USING AN IPAD APPLICATION TO PROMOTE EARLY LITERACY DEVELOPMENT IN YOUNG CHILDREN WITH DISABILITIES

by

ZHEN CHAI

(Under the Direction of Cynthia Vail)

ABSTRACT

The primary purpose of this study was to examine the effects of using an iPad application to teach four young children with disabilities to receptively identify initial phonemes through 0-5s constant time delay procedures. A multiple probe design across three sets of target phonemes, replicated with four students was used. The dependent variable was the percentage of unprompted correct receptive identification responses for target phonemes during instruction and probes. The results indicated that all four students mastered their target phonemes, and generalized the skills across materials. Data gathered in the generalization across positions probes showed mixed results. Maintenance data were collected four and seven weeks after the intervention was completed for three of the four students, and the students maintained the skills at or above 50% of accuracy.

INDEX WORDS: iPad instruction, Young children with disabilities, Phonological awareness, Constant time delay

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DEDICATION

To my husband, Kevin, without your love and support, this dream cannot become true.

To my baby, Aaron, you make me a better person.

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CHAPTER 1

INTRODUCTION

Background

In recent years, the expectations and demands regarding literacy have increased for students with disabilities. No Child Left Behind Act of 2001 (NCLB) clearly demonstrated an emphasis on improving the educational outcomes of all students, and by the 2013-2014 school year *all* students are expected to reach 100% proficiency level in reading. Literacy has a great impact on the quality of life of people with disabilities. Those who can read tend to have more self-confidence, more chances to be employed, more chances to live independently, and are more easily accepted by others (Erickson, 2005).

Literacy instruction for people with intellectual disabilities usually focuses on teaching sight words (Browder, Gibbs, Ahlgrim-Delzell, Courtade, Mraz, & Flowers, 2009). Though sight-word instruction is important, it is impossible to teach all of the words that a person will encounter during daily life. As a result, it is necessary to teach people with intellectual disabilities to become independent readers.

Phonological awareness (PA) skills are essential in helping children become independent readers. PA is the “awareness of the phonological segments in speech” (Blachman, 2000, p.483). Phonological segments refer to phonemes as well as the larger units in spoken language, such as syllables and rhyming words (National Reading Panel, 2000). Students’ PA skills are significantly related with their reading skills (Olson & Wise, 1992). The reasons that PA skills are difficult for some students are: 1) people are not born with or develop PA skills naturally

(Brady, Fowler, Stone, & Winbury, 1994; Phillips, Clancy-Menchetti, & Lonigan, 2008); and 2) people cannot identify individual phonemes in the spoken language (Stahl & Murray, 1994). Moreover, students with low initial PA skills take longer than their peers to master early PA skills (Leafstedt, Richards, & Gerber, 2004). The difficulty in acquiring PA skills is one reason that students with intellectual disabilities perform worse than their peers in reading (Connors, Rosenquist, Sligh, Atwell, & Kiser, 2006). Specific training in PA skills provides a chance for these students to catch up with their peers (Brady, et al., 1994; Conners, et al., 2006; Macaruso, Hook, & McCabe, 2006; Macaruso & Walker, 2008). Improved PA skills lead to better decoding skills (Macaruso, et al., 2006), which help students read more fluently and better comprehend the text (Olson & Wise, 1992; Wise, Ring, & Olson, 2000).

Developmentally appropriate use of technology may be one way to teach PA skills to young children with intellectual disabilities. According to the position statement published by the National Association for the Education of Young Children of technology with young children aged from 3 to 8 years old (2012), technology, if used appropriately, could assist students with disabilities in participating in the same activities as their typically developing peers. In addition, MacArthur, Ferretti, Okolo, and Cavalier (2001) found that most special education teachers thought it was an effective way to teach reading. Thus, teachers should promote the use of technology, especially for students with disabilities (NAEYC, 2012), and incorporate technology as a natural part of instruction for all students. Computer-assisted instruction (CAI) has been used to teach a variety of academic skills to students with disabilities. These skills include multiplication facts (Koscinski & Gast, 1993), counting (Ortega-Tudela & Gomez-Ariza, 2006), sight words (Lee & Vail, 2005), letter sounds (Campbell & Mechling, 2009), and writing skills (Englert, Manalo, & Zhao, 2004). The results found CAI to be effective because computers usually provide more chances for practice, instruction can be individualized based on the student's ability, students can receive immediate feedback and reinforcement, and students are often more motivated (Hitchcock & Noonan, 2000; Xin, 1999).

Statement of the Problem

The review of literature has revealed gaps in research. There are a limited number of studies that teach PA skills to young children with intellectual disabilities, i.e., children younger than 8 years of age. Moreover, the majority of the studies on computer-assisted PA instruction involved students who were at risk for reading disabilities. Thus, more research in this area is needed with students who have identified disabilities.

In the field of Special Education, some systematic errorless teaching strategies like constant time delay (CTD), progressive time delay, system of least prompts, and simultaneous prompting, are commonly used. However, when using CAI to teach academic skills to young children with disabilities, only three studies were found to use CTD procedures, and none of them focused on PA skills.

Furthermore, most of the studies on PA instruction, both computer-assisted format and teacher-directed format, used a pretest-posttest group design, which failed to reveal how the participants' individual characteristics impacted the effectiveness of the intervention. Thus, well-designed single subject studies should be conducted.

The iPad is a tablet computer, which is controlled by a multi-touch display and supports both audio and video. It is 9.56 in. x 7.47 in. in size, weighs 1.33lb, and is highly portable, which makes it possible for learning to happen anywhere. On the iPad, the presentations of text and images are flexible. For example, people can easily change the orientation of the webpage from portrait to landscape by rotating the iPad, and the size of text and images can be changed by just using the fingertips to pinch in or out. There are numerous applications available to download on iPad related to education, entertainment, music, and news, etc. All these features make the iPad distinct from the traditional computers.

Many educators believe that the iPad may revolutionize education. Since the first version of iPad was released in April 2010, many applications have been developed to teach different skills to people with disabilities, such as iComm (Bappz, 2010), which provides picture and communication aid for young children with communication difficulties; First Then Visual Schedule (Good Karma Applications, 2011), which is designed to provide visual supports for the routines; and Stories2Learn (MDR, 2010), which can be used to develop social stories. However, so far there is no empirical data on the effects of using an iPad application to teach students with disabilities. It will be interesting to see how the iPad features impact students' learning.

Purpose of Study

The purpose of the current study was to evaluate the effectiveness of using an application on a touch screen portable device, i.e., iPad, with 0-5s CTD procedures to teach PA skills to young children with disabilities. This investigation extended the literature on PA skills instruction to young children with intellectual disabilities, furthered our knowledge on using the CTD procedures in CAI, and expanded our understanding on the possibility of using the iPad application in special education with young children.

Research Questions

Specifically, this study addressed 3 questions:

1. What are the effects of using an iPad application that incorporates 0-5s CTD procedures to teach young children with disabilities to receptively isolate initial phonemes?

2. If young children with disabilities acquire the PA skills through the iPad application, will they generalize the target behaviors across positions and across materials?
3. If young children with disabilities acquire the PA skills through the iPad application, will they maintain the target behaviors after the intervention ends?

CHAPTER 2

LITERATURE REVIEW

The design of the intervention and the development of the iPad application were informed by the review of literature. First, the framework of this study included four parts: the influence of PA training on early reading development, PA training and young children with intellectual disabilities, the effectiveness of using CAI to improve PA skills, and CTD procedures in computer-assisted academic instruction. Second, the theories and principles that guided the design of the iPad application used in the current study were also reviewed.

