skills tend to have lower phonological awareness, these children were not selected for their low phonological awareness. Therefore, statistical regression is not likely to be a factor in the increase in phonological awareness made by the children in this study.

Selection bias occurs when participants are not randomly selected to represent the population. For example, children may be more likely to be enrolled in the study when their parents are interested in or have concerns about their child's phonological awareness. There could be an extraneous variable that distinguishes families who are able to make commitment to attend all eight training sessions and two assessment sessions that also contributes to an increase in their level of phonological awareness over the training period. In order to control for this confounding factor, the children need to be randomly selected from the population and randomly assigned to experimental and control groups.

Mortality can also be a threat to internal validity; however, it did not pose a problem in the present study since all of the participants were able to complete the training program and assessments.

External validity is a measure of the effectiveness of a treatment program. This study suffered from some threats to external validity, which will be addressed below.

However, since this study was not a randomized control trial and occurred in a more clinically realistic fashion, some typical threats to external validity typically encountered when running randomized clinical trials, were avoided. Randomized clinical trials run the risk of being ungeneralizable to the target population due to the irregular setting, exceptional type of treatment or atypical participants. In this study, the hospital setting and style of treatment were very clinical in nature and likely to be replicated if the training program were to be made use of by other professionals on other members of the same population. With the existing study design, threats to external validity remain, despite these positive features.

Lack of random selection is a threat external validity, as well as to internal validity, as it makes generalization difficult. In order to overcome this obstacle, children should be randomly selected from the population, in this case, the caseloads of speech language pathologists, and randomly assigned to treatment conditions.

The Hawthorne effect occurs when the act of participating in the training program, and not the training program itself, changes the abilities of the study participants. For example, the extra attention received by the children in the experimental group could have contributed to the increase in their phonological awareness score. In order to control for the Hawthorne effect, the control condition would include some form of training in order to provide the control group with similar levels of attention and stimulation.

Novelty effects can impact the effectiveness of a treatment program, often causing inflated results. In order to avoid this effect, the measurement period must be sufficiently long. It does not seem likely that this is a very large threat to external validity in the present study since there was a two month period between pre-treatment and post-treatment measurements.

Some external event may interact with the treatment that can cause changes in the dependent variable. For example, a parent may have a lot of enthusiasm for the study or be extremely motivated to improve their child's prereading skills, thus providing the child with additional encouragement and learning opportunities that may contribute to an increase in phonological awareness. Matching participants and randomly allocating them to experimental and control conditions will help to control for these types of external events, particularly if the control condition includes some type of alternative training program.

Experimenter effects can also impact the results of a training study. The participant's performance may be influenced by the experimenter's personality or teaching style. Different experimenters can be trained to facilitate the training program in order to explore the differences or effectiveness of different teachers. Alternatively, the same teacher can teach multiple training programs to determine if it is the training program or the teacher which causes a change in the dependent variable.

Key Components for a Successful Phonological Awareness Training Program

Ehri, et al. (2001) conducted a meta-analysis of 96 phonemic awareness training programs. Their results yielded information about the characteristics of training programs that were more likely to facilitate the development of phonemic awareness, and future reading and spelling abilities. The present study incorporated many of their suggestions; however, future studies should attempt to incorporate as many more of these characteristics as possible in order to maximally improve the phonological awareness skills of the participants.

It was found that small group training sessions were more beneficial than classroom sessions and individual therapy (Ehri, et al., 2001). However, it is was not determined if small group sessions would be just as effective with preschoolers with or without articulation disorders, since this analysis was not made based on training age. Training sessions that incorporated letter-sound training were more effective than programs that did not (Ehri, et al., 2001). Using letter-sound training and phonics has been shown to be effective in increasing the phonological awareness of preschoolers (Bradley, & Bryant, 1983; Solity, Deavers, Kerfoot, Crane, & Cannon, 1999; Roth et al, 2002), however, Lundberg, et al. (1988) were successful in impacting the phonological awareness and later reading and spelling of prereaders without the incorporation of grapheme-phoneme correspondences.