Multiple means were used to locate articles published between 1990 and 2011 that addressed computer technology, PA skills, reading skills, and young children with disabilities. First, an electronic-based search was conducted through ERIC, PsycINFO, and Education Full Text using key words “computer”, “disabilities”, “young children”, “at-risk”, “intellectual disabilities”, “mental retardation” “phonological awareness”, “phonemic awareness”, and “reading”. Second, the reference lists of the articles gathered were searched. Studies which only included students with speech impairments were excluded. Articles included in this review met the following criteria: 1) peer reviewed articles which were published between 1990 and 2011; 2) participants included children younger than 8 years old who had disabilities or were at risk; and 3) the studies were empirical investigations.

The Influence of PA Training on Early Reading Development

Several studies (de Jong & van der Leij, 1999; Muter, Hulme, Snowling, & Stevenson, 2004; Muter & Snowling, 1998; Savage & Carless, 2005; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004) followed groups of young children for years to examine the contribution of PA skills to reading. The results confirmed that early PA skills were a good predictor for later reading achievement. In Stahl and Murray's (1994) study, students who could not master the easiest PA skill - phoneme isolation, could not read beyond preprimer level.

A great deal of research has evaluated the effectiveness of PA instruction in improving PA and reading skills. In 1999, Bus and van IJzendoorn conducted a quantitative meta-analysis of 32 articles from 1974 to 1997 that examined the effects of PA instruction on PA and reading skills. The short-term training effects on PA skills and reading were significant, and the effect size was strong for PA (d=1.04) and was moderate for reading (d=.44). The long-term effects on PA and reading skills were smaller than the short-term effects (d=.48 for PA; d=.16 for reading), and the effect was only significant for PA skills. Similarly, Ehri and her colleagues (2001) conducted a more in-depth meta-analysis. They examined 52 studies from 1976 to 2000. They found that the effect size immediately after training was large for PA skills (d=.56), and was moderate for reading (d=.53). They were not significantly different from the effect sizes in the follow-up testing. The results confirmed that PA instruction was effective in improving PA and reading skills, and the gains were maintained after training.

In a study of the relationships between training on segmentation, blending and reading new words for a group of kindergarten students who scored below average on PA skills, Torgesen, Morgan, and Davis (1992) reported that students who were taught both segmenting and blending skills scored significantly higher than the control group on both skills. The group that was only taught blending skills significantly outperformed the control group on the trained skills, but did not differ significantly from the control group in segmentation. The most important finding was that students who were taught both blending and segmenting skills spent less time than the other groups of students in learning new words. The group that only learned blending skills did not outperform the control group. These results indicated that training in blending skills alone would not lead to better word reading skills.

In contrast, O'Connor and Jenkins (1995) studied the effects of a segmentation/spelling treatment to improve PA and reading skills. Ten kindergarten students with developmental delays participated in the study. Students in the treatment group received twenty 10-min sessions of training to link letters to their sounds or to spell words. Students in the control group were given the same words to read. The results showed that the two groups of students were not significantly different on PA skills after training, but the experimental group outperformed the control group in spelling and word/non-word reading, indicating training in segmenting skills would produce improvement in reading. However, the results of this study should be interpreted with caution due to the small number of participants.

Moreover, another study that examined the effects of activity-based PA training was conducted by O'Connor, Notari-Syverson, and Vadasy in 1996. The intervention was implemented by classroom teachers on a group of kindergarteners with various ability levels. Throughout six months, the classroom teachers implemented 25 activities, which focused on word and syllable awareness, rhyming, first sound isolation, onset-rime level blending and segmenting, and letter-sound correspondence. After training, the experimental group significantly outperformed the control group on blending, segmenting, and the literacy measures.

Besides that, several studies found that improved PA skills would help those students who were at risk for reading delays catch up with their peers. For example, Israeli kindergarten students with the lowest PA skills were randomly assigned to one of four conditions. One group received training on phonemic segmentation, one group received training on phonemic segmentation with exposure to the shape of letters, one group received general language skills training, and one group that served as control received regular kindergarten instruction. After training, the two PA training groups scored significantly higher than the other two groups on segmenting skills, though there was no significant difference between the two PA training groups. Their performance on PA skills was similar to that of students with higher initial PA skills. The reading tests conducted four months and nine months after training showed that the two PA training groups scored significantly higher than the other two groups, and were not significantly different from those of students with higher initial PA skills (Bentin & Leshem, 1993).

In a study that compared specific PA training to the “whole language” curriculum conducted by Brady and her colleagues (1994), students from four inner-city public school kindergarten classes from low SES homes with poor PA skills participated. Two classes received three 20-min PA training sessions per week for 18 weeks, and two classes received regular “whole language” curriculum. The training focused on larger phonological units at the beginning and gradually moved to smaller units. Students in the PA training group made significant progress compared to the “whole language” group on PA skills. During the follow-up test, which was taken a year after training, students in the PA training group significantly outperformed the “whole language” group in word identification, and more students in the PA training group were performing at grade level compared to students in the “whole language” group.

Likewise, O’Connor, Jenkins, and Slocum (1995) compared specific segmenting and blending training with a more general approach PA training and their impacts on reading. Sixty-seven kindergarten nonreaders with low PA skills participated in the study, including students who were receiving special education services and those who were referred for special education.

The results showed that the two kinds of PA training were equally effective. Both PA groups outperformed the control group on blending and segmenting skills. The improvement on PA skills also transferred to reading skills. When compared to a group of kindergarten students with initially higher PA skills, students in the PA training groups were performing at the same level in blending, segmenting, and reading tasks.

In addition, some researchers suggested combining a reading component or letter knowledge with the PA training to reach better results. Students in the reading with phonology group made significantly more gains than students who received reading instruction alone, those who received phonology instruction alone, and those who received the regular classroom instruction in reading and spelling; and their gains in reading maintained nine months after the intervention ended. The results indicated that PA training with a reading component would better improve literacy skills (Hatcher, Hulme, & Ellis, 1994).

Similarly, Defior and Tudela’s study (1994) suggested that PA training alone was not sufficient to improve reading skill. In their study, the group that received PA training with manipulation of plastic letters significantly outperformed the other groups in reading and writing when tested right after the training and two months after the training. The group that received PA training without the manipulation of letters did not differ significantly from the control in any measure.

In summary, young children who were at-risk improved their PA skills through training, and their gains in PA skills transferred to early reading skills. However, as suggested by Bus and van IJzendoorn (1999), teaching PA skills combined with letters or with some reading components would achieve better outcomes. The review revealed that different characteristics of

PA instruction affect the results. PA training that only focused on blending alone would not improve reading skills, but training on segmenting alone would facilitate reading acquisition.

The review also demonstrated a paucity of research on PA training for young children with disabilities. Most studies excluded students whose IQs were one standard deviation below the mean, who were receiving special education services, and who had behavior issues. However, these students might be those who needed the intervention most. Additionally, group research methods were used in these studies. When studying students with disabilities, a group design would not be sufficient to monitor improvement and to capture individual differences. Table 1 summarizes studies of the influence of PA training on early reading development.

PA Training and Young Children with Intellectual Disabilities

Like their typically developing peers, students with intellectual disabilities who have better PA skills tend to develop better reading skills (Lemons & Fuchs, 2009; Wise, Sevcik, Romski, & Morris, 2010). The number of studies of teaching PA skills to young children with intellectual disabilities is limited (Conners, Atwell, Rosenquist, & Sligh, 2001; Snowling, Hulme, &Mercer, 2002; Wise, et al., 2010), though 10% of the students who are receiving special education services in the U.S. have some degree of intellectual disabilities (NICHCY, 2009). There are at least three possible reasons. First, historically, people have lower academic expectations for children with intellectual disabilities, and they believe low IQ is the cause of poor reading performance (Browder, et al., 2009; Conners, et al., 2001). Second, a functional reading approach, i.e., sight word instruction, is often used for this group of children (Browder, et al., 2009; Saunders, 2007). Third, students with intellectual disabilities tend to be less responsive to intervention compared to students without disabilities (O'Connor et al., 1996), so

Table 1

Studies on PA Training and Reading

Reference	Participants	Dependent Variable	Independent Variable	Experimental Design	Results
Bentin & Leshem (1993)	N=508 Israeli kindergarteners aged from 59 to 77 months with lowest PA skills	Segmentation, and reading one-syllable/ two-syllable words/ nonwords	A comparison of 4 matched groups: training on phonemic segmentation, training on phonemic segmentation with exposure to letter shapes, training on general language skills, and a control group	Longitudinal between grades quasi-experimental design	Before training, the four groups were not significantly different on segmenting skills. After training, the two PA training groups scored significantly higher than the other two groups on segmenting skills. The performance of the students in the two PA training groups was similar to that of those students with higher initial PA skills. There was no significant difference between the two PA training groups. The reading scores of the two PA training groups were significantly higher than the other groups, and were not significantly different from those of students with higher initial PA skills after 4months and 9 months of training.
Brady, Fowler, Stone, & Winbury (1994)	N=42 Inner-city kindergarten students from low SES background	Cognitive ability, academic achievement, PA skills, and basic phonological processes	A comparison of 2 PA training classes to 2 control classes who received regular “whole language” curriculum	Longitudinal group pretest-posttest control group study	The two groups of students did not differ from each other on any measures before training. They all made some gains during the training period. However, the training group significantly outperformed the control group on rhyming and segmenting skills. The students were followed one year after training. More students in

					the training group were promoted to 1st grade than the control group. The training group scored significantly higher than the control group on word identification.
Defior & Tudela (1994)	N=60 1st level students with poor PA skills in a primary school in Spain	Reading, writing, and mathematics	A comparison of 5 matched groups: training on word categorization based on phonemes, training on word categorization based on phonemes with manipulation of plastic letters, training on word categorization based on conceptual criteria, training on word categorization based on conceptual criteria with written words, and control	Group experiment design	The group that received training on word categorization based on phonemes with manipulation of plastic letters significantly outperformed the other groups in reading and writing when tested right after the training and 2 months after the training.
Hatcher, Hulme, & Ellis (1994)	N=124 7 yr old poor readers in UK	Word recognition, reading accuracy & comprehension nonword reading, spelling, PA skills (sound deletion, blending, nonword	A comparison of 4 matched groups: reading with phonology, reading alone, phonology alone, and control	Group experiment pretest-posttest control group longitudinal study	The reading with phonology group made significantly more gains than the control group in all reading measures and spelling, and the gains in reading were maintained after 9 months. The other two training groups did not differ significantly from the control group in reading and spelling. For PA skills, the phonology alone group significantly outperformed the control group in sound deletion and blending, and the other training groups did not

		segmentation, and sound categorization)			show any significant difference from the control group.
O’Connor & Jenkins (1995)	N=10 Kindergarten students with developmental delays	Blending & segmenting, word and pseudoword reading, and spelling	A comparison of a group of students who received the segmentation/spelling treatment and a reading control group	Group experiment pretest-posttest control group study	The two groups of students did not differ significantly on pretest. During posttest, students in the experimental group scored significantly higher than students in the control group in spelling, and they generalized the skill to untrained words. The two groups did not differ significantly on either blending or segmenting. As for transferring to reading, students in the experimental group outperformed students in the control group on reading real words and pseudowords from the Reading Mastery program, and on word identification from Woodcock Reading Mastery Tests-Revised (WRMT), but the two groups did not differ significantly on word attack skills from WRMT.
O’Connor, Jerkins, & Slocum (1995)	N=67 Kindergarten students who scored between 0 and 30% on pretest blending and segmenting. Students who received special	Blending, segmenting, syllable deletion, rapid letter naming, first sound, mastery of trained items, Lindamood Auditory Conceptualizat	A comparison of 3 groups of kindergarten students. One group received blend-segment treatment, one group received training on a global array of PA tasks, and one group were taught phoneme-grapheme correspondences that the	Group experiment pretest-posttest control group study	The two PA training groups outperformed the letter-sound group in blending, segmenting, and LAC, but the two PA groups did not differ from each other significantly. As for reading analog, no significant difference was found between the two PA groups, but significant difference was found only between the blend-segment group and the letter-sound group. When compared to the high-

	education and those who were referred were included.	-ion Test, and reading analog	other two groups were taught. After training, the PA skills of these students were also compared to that of a group of randomly selected students with high PA skills.		skilled students, students in the PA training groups were performing at the same level in blending, segmenting, LAC and reading analog; but the high-skilled students were still superior in letter naming and syllable deletion.
O'Connor, Notari-Syverson, & Vadasy (1996)	N=17 Kindergarten students in self-contained classrooms N=14 Kindergarten students with disabilities in general and transition classes N=57 Regular kindergarten students N=19 Repeating kindergarten students	PPVT-R, sound repetition, rapid letter naming, syllable deletion, blending, first sound isolation, segmenting, rhyme production, and letter-word identification and dictation subtests from Woodcock-Johnson Tests of Achievement	Two general kindergarten classes including students with mild disabilities, 1 transition class, and 2 self-contained classes were assigned to receive the activity-based PA training implemented by classroom teachers. One general class, 1 transition class, and 1 self-contained class served as control, which received regular kindergarten curricula.	Group experiment pretest-posttest control group study	The students in the experimental group outperformed the control group in blending, segmenting, and WJ subtests. No significant treatment effects were found in PPVT-R, sound repetition, letter naming, first sound isolation, or rhyming. Students with disabilities made smallest gains.
Torgesen, Morgan, & Davis (1992)	N=51 Kindergarten students scored between 15th	Segmentation, blending, and reading analog	A comparison of 3 matched groups: PA training with analysis and synthesis, PA	Group experiment pretest-posttest	The group that received PA training with both analysis and synthesis scored significantly higher than the control group in segmentation and

	and 50th percentile on Screening Test of Phonological Awareness	training with synthesis, and a language-experience control group	control group study	blending skills, and the effects were transferred to reading analog. Students in the group that received PA training with both analysis and synthesis took fewer trials to learn the new words. The group that received PA training with synthesis significantly outperformed the control group in blending skills, but did not differ significantly from the control group in segmentation and reading analog.

the results of many studies may be not very impressive and cannot get published (Saunders, 2007).

In 2007, Saunders reviewed the literature on PA and word-attack skills in students with intellectual disabilities. The results showed a significant relationship between the PA skills and word-attack skills, and training in PA skills effectively improved word-attack skills. Lemons and Fuchs (2009) conducted a review of 20 studies from 1970 to 2008 that examined the relationships between PA and reading skills for students with Down syndrome. They found that students with Down syndrome had lower PA skills compared to their peers without disabilities. However, similarly to their typically developing peers, their PA skills correlated to their concurrent and future reading skills. PA training, either alone or combined with reading instruction, improved their PA and reading skills. Both studies supported that students with intellectual disabilities would benefit from PA training.

Five articles (See Table 2) that investigated the effectiveness of PA intervention for young children with intellectual disabilities were reviewed in this section. Three of them involved young children with intellectual disabilities of mixed etiology, and the other two involved young children with Down syndrome.