Ehri, et al. (2001) also found that a total number of treatment hours between 5 and 18 brought about the best phonemic awareness outcomes and that focusing on only one or two skills was optimal. This study kept within both of theses specifications with a total treatment time for each child between 6 and 8 hours and by focusing on two phonological awareness skills, onset and rime.

Ehri et al.'s results (2001) demonstrate that preschoolers are more likely than older children to benefit from phonological awareness training and children at risk for reading disabilities are as likely as normally developing children to benefit from phonological awareness training. These are two strengths to the present study since the intervention is targeted towards preschoolers and even though they are at risk for phonological awareness difficulties they are as likely as normally developing children to benefit from the training program. They also found that children already diagnosed with reading disabilities were less likely to benefit from training (Ehri, et al., 2001). This further emphasizes the importance of early intervention since children are not diagnosed with reading disabilities until they are of reading age and thus younger children may be more amendable to training.

Future Study Design

Future studies should attempt to minimize the limitations of the current study design, as well as incorporating Ehri et al.'s (2001) guidelines for successful phonological awareness training programs. In order to replicate the results of the present study and prove the causal nature of this phonological awareness training program the study should be set up as a randomized clinical trial with four groups and pre-test and post-test control.

Ideally, the four groups should consist of; 1) children with articulation disorders receiving the phonemic perception based phonological awareness training program, 2) children with articulation disorders receiving no training, 3) children with articulation disorders receiving a phonological awareness training program with a non-phonemic perception based computer training component, and 4) children with normally developing articulation skills. After the initial assessment, children with articulation disorders should be matched on age, SES, phonological awareness ability, and PPVT and randomly assigned to one of the three conditions for children with articulation disorders. After the completion of the training programs or passage of the equivalent amount of time, children from all four conditions should participate in the post-treatment assessment.

Each of these four groups makes an important contribution to the maintenance of the internal and external validity of the study. The first group is the experimental group. The second group provides a picture of what happens when these children do not receive any training over the same period of time. This condition allows us to determine if phonological awareness skills are likely to develop in the absence of training over the same time period due to maturation or some extraneous variable. However, due to ethical considerations, it may not be possible to form a no-treatment control group. Since many studies have shown the value of phonological awareness training programs (e.g., Roth, et al., 2002), it may not be ethically sound to withhold this type of program. One potential solution to this ethical problem is to enrol this group in the training program after the pre-treatment and post-treatment measures have been obtained. This way the potential for this group to benefit from the treatment program is delayed but not prevented entirely.

The third group serves multiple purposes. By having a second treatment group, the threats to internal and external validity such as Hawthorne effects, test-retest effects, teacher effects, interactions between history and the treatment, selection bias effects, and novelty effects can be controlled. This group also helps to establish the effectiveness of the training program in changing the dependent variable since it allows the direct comparison of the effects of another training program on the same measurement. For this study specifically, this third group allows the isolation of the effects of phonemic perception training on phonological awareness. This group would undergo the same phonological awareness training program, minus the phonemic perception training component. Instead, this group would participate in another computer game which would not focus on auditory attention to phonemes in words. Therefore, the phonemic perception based phonological awareness training program can be compared to a program which incorporates training tasks of the same nature and duration, only differing by its lack of focus on the perception of phonemes.

The fourth group consists of the children with normally developing articulation skills. Since the phonological awareness skills of normally articulating children has been shown to be significantly higher than that of children with articulation disorders, the phonological awareness score of this group serves as a target which the children in the experimental group should attain if this treatment program is to be proven effective. This fourth group should also be compared to the other two groups of children with articulation disorders since the effectiveness of this treatment program can only be established if the children in the experimental group make gains over and above those of the children in the treated control conditions. Figure 6 outlines this ideal experiment.