Forty-seven four- to six-year-old preschool nonreaders with developmental delays were randomly assigned to one of four conditions: rhyming, blending, and segmenting, and control in O'Connor, Jenkins, Leicester, and Slocum's study (1993). The results showed that students in the treatment groups, regardless of their cognitive abilities, all learned the PA skills they were taught. Their performance on the trained skills was significantly better than that of students in other treatment conditions and in the control group. However, the gains in one type of PA skills failed to transfer to other types of PA skills within one category (e.g., from blending onset-rime

Table 2

Studies on PA training and Young Children with ID

Reference	Participants	Dependent Variable	Independent Variable	Experimental Design	Results
Celek, Pershey, & Fox (2002)	N=16 7-13 year-old students with dual diagnosis of ID and BD	5 subtests of the Phonological Awareness Test: rhyming, segmenting, isolating, deleting and blending	The students received PA training in rhyming, segmenting, isolating, deleting, and blending, and the intervention was processed from larger phonological units to smaller phonological units. Repeated measures of trained PA skills were conducted throughout training.	A quasi-experimental, within subjects, time series design	Students made significant growth in all the five PA skills during training. Cognitive abilities did not predict the gains in PA skills. There were no correlations between PA improvement and behavior.
Conners, Rosenquist, Sligh, Atwell, & Kiser (2006)	N=40 7-12 year-old students with ID IQ ranged 40-70	Sounding out: instruction set, sounding out: transfer set, non-word and sight word reading	The students in the treatment group received 22 individual lessons on PA skills over 10 weeks.	A matched control group design	Students in the treatment group scored significantly higher than those in the control group in sounding out. Students did better in sounding out than pronouncing. In the treatment group, students with better initial reading skills and better language ability performed better in sounding out. In the control group, students with better initial reading skills, PA skills, and articulation speed performed better.

Kennedy & Flynn (2003)	N=3 Students with Down syndrome aged 7;2, 8;4, and 8;10	Alliteration detection, phoneme isolation, spelling of orthographicall-y regular words, rhyme detection, comprehension of passive structure and spatial terms, and phoneme segmentation	Students received training on alliteration detection, phoneme isolation, spelling of orthographically regular words, and rhyme detection.	A multiple baseline across behaviors	Students showed improvement on trained PA skills, and did not show improvement on the controlled behaviors, but the improvement failed to generalize to the untrained phoneme segmentation. Data from the spelling analysis revealed that students moved from an awareness of initial phonemes to an awareness of final phonemes.
O'Connor, Jenkins, Leicester, & Slocum (1993)	N=47 Preschool children aged 4-6 years with developmental delays, who had not received formal reading instruction	Cognitive ability, PA tests, phonological mastery tests, and letter recognition	A comparison of three treatments: rhyming, blending, and segmenting, and a control group	Group experiment pretest-posttest control group study	Students in experimental groups made significantly higher gains in the PA skills they received training on regardless of their cognitive ability. However, they failed to generalize the skills within a category or between categories.
van Bysterveldt, Gillon, & Moran (2006)	N=7 4-year-old children with Down syndrome	Initial phoneme identification, letter name and sound knowledge, and print concepts	A comparison of the performance of students with Down Syndrome who received parent conducted reading intervention using print referencing	Pretest – posttest with an age-matched control group study	During both pretest and posttest, students with Down Syndrome performed significantly worse than their typically developing peers. As a group, the students with Down Syndrome made significant gains in letter sound knowledge, print concepts, and initial phoneme

	techniques and that of an age-matched control group who received no special treatment	identification. The control group only made significant gains in letter name knowledge. However, not every child with Down Syndrome benefitted from the training, and two children's performance remained stable.

to blending separated sounds), and failed to generalize to PA skills in other categories (e.g., from blending to segmenting).

In a study to teach PA skills to a group of 7-13 year-old students who were dually diagnosed with intellectual disabilities and behavioral disorders, students were first taught to be aware of the larger phonological units, i.e., rhyming and awareness of words; and gradually exposed to the smaller units, i.e., syllables and phonemes (Celek, Pershey, & Fox, 2002). The results indicated that by the end of the training, all students made significant growth in PA skills. Cognitive abilities could not completely predict the gains in PA skills. Though students with higher IQs scored higher than those with lower IQs on most measures, there were also many times when students with lower IQs outperformed those with higher IQs.

Additionally, Connors and her colleagues (2006) investigated the effectiveness of a 10-week training on blending, letter sound correspondence, and sounding out to a group of students with intellectual disabilities who could not decode. Students were aged from 7 to 12 years, with IQs from 40 to 70. The students were matched in pairs on age, IQ, PA skills, decoding, and language comprehension, and were randomly assigned to the treatment or the control group. The results showed that students in the treatment group scored significantly higher than the control group on sounding out words, indicating that students with intellectual disabilities benefited from PA training.

Three students with Down syndrome in Kennedy and Flynn’s (2003) study received eight hours of PA training across four weeks. Specifically, they received training on alliteration detection, phoneme isolation, spelling of orthographically regular words, and rhyme detection. The study utilized a multiple baseline across behaviors design. In general, results indicated all three students improved on the trained skills, and their performance on the controlled skills remained stable. Data from the spelling analysis revealed that students moved from an awareness of initial phonemes to an awareness of final phonemes.

In van Bysterveldt, Gillon, and Moran's (2006) study, parents of seven young children with Down syndrome were trained to use print referencing techniques to lead children's attention to initial phonemes, letter names and sounds, and print concepts during reading. The performance of the children with Down syndrome was compared to that of a group of randomly selected, age-matched typically developing children who did not receive any special treatment. Though children with Down syndrome scored significantly lower than their peers even after training, they made significant gains in letter sound knowledge, print concepts, and initial phoneme identification. However, not every child with Down syndrome was responsive to the intervention, and two children did not show any improvement from pretest to posttest. Students who could identify the initial phonemes had better letter sound knowledge.

In conclusion, young children with intellectual disabilities could be taught PA skills. However, the gains were restricted to the trained skills. This review indicated that there was a great need for studies on PA training for young children with intellectual disabilities. Because individual differences greatly impact the training effectiveness among this group of students, well-designed single subject studies are needed.

Effectiveness of CAI in Teaching PA Skills

From 1990 to 2010, a total of 12 studies (See Table 3) reported successfully using CAI to teach PA skills. The participants were preschoolers to 5th graders, and they were students who were at risk. All these studies employed a group experimental pretest-posttest control group design. Researchers in seven studies compared the effectiveness of computer-assisted PA training to a control group that received no intervention (Foster, Erickson, Foster, Brinkman, &

Table 3

Studies on CAI of PA Skills

Reference	Participants	Dependent Variable	Independent Variable	Experimental Design	Results
Barker & Torgesen (1995)	N=54 At risk 1st grader	Computerized PA test, sound categorization, phoneme elision, segmenting, blending, word and non-word reading	A comparison of CAI PA training, CAI decoding training, and CAI math training groups	Group experiment pretest-posttest control group design	The experimental group significantly outperformed the control groups in the computerized PA test, segmenting, elision, and word identification. The two control groups did not differ significantly on all PA measures.
Foster, Erickson, Foster, Brinkman, & Torgesen (1994)	Experiment I: N=25 Preschoolers who scored less than 67% in PAT, and above 75 in PPVT-R Experiment II: N= 69 Kindergarteners	Experiment I: PAT & STOPA Experiment II: computerized PA test, STOPA, test of segmenting, and test of blending	A computer program, DaisyQuest I and II	Group experiment pretest-posttest control group design	In experiment I, the experimental group scored significantly higher than the control group in both the PA tests, and all participants enjoyed learning on the computer. In experiment II, the experimental group outperformed the control group in the computerized PA test, test of segmenting, and test of blending. The two groups did not differ significantly in STOPA, which might be due to ceiling effects.
Lonigan, Driscoll, Phillips, Cantor, Anthony, & Goldstein	N=45 Preschoolers at risk for reading disabilities	Pretest: Oral language and cognitive ability, print knowledge, and phonological	A comparison of CAI PA training and a control group who received no intervention	Group experiment pretest-posttest control group design	Students in the CAI group performed significantly better than students in the control group in rhyming and elision skills.

(2003)		sensitivity Posttest: Picture vocabulary, print knowledge, and phonological sensitivity			
Macaruso, Hook, & McCabe (2006)	N=179 1st graders 30 of whom were at risk	The Gates-MacGinitie Reading Test, Level BR	A computer program which taught PA skills and phonic word-attack strategies	Group experiment pretest-posttest control group design	Students in both groups made great gains from pretest to posttest. The difference between the experimental group and the control group was not significant. The at-risk students in the experimental group significantly outperformed the at-risk students in the control group in the letter-sound correspondence sub-tests, but not in the basic story words sub-test. In the experimental group, the at-risk students scored significantly lower than those who were not at-risk in pretest, but the difference was not significant in posttest. In the control group, the significant difference between the at-risk students and the non-at-risk students existed in both pretest and posttest.
Macaruso & Walker (2008)	N=71 Kindergarteners 24 of whom were low performers	Pretest: DIBELS initial sound fluency and letter naming fluency subtests Posttest: DIBELS initial	A phonics-based CAI program	Group experiment pretest-posttest control group design	No significant difference was found between the experimental group and the control group in all the DIBELS subtests on either pretest or posttest. The posttest score in Gates-MacGinitie favored the experimental group in all subtests, but significance was only found in the PA skills subtest.

		sound fluency and phoneme segmentation fluency subtests, and Gates-MacGinitie Reading Test, Level PR			The same pattern of results was found when comparing the scores of low performers in both groups.
Mitchell & Fox (2001)	N=72 At risk kindergarteners and 1st graders	Phonological Awareness Test	A Comparison of CAI PA training, TDI PA training, and CAI math training groups	Group experiment pretest-posttest control group design	Both CAI PA training group and TDI PA training group significantly outperformed the math training group on the posttest PA skills test. No significant difference was found between the CAI PA training group and the TDI PA training group on all measures. The CAI PA training was equally effective for at-risk kindergarteners and 1st graders.
Mioduser, Tur-Kaspa, & Leitner (2000)	N=46 Preschoolers at risk for LD	PA skills, word recognition, and letter naming skills	A comparison of both CAI plus print training, print only training, and no special training groups	Group experiment pretest-posttest control group design	The CAI plus print group showed significantly higher improvement than the control groups in all three measures, and significantly outperformed the two control groups in 6 out of 11 PA tasks.
Olson & Wise (1992)	Phase I: N=37 Phase II: N=149 2nd -6th grade poor readers with normal IQ scores	PIAT for word recognition, comprehension, and spelling; timed word-recognition; phonological decoding; and	A comparison of whole-word feedback, syllable feedback, onset-rime feedback, and untrained control groups	Group experiment pretest-posttest control group design	The experiment groups made about twice as many gains in word recognition, and about four times as many on non-word reading as did the control group. The difference between different feedback conditions was not significant. The comparison between Phase I and II revealed the importance of pretraining and monitoring during

		phonological awareness skills			intervention. Students' pretest PA scores predicted their gains in decoding and word recognition.
Wise & Olson (1995)	N=103 2nd -5th grade poor readers	PIAT for word recognition, comprehension, and spelling; timed word-recognition; phonological decoding; and phoneme awareness skills	A comparison of PA focused CAI training and comprehension strategy focused CAI training	Group experiment pretest-posttest control group design	Both groups made great gains. Students in the PA condition significantly outperformed students in the CS condition in PA skills and nonword reading. Students with lower initial PA skills gained as much as those with higher initial PA skills in the PA condition.
Wise, Ring, Sessions, & Olson (1997)	N= 43 2nd -5th grade poor readers	Word recognition, PA skills, decoding, and spelling	A comparison of PA training with and without articulatory component	Group experiment pretest-posttest control group design	Both groups made great gains, and the results slightly favored the nonarticulatory group. Students with lower PA skills might need articulatory training more than students with higher PA skills.
Wise, Ring, & Olson (1999)	N=153 2nd -5th grade poor readers	Word recognition, phonological decoding, PA skills, nonword repetition, orthographic coding, spelling, comprehension, and arithmetic	A comparison of three PA training conditions with articulatory component, with manipulation of sounds, with both components, and a control group who	Group experiment pretest-posttest control group design	All students in the training conditions made great gains compared to the control group. No difference between combined condition and sound-manipulation condition. Sound-manipulation condition outperformed the articulation-only condition in both PA skills.

			received regular instruction		
Wise, Ring, & Olson (2000)	N=200 2nd -5th grade poor readers	Rapid naming, PA skills, decoding, word recognition, spelling, and comprehension	A comparison of PA training with phonological analysis and PA training with accurate-reading-in-context	Group experiment pretest-posttest control group design	Students in the phonological analysis group made significantly more gains than the read-in-context group in PA skills, decoding, and untimed word reading. Students with low initial PA skills made more gains in the phonological analysis condition than in the read-in-context condition.

Torgesen, 1994; Lonigan, Driscoll, Phillips, Cantor, Anthony, & Goldstein, 2003; Macaruso, et al., 2006; Macaruso & Walker, 2008; Mioduser, Tur-Kaspa, & Leitner, 2000; Olson & Wise, 1992; Wise, Ring, & Olson, 1999). Six studies compared the effectiveness of different CAI programs or different features of a CAI program on improving PA skills (e.g., a program focused on phonological analysis vs. a program focused on comprehension strategies) (Barker & Torgesen, 1995; Olson & Wise, 1992; Wise & Olson, 1995; Wise, Ring, Sessions, & Olson, 1997; Wise, et al., 1999; Wise, et al., 2000).Two studies compared CAI to teacher-directed instruction (TDI) (Mitchell & Fox, 2001; Mioduser, et al., 2000). Two studies compared computer-assisted PA training to computer-assisted math training (Barker & Torgesen, 1995; Mitchell & Fox, 2001).

The presentation of instruction in these CAI studies varied according to three formats: games, reading-in-context, and worksheet. Five studies used computer games. Four of them (Barker & Torgesen, 1995; Foster, et al., 1994; Lonigan, et al., 2003; Mitchell & Fox, 2001) examined the effectiveness of using different versions of *Daisy's Quest* and *Daisy's Castle* to teach PA skills. *Daisy's Quest* and *Daisy's Castle* included interactive activities that provided training and practice on rhyming, recognizing beginning, middle, and ending sounds, blending, and counting phonemes in words. During these activities, students got clues to search for Daisy, a friendly dragon, or her lost eggs. All instructions were provided via the computer using digitized speech. The program explained and modeled each skill to the students before they practiced by themselves, and provided feedback on their responses. Once children mastered a lower level skill, they would be introduced to a more difficult level. When they mastered all three levels in one area, they would start instruction in another area. The other game-format program used was "*I have a secret – I can read*" (Mioduser, et al., 2000). This computer program included exercises, tutorials, and practice games. The instruction was delivered through the use of sound, text, and animation.

Five studies conducted by Wise and Olson and their colleagues (1992, 1995, 1997, 1999, & 2000) used accurate reading-in-context as part of their computer-assisted PA training. Students in their studies read stories on the computer using a program that provided word assistance (i.e., Reading with Orthographic and Segmented Speech [ROSS]). When students met an unknown word, they could click on the word and the computer would highlight either the whole word or word segments with alternating backgrounds, and would pronounce either the word or segments upon request.

In addition to the accurate reading-in-context, four of the Wise et al. studies (1995, 1997, 1999, & 2000) used a worksheet format. The students practiced phonological analysis, non-word reading, and spelling on the computer. Other researches also used worksheet formats (Macaruso, et al., 2006; Macaruso & Walker, 2008). In their studies, they used CAI programs designed by Lexia Learning Systems to supplement regular reading instruction. The students worked on phonic word-attack strategies at different levels, sound identification, rhyming, segmentation and blending, and letter-sound correspondences on the computer.