Despite the many theoretical problems with the quasi-experimental design of this study, there are reasons to believe that the results are valid. Other phonological awareness training programs have used quasi-experimental designs that lack random assignment of participants and thus have non-equivalent groups (e.g., Lundberg, et al., 1988, & O'Connor, Notari-Syverson, & Vadasy, 1998, as sited in Ehri, et al., 2001). These training programs were not shown to have greater effect sizes as a result of this poorer study design (Ehri, et al., 2001). These findings, however, do not eliminate the threats to internal and external validity so we cannot be sure that the training program is effective or generalizable. In addition, in future studies recruitment should continue until the sample characteristics, especially with respect to phonemic perception abilities and socio-demographic variables, are representative of the larger population of preschoolers with articulation disorders. In order to better control for these risks, future training programs should be attempted, which incorporate the suggestions listed above.

Figure 6

Ideal study design

R (randomized)	O1	X1	02
	O1		02
	O1	X2	02
Normal Controls	O1		02

Note. R = Randomized. O1 = Initial assessment; O2 = Final assessment; X1 = Phonemic perception based phonological awareness training program; X2 = Phonological awareness training program with non-phonemic perception computer training. Children in the randomized groups have disordered articulation.

Implications for Practice

The success of this training program demonstrates that phonological awareness can be successfully implemented with preschoolers with articulation disorders in a clinical setting. Generalization of these results in other clinical settings is quite likely given that the training program was carried out in a clinical setting and that the training program itself is quite practical in nature. Speech-Language Pathology clinic administrators often contend with barriers to prompt and efficient treatment when attempting to cope with the large number of children requiring treatment and the relatively small number of clinicians. This treatment program has a small number of sessions, which increases the likelihood that it could be incorporated into other treatment programs in these overburdened clinics. Each child participated in only eight weekly sessions, demonstrating that a large time commitment is not required to effect a positive change in the phonological awareness. However, clinicians should note the importance of direct training in both phonological awareness and articulation in order to elicit change in both areas. Clinicians may also choose to adapt the phonological awareness training sessions used in this study in order to include other speech and language goals, although it is not known how this may change the effectiveness of the training.

The success of this training program illustrates the importance of screening preschoolers with articulation disorders for concomitant delays in phonological awareness, since not only are we able to identify preschoolers with delayed phonological awareness, but it is possible to raise their level of phonological awareness to that of normally developing children. In most cases, before the onset of any treatment program, children are given a thorough assessment of their speech and language abilities. The inclusion of a phonological awareness test would be a simple addition to these types of assessment batteries. Although children with articulation disorders are more likely to have below average phonological awareness skills then children with normally developing articulation skills, it is not necessarily the case (Rvachew, et al., 2003). Therefore, Speech-Language Pathologists should assess the phonological awareness of these children before the commencement of specific intervention.

Implementation of this type of training program for children with delayed phonological awareness skills is particularly important before the commencement of formal reading education. Screening should take place early, when children are 4- or 5-years old in order to reduce or eliminate any immediate delays in these skill areas and allow the children to start with the same pre-reading skills as other, normally developing children. Early intervention and successful remediation of phonological awareness deficits allows children to catch up before they get too far behind, thereby potentially preventing delayed decoding and reading skills.

Conclusion

This study demonstrates that the phonemic perception based phonological awareness training program was successful in increasing the phonological awareness of preschoolers with articulation disorders. Literature supporting the relationship between phonological awareness, articulation skills, and phonemic perception, and their theoretical linkage through underlying phonological representations formed the basis for the study design. Not only did the trained group make significant gains compared to their own pre-treatment scores, but their level of phonological awareness was increased to the level of the children with normally developing articulation skills. The improvement took place with less than 8 hours of training, a considerably shorter time than many other phonological awareness training programs. The results indicate that children with articulation disorders that demonstrate delayed phonological awareness skills are able to improve their levels of phonological awareness to the normal range, potentially decreasing their risk of future decoding and reading difficulties.