The computer-assited PA intervention generally involved students practicing PA related skills on the computer individually and independently (Barker & Torgesen, 1995; Foster, et al., 1994; Macaruso, et al., 2006; Macaruso & Walker, 2008; Mitchell & Fox, 2001; Mioduser, et al., 2000). In many studies, teachers provided supports on computer related problems only, rather than on reading instruction. In some studies, however, adults provided more than just technical support. For example, in the Lonigan, et al. (2003) study, teachers provided corrective feedback for each student. Moreover, in the research series conducted by Olson and Wise and their colleagues (1992, 1995, 1997, 1999, & 2000), teachers monitored part of the training when students were reading with ROSS.

The results of studies of computer-assisted PA training were promising. All the students in the experimental groups scored significantly higher than those in the control groups. In Barker and Torgesen's (1995) study, the PA training group did not only score significantly higher than the two control groups on the trained PA skills, but also scored significantly higher on the untrained skills like segmentation, phoneme elision, and word identification. The results of two of Macaruso and his colleagues' studies (2006 & 2008) suggested that CAI might be helpful for those low-performers to catch up with their peers. Students who scored lowest in the experimental group made significantly more gains than those students in the control group, and the gap between those low performers and their regular peers diminished in the treatment group after training. When comparing CAI with the TDI, in Mitchell and Fox's (2001) study, the two groups did not differ significantly on all measures, indicating computer-based PA instruction was as effective as the teacher-led instruction in promoting the development of PA skills. In Mioduser et al.'s study (2000) students in the CAI condition significantly outperformed those in the TDI condition in PA skills, word recognition, and letter naming. In Wise and colleagues' studies (1992, 1995, 1997, 1999, & 2000), where ROSS was used to improve PA and reading skills for 2nd to 5th grade elementary students who were low performers, all students made great gains during the CAI training.

In summary, all studies in this section were well designed and provided evidence that CAI was effective to improve poor PA skills. CAI was equally effective as TDI (Mitchell & Fox, 2001; Mioduser et al., 2000). Students did not only learn trained items, but also generalized to untrained skills (Barker & Torgesen, 1995). Students with the lowest performance benefitted most, and CAI provided a chance for them to catch up with their regular peers (Mitchell & Fox, 2001; Macaruso et al., 2006; Macaruso & Walker, 2008; Wise et al., 1995 & 2000). However, the review revealed gaps in research. All of the studies reviewed only included students at risk for reading disabilities. There was a paucity of studies on computer-assisted PA training for students with identified disabilities. All of the studies also utilized a group design, which failed to show the impact of the intervention on individual students.

CTD Procedures in Computer-assisted Academic Instruction

CTD procedures have been widely used to teach a variety of skills to students with disabilities, and it has been found to be effective and efficient. CTD procedures involve two parts. During the first part, when the task direction is presented, the student receives a simultaneous controlling prompt. During the second part, after presenting the task direction, a fixed amount of time is inserted before the prompt is given (Wolery, Ault, & Doyle, 1992). CTD procedures have been effective in teaching academic skills to young children with disabilities (Doyle, Wolery, Gast, Ault, & Wiley, 1990; Gast, Doyle, Wolery, Ault, & Baklarz, 1991; Knight, Ross, Taylor, & Ramasamy, 2003; Schoen & Ogden, 1995). When combined with computer technology, CTD procedures have also been successfully used to teach academic skills to older students with disabilities (Edwards, Blackhurst, & Koorland, 1995; Koscinski & Gast, 1993; Stevens, Blackhurst, & Slaton, 1991).

Three studies (See Table 4) were identified to use CTD procedures in computer-assisted academic instruction for young children with disabilities. All the three experiments utilized a single subject design. Hitchcock and Noonan (2000) compared the effectiveness of CAI and teacher-assisted instruction on teaching early academic skills (i.e., matching shapes, colors, and

Table 4

CTD in Computer-assisted Academic Instruction

Citation	Question	Participants	Procedures	Measures	Instructional Techniques	Results
Campbell & Mechling (2009)	Effects of CAI and CTD to teach letter sounds in a small group setting	Three kindergarten students with learning disabilities	Students were taught letter sounds in a small group of three using PowerPoint and SMART board.	Phonics	CTD	All students mastered their target letter sounds, and learned some of the other students' target letter sounds through observation, and learned the incidental information (i.e., letter names), which was delivered as feedback
Hitchcock & Noonan (2000)	Compare the effect of CAI and TAI on teaching early academic skills	Five preschool students with disabilities, aged from 3 years 2 months to 4 years 7 months	Two skills were taught using TAI, and two equivalent skills were taught using CAI.	Percentage of correct matches, and naming	CTD	CAI with CTD was a more effective intervention than TAI with CTD across most of the skills taught in this study.
Lee & Vail (2005)	Effects of CAI and CTD to teach sight words	Four boys aged 6 to 7 with disabilities	Students individually watched a video of the target word and then click on the word within 5s.	Percentage of correct responses	CTD	All students mastered their target words, and the skill was generalized. The students also learned incidental information. Some of the skills were maintained.

numbers or letters) to five preschool students with disabilities. An Adapted Alternating Treatment Design (AATD) was used. Results showed that CAI with CTD procedures was a more effective intervention than TAI with CTD procedures across most of the skills taught in the study, and the skills were maintained two, four, and six weeks after the intervention was completed. Students also demonstrated some improvement on the non-target skill, naming.

In 2005, Lee and Vail examined the effectiveness of using a multimedia computer program combined with 0-5s CTD procedures in teaching sight words to four six to seven-year-old boys with disabilities. The study used a multiple probe design across four word sets replicated by four students. The intervention was delivered individually. Eight target words were selected from Dolch word lists for each student. All students mastered their target words after the introduction of the multimedia computer program and CTD procedures. The skill was also generalized to functional materials (i.e., storybooks), and across materials and modes (i.e., pencil and paper, and index cards). Students also showed improvement on incidental information (i.e., word definition). As for maintenance, data were collected two and four months after the intervention for two students, and the results ranged from 25% to 100%.

Finally, Campbell and Mechling (2009) used CAI with SMART Board technology and 0-3s CTD procedures to teach letter sounds to three kindergarten students with learning disabilities in a small group format. A multiple probe design across three letter sets replicated with three students was used. All participants mastered their target letter sounds, and also learned some of the other participants' letter sounds or letter names through observation and feedback.

In conclusion, young children with disabilities improved their academic performance through the use of CAI with CTD procedures. In all three studies, students did not only improve on target skills, but also made progress on non-target skills. What's more, in two of the three studies, students maintained the skills learned. However, the small number of CAI studies with CTD procedures indicates that more empirical research is needed.

Summary

The current literature review supported that 1) there was a positive relationship between PA skills and early reading skills; 2) students with disabilities or at-risk could benefit from PA interventions, and their improved PA skills will lead to improved reading skills; 3) CAI was an effective way to improve PA skills; and 4) CTD procedures could be used for CAI to teach academic skills to young children with disabilities.

However, gaps were also revealed. First, there was a paucity of research on PA intervention for young children with disabilities, esp. intellectual disabilities, whether teacher-directed or computer-assisted. Second, no study to date had incorporated CTD procedures in using CAI to teach PA skills. Moreover, most of the researchers employed a group experimental design, which was not sufficient to monitor individual progress.

As a result of these findings, in the current study, the researcher embedded CTD procedures within the iPad application to teach early PA skills to young children with disabilities or developmental delays. Specifically, the target behavior was receptive isolation of initial phonemes, which was a fundamental PA skill (Kennedy & Flynn, 2003; van Bysterveldt, et al., 2006).

The Theories and Principles of Instructional Design

A multimedia intervention program is usually guided by some theories and principles for why it was put together in a particular way. Some commonly used theories include information processing theory and the cognitive theory of multimedia learning. These theories consist of different principles, such as modality principle, self-explanation principle, pacing principle, multisensory principle, and self-modification principle. This section presents the theories and principles that were used to create the current iPad application.

Cognitive theory of multimedia learning. The cognitive theory of multimedia learning draws on cognitive load theory, dual coding theory, and constructivist learning theory. It is based on three assumptions: dual-channel assumption, limited capacity assumption, and active processing assumption (Mayer, 2005a). Cognitive theorists (Mayer, 2005a) believe that working memory has two channels to process visual and auditory information separately, each time the amount of information that a person can process in each channel is limited, and humans are active processors who can pay attention to the different formats of multimedia information, organize them, and integrate them to make sense. Several design principles for how to create an effective electronic learning environment are derived from the cognitive theory of multimedia learning, such as the modality principle, the self-explanation principle, and the pretraining principle.

Modality principle. When the information is too complicated or too much is presented at one time, a student may not have enough cognitive capacity to process the information. One of the ways to minimize the cognitive overload is to design the instruction using the modality principle. The capacity of working memory is increased when using mixed modes to deliver instruction. Because visual and auditory information is processed using different channels, students learn better if the information is presented as animation/picture and narration than if the information is presented as animation/picture and on-screen text (Mousavi, Low, & Sweller, 1995).

Several studies have successfully used mixed modes to present information. For example, Olson, Wise, and their colleagues (1995, 1997, 1999, & 2000) incorporated both auditory and visual channels to deliver the information throughout their studies of teaching PA and reading skills to young children who are at-risk for reading disabilities. First, the word/non-word or syllable was presented on the screen or highlighted, and at the same time, the computer would pronounce it. Second, when the student was typing in the syllable or the word/non-word that was pronounced by the computer, the computer would pronounce any pattern the student made, and by listening to the computer, the student could make corrections. Third, when students met a difficult word when they were reading with ROSS, they could click on the word, and the computer would pronounce the word and at the same time highlight the word in segments with alternating backgrounds after the student made an attempt. By looking at the word or syllable on the screen and listening to it being pronounced by the computer, the students got to pay attention to the specific phoneme and were exposed to the phoneme by two modalities.

Likewise, Barker and Torgesen (1995) and Mitchell and Fox (2001) utilized the auditory channel to reduce the burden of the visual channel. They used *Daisy's Quest* and *Daisy's Castle* to teach PA skills to young children who were at-risk for reading difficulties. During the intervention, students played interactive games on computer. The interactive activities provided training and practice on rhyming, recognizing beginning, middle, and ending sounds, blending onsets and rimes, blending individual phonemes, and counting phonemes in words. All the instruction and feedback were given auditorially, and the children were not exposed to any written text.

Pretraining principle. The pretraining principle is also used to reduce the cognitive load. When both the visual and auditory channels are overloaded, providing the students with some prior knowledge of what is going to be taught before the instruction begins will reduce the need of processing during learning (Mayer, 2005b). For example, in the Olson and Wise (1992) study, students in phase I received more pretraining and monitoring by the researcher to see if they could target every miscue than students in phase II. Though students in phase II received longer training, the results on decoding favored students in phase I, indicating the importance of pretraining and monitoring of the target behavior.

Pacing principle. The pacing principle asserts that students learn better if they control the pace of learning themselves (Sorden, 2005). Each student is different, so the amount of time for him or her to master a skill is different. Based on the student's performance, he or she was automatically moved to a lower or higher level of activity. For example, the teacher selected the beginning level for the student, and then the student worked on the computer individually. The pace was based on the student's performance (Mioduser, et al., 2000). Similarly, in studies conducted by Olson, Wise and their colleagues (1995, 1997, 1999, & 2000), the computer program would change level based on the student's performance. In other studies, the difficulty level of the activities was branched automatically (Macaruso, et al. 2006; Macaruso & Walker, 2008). Based on the student's performance, the programs would review skills that had not been mastered or move on to more advanced skills.

Information processing theory. The information processing approach views the human brain as a computer that can process information. During this process, people learn from the environment, process and store the information in memory, and retrieve the information when being asked to. Similar to the computer, the human brain has limited capacity and processing speed, so just like a computer works better when it has more advanced systems or programs, the human brain can process information better when the brain and the sensory system become more developed and when people learn to use more advanced strategies (Driscoll, 2000).

Self-modification principle. The information processing theorists believe that children are active learners, and the learning process is a self-modifying process (Parke & Gauvain, 2009). Learning happens when children use knowledge and strategies that they have learned during working on previous problems to modify their responses to the current problem (Parke & Gauvain, 2009). In this way, children can make more sophisticated responses. In Wise and Olson's series of studies (1995, 1997, 1999, & 2000), when the student was typing in the syllable or the word that was pronounced by the computer, the computer would pronounce any pattern the student made, and by listening to the computer, and comparing the differences between what he or she made and the target, the student could make corrections. The student could also ask for feedback from the computer so he would know how to make corrections.

Multisensory strategies. Multisensory teaching was recommended by experts even before the 20th century (Moats & Farrell, 2005). It is believed that the memory is reinforced when learning occurs through multiple senses. A multisensory strategy uses two or more senses simultaneously, which may include visual, auditory, tactile-kinesthetic, and articulatory-motor (Moats & Farrell, 2005).

In 2004, a survey was conducted among 30 senior clinicians on which kind of multisensory strategies they usually used in teaching reading skills (Moats & Farrell, 2005). The results demonstrated that, for teaching phonology, auditory strategies were most commonly used. For example, the students listened to discriminate different sounds, and counted numbers of sounds when they heard the word. The next most commonly used multisensory strategies were kinesthetic and tactile. For example, students could feel the articulatory movements when they made the sound, feel the airflow, and tap out each sound in a word. The relatively less commonly used strategy was visual strategy, such as using a mirror to discriminate mouth positions, and only about 50% of the clinicians used it systematically. Wise and her colleagues conducted 4 studies (1995, 1997, 1999, & 2000) to successfully improve the PA skills of young struggling readers using the Lindamood Auditory Discrimination in Depth (ADD) program. Students were taught to associate the mouth movements with the labels, letters, sounds, and mouth pictures. They practiced using mouth pictures to represent changes in syllables in small group instruction and on the computer.

Other examples of using multisensory strategies included providing multi-sensory activities like auditory/visual matching, and then requiring students to provide motor responses (Macaruso et al., 2006); and utilizing a touch-screen, which allowed the student to touch the letter, syllable, word, or sentence to let the computer pronounce it (Mioduser et al., 2000).

Summary. These theories and principles of instructional design have been successfully used in different studies (See Table 5) to teach PA skills to young children with disabilities or who were at risk for reading difficulties. Usually more than one principle was used in one study to guide the instructional and technological design. These principles interacted with each other to reach the best intervention results. The current study incorporated these theories and principles to design the iPad application.