Confidence in the findings of this study is limited due to the non-experimental design. Future studies should implement randomized control trials to ascertain that the training program, and not other confounding factors, is responsible for the change in phonological awareness. In addition, the impact of phonemic perception training on the phonological awareness should be isolated to determine its usefulness in the implementation of phonological awareness training programs.

Although this training program has provided new clinical insights, it leaves us with many questions and directions for future research. Will the children be able to transfer their acquired phonological awareness skills to reading? Will the training program have any long-term impact on articulation skills? Will the training of onset and rime generalize to other phonological awareness abilities? Will children resistant to phonological awareness training have lower reading ability in the future? Will the trained group maintain their level of phonological awareness compared to normally articulating children? Fortunately, many of these questions will be answered since the children who participated in the training program are also participating in a longitudinal study, which will reassess all the pre-treatment measures for two years following the treatment program.

Other questions are still open to discovery through future research initiatives. Could a computer program be effective in teaching onset and rime to preschoolers? What would be the effect of parents being trained as instructors? What is the contribution of phonemic perception training to the acquisition of phonological awareness skills? How would the phonemic perception be altered for people with atypical or inconsistent auditory input, such as children with hearing aids and cochlear implants? Would training phonemic perception impact underlying phonetic detail resulting in increased vocabulary development? Would expressive language therapy contribute to gains in phonological awareness?

In summary, this study has demonstrated that is it possible to impact the phonological awareness and phonemic perception skills of preschoolers with articulation disorders. Further research is required to establish the nature of the relationship between phonemic perception, articulation, phonological awareness, and underlying phonological representations.

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Appendix A

Phonological Awareness Test

Rime Matching **Total ___/34**

Training Items

"This animal's name is Paul. Paul likes things that sound like his name. Listen, which one of these things does Paul like?"

1)	□ key	□ hen	□ map	□ball
2)	□fork	□doll	□comb	□ boot

"This animal's name is Ken. Ken likes things that sound like his name. Listen, which one of these things does Ken like?"

3)	□ bird	□ fish	□ mop	□ hen
4)	□ carrot	□ men	□ bell	□ tap
5)	□ worm	□ fork	□ pen	□ top

Testing Items

"This animal's name is Dan. Dan likes things that sound like his name. Listen, which one of these things does Dan like?"

1)	□ spoon	□ cup	□ pan	□ fork
2)	□ kite	□ plane	□ fan	□ bike
3)	□ vase	□ can	□ tap	□ mug
4)	□ house	□ boat	□ car	□ van

"This animal's name is Wug. Wug likes things that sound like his name. Listen, which one of these things does Wug like?"

5)	□ chair	□ bed	□ table	□ rug
6)	□ mug	□ plate	□ knife	□ cake
7)	□ pot	□ cup	□ jug	□ fork

"This animal's name is Pat. Pat likes things that sound like his name. Listen, which one of these things does Pat like?"

8)	□ ham	□ hat	□ shoe	□ fish
9)	□ cat	□ cap	□ sock	□ pan
10)	□ mat	□ scarf	□ book	□ map
11)	□ bag	□ purse	□ bat	□ comb

"This animal's name is Zap. Zap likes things that sound like his name. Listen, which one of these things does Zap like?"

12)	□ top	□ ball	□ cat	□ cap
13)	□ saw	□ matt	□ map	□ door
14)	□ pen	□ tag	□ tap	□ book

Onset Matching

Training Items

"This animal likes everything he owns to begin with the same sound. The sound he likes is /f/. Which one of these will he want?"

1)	☐ cat	☐ saw	☐ fork	☐ ball
2)	☐ mop	☐ fan	☐ bee	☐ gun
3)	☐ fish	☐ sock	☐ worm	☐ bell
4)	☐ car	☐ dog	☐ ship	☐ fence
5)	☐ cake	☐ pen	☐ feet	☐ duck

Testing Items

"This animal likes everything he owns to begin with the same sound. The sound he likes is /p/. Which one of these will he want?"

1)	☐ pipe	☐ fan	☐ kite	☐ house
2)	☐ fork	☐ pan	☐ cup	☐ vase
3)	☐ key	☐ hen	☐ watch	☐ pig
4)	☐ jug	☐ hand	☐ purse	☐ ring
5)	☐ car	☐ pen	☐ saw	☐ duck

"This animal likes everything he owns to begin with the same sound. The sound he likes is /tʃ/. Which one of these will he want?"

1)	☐ bike	☐ peg	☐ chair	☐ map
2)	☐ bell	☐ chain	☐ key	☐ net
3)	☐ chips	☐ fan	☐ fish	☐ cat
4)	☐ carrot	☐ pig	☐ tap	☐ chicken
5)	☐ worm	☐ tree	☐ dog	☐ cherry

Onset Segmentation and Matching

Training Items

"This animal's name is Marg. Marg likes things that start with the same sound as her name. Which one of these things will Marg want?"

1)	☐ spoon	☐ mat	☐ vase	☐ bed
2)	☐ map	☐ chicken	☐ purse	☐ kite
3)	☐ tag	☐ boat	☐ mug	☐ door
4)	☐ house	☐ key	☐ bee	☐ mop
5)	☐ hen	☐ sock	☐ meal	☐ boot

Testing Items

"This animal's name is Tom. Tom likes things that start with the same sound as her name. Which one of these things will Tom want?"

1)	☐ sock	☐ tie	☐ pipe	☐ hat
2)	☐ bird	☐ teddy	☐ book	☐ doll
3)	☐ table	☐ cake	☐ shoe	☐ fence
4)	☐ gun	☐ ship	☐ van	☐ tap
5)	☐ tea	☐ box	☐ mug	☐ lamp

"This animal's name is Sam. Sam likes things that start with the same sound as her name. Which one of these things will Sam want?"

1)	☐ sun	☐ car	☐ fan	☐ ball
2)	☐ bee	☐ tie	☐ saw	☐ hat
3)	☐ boot	☐ pen	☐ mop	☐ sock
4)	☐ cup	☐ soup	☐ knife	☐ fork
5)	☐ table	☐ bed	☐ soap	☐ mat

Appendix B

Phonological Awareness Training Items

Onset				Rime					
/m/	**/t/**	**/w/**	**/s/**	**/æn/**	**/ɔl/**	**/ɛn/**	**/æp/**	**/æm/**	**/ɪŋ/**
mitt	tail	wall	sand	can	mall	hen	cap	clam	thing
mask	toes	wheel	soap	fan	doll	Ben	tap	Pam	ring
moon	tea	wand	saw	man	wall	Ken	sap	jam	swing
mice	teeth	witch	sock	van	call	men	nap	lamb	king
milk	tools	watch	seal	tan	fall	pen	map	ram	sing
mouse	tent	wolf	soup	Dan	hall	ten	zap	cram	wing
mouth	toys	web	sign	pan	Paul	den		ham	
mug	tie	worm	sink	ran	ball	when		Sam	
mop	tap	whale	sword					yam	
mat									
/f/	**/b/**	**/k/**	**/p/**	**/æt/**	**/ɪg/**	**/ɪt/**	**/æd/**	**/æg/**	**/ʌg/**
fish	bell	kite	paint	hat	rig	mitt	sad	bag	jug
fan	bike	key	pen	bat	pig	sit	bad	flag	bug
five	bat	keys	park	cat	big	fit	dad	tag	mug
farm	bird	coat	pie	mat	dig	hit	glad	rag	plug
foot	bear	cat	peach	rat	jig	kit	mad	wag	slug
feet	bed	cow	pig	fat	wig	lit	pad	zag	hug
fork	book	car	pear	pat		pit	tad	gag	rug
fence	bath	cane	pot						dug
fox	barn	couch	peas						tug
face	beach	corn							
food	bug	cake							
	bee	comb							
		cone							
		cup							
		can							