First, guided by the multisensory principle, in this study the researcher chose to use the iPad, so students heard the directions, looked at the pictures on the screen, and used their fingertips to operate the program. Second, using the principles of the cognitive theory of multimedia learning, the researcher provided history training to the participants (pretaining principle), the application read each word on the screen before giving directions (modality principle), and the pace of the intervention was individualized based on the performance of the participant (pacing principle). Third, influenced by the self-modification principle of the

Table 5

Design Principles and PA skills

Citation	Question	Participants	Procedures	Measures	Results	Principle(s) Used
Olson & Wise (1992)	Effects of targeting difficult words during reading to improve PA and phonological decoding	2nd -5th grade poor readers	Students read stories at their appropriate levels on the computer for about 30 minutes each day. When the student encountered a difficult word, he or she could use the mouse to click on the word to get assistance.	PA, phonological decoding, word recognition, comprehensi on, and spelling	Students in the experimental groups outperformed students in the control group. Their pre-test scores in PA were significantly associated with their gains in phonological decoding and word recognition.	Pretraining
Barker & Torgesen (1995)	Effects of Daisy Quest and Daisy' Castle on phonological awareness and word level reading	1st grade poor readers	Experimental group received training on phonological awareness using Daisy Quest and Daisy' Castle. The first control group received training on medial vowels using Hint and Hunt I. The second control group played math games on the computer.	PA, word and nonword reading	Experimental group significantly outperformed the control groups on all measures of Undersea Challenge, segmentation, and word identification	Modality, Contingencies of reinforcement
Wise & Olson (1995)	Effects of using CAI with the ADD method to improve	2nd -5th grade poor readers	The PA group received training on phonemic awareness skills with ADD method on the computer, read stories	Phonemic awareness, word reading, comprehensi	PA students outperformed CS students in phoneme awareness and non-word reading. Students	Modality, Self-explanation, Pacing, Self-modification,

	phonemic awareness		on ROSS with word assistance, practiced non-word reading and spelling on the computer. The CS group received training on comprehension strategies and then read stories on ROSS.	on, and spelling	with low PA scores at pretest made more gains in the PA condition.	Multisensory
Wise, Ring, Sessions, & Olson (1997)	Compared the effects of articulatory and nonarticulatory training of PA skills	2nd -5th grade poor readers	The experimental group was trained in PA skills using the articulatory method, and the control group was trained manipulating sounds.	PA, decoding, word recognition, articulatory awareness, spelling	Both groups made strong gains. The results slightly favor the nonarticulatroy group. Students with lower PA skills might need articulatory training more than students with higher PA skills.	Modality, Self-explanation, Pacing, Self-modification, Multisensory
Wise, Ring, & Olson (1999)	Compared the PA trainings with or without explicit attention to articulation and with or without manipulation of sounds.	2nd -5th grade poor readers	One group of students used the articulatory method, one group used the manipulation method, and one group used both methods.	Word recognition, PA skills, decoding, orthographic coding, spelling, comprehensi on, and arithmetic	All students made great gains. No dif. between combined condition and sound-manipulation condition. Sound-manipulation condition outperformed the articulation-only condition in both PA skills. The lowest and highest children performed equally well on all reading measures, whether or	Modality, Self-explanation, Pacing, Self-modification, Multisensory

					not they had had articulatory training.	
Mioduser, Tur-Kaspa, & Leitner (2000)	Compared the computer assisted instruction and teacher directed instruction in teaching early reading skills	Preschool children who were at risk for learning disabilities	The students in the experimental group used both the printed and the computer-based materials of the reading program "*I have a secret – I can read*".	PA	Students in the experimental group significantly outperformed the control groups in PA skills, word recognition, and letter naming.	Pacing, Multisensory
Wise, Ring, & Olson (2000)	The effects of PA training when students were reading with speech-assisted text	2^{nd} -5^{th} grade poor readers	Students in the control condition spent their small group time in learning comprehension strategies, and all their computer time on ROSS. Students in the experimental group spent their small group time in PA training using ADD, and half of their computer time on PA skills, and half on ROSS.	Naming speed, PA, decoding, word reading, spelling , comprehension	Students who began low PA skills benefited from the PA training. Students who began high benefited equally from the two conditions.	Modality, Self-explanation, Pacing, Self-modification, Multisensory
Mitchell & Fox (2001)	Effects of Daisy Quest and Daisy's Castle on PA skills of different grade levels, in comparison	At-risk Kindergarteners and 1^{st} grade students	Experimental group received CAI training on PA skills, the first control group received teacher-led PA instruction, and the second control group played math and	PA	CAI was as effective as teacher-led instruction and CAI was equally effective for the two grades.	Modality, Contingencies of reinforcement

	with teacher-led instruction		drawing games on computer.			
Macaruso, Hook, & McCabe (2006)	Effects of CAI on phonetic word-attack skills	First grade students	The experimental group received training on computers and the control group received regular instruction.	Phonics and simple word recognition	Both groups made significant gains. Title I students in the experimental group caught up with their regular peers after training.	Pacing, Multisensory
Macaruso & Walker (2008)	Effects of CAI on phonics	Kindergarten students	The experimental group received training on computers and the control group received regular instruction.	Phonics	Experimental group significantly outperformed the control group on PA skills. Low performers in the treatment group made more gains.	Pacing

information processing theory, whenever the student gave an incorrect response, after the prompt, the student was always given a second chance to answer the question.

CHAPTER 3

METHOD

Participants

Four young children between five and eight years old with disabilities participated in the study. They were all verbal, and were placed in collaborative classes. In their classrooms, they all had access to computers. According to their teachers, they had never been taught using an iPad, nor did they have experience with CTD procedures. The students were recommended by their teachers because improvement of PA skills was one of their current IEP goals. Written permission from the University of Georgia Institutional Review Board (IRB) for Research Involving Human Subjects, the county school district, and the student's parent or guardian was obtained before the start of the study.

Sarah was a five-year-old African American girl. She scored .81 standard deviation below the mean in intellectual functioning on the Learning Accomplishment Profile-Diagnostic (LAP-d; Hardin, Peisner-Feinberg, & Weeks, 2005), 1 standard deviation below the mean on Oral and Written Language Scale (OWLS; Carrow-Woolfolk, 1996), and 1 standard deviation below the mean on Clinical Evaluation of Language Fundamentals Preschool - 2 (CELF-Preschool-2; Semel, Wiig, & Secord, 2004). According to her teachers, Sarah played appropriately with toys in her class, interacted with her peers, and adapted well to new teachers. She could get frustrated easily and also had difficulty staying involved in an activity for a long time. She could count to 10, but she did not recognize any numerals from 1 to10. She did not recognize any letters of the alphabet except for "Y". Sarah was found eligible for special education services under the classification of significant developmental delay, and she was in a collaborative kindergarten class.

Zach was a six-year-old African American boy. Zach scored 2 standard deviation below the mean in the area of social emotional development and 1.5 standard deviation below the mean in fine motor skills according to the LAP-d. His performance on Georgia Kindergarten Inventory of Developing Skills (GKIDS) indicated that he was operating well below grade level in language arts, and he only mastered 3 out of 19 skills. Zach could recognize and name all the two-dimensional and three dimensional shapes. He could name the days of the week, the months of the year, and the four seasons. He could count up to 30 objects, and he knew positional terms. He could not name all the letters and sounds, and he had a difficult time blending sounds to make words and distinguishing between a letter, word, or sentence. Based on the interview of his teachers and observation, Zach had poor self-control. He had trouble paying attention in a large or a small group setting. Following directions was a primary concern. Zach often chose to not comply when directions were given. If the teacher redirected him to not talk, he often had to finish what he was saying or he would argue with the teacher. Zach received Special Education services under the category of significant developmental delays. He was repeating kindergarten in a collaborative class.

Lucy was an eight-year-old Caucasian girl. She has met criteria for 4 out of 19 kindergarten reading and writing goals in GKIDS from 2009-2010. Lucy wore glasses and hearing aids, and she had success wearing them. She exhibited voice and fluency skills within normal limits, and she produced most speech sounds correctly. Lucy loved to look at books and listen to stories, but she was reading well below grade level. She had trouble segmenting sounds in words, and she was highly distractible and often lost focus on the word she was trying to decode. Her teacher suggested that she needed a quiet place for one-on-one assistance in reading. Lucy has been diagnosed as having significant developmental delays in all domains and reading disabilities. She was placed in a collaborative 2nd grade class, and visited a separate class for speech and language services 45 minutes per week.

Evan was a five-year-old Caucasian boy. He did not have an IEP at the beginning of the study, but his teacher insisted that he would need the extra help. His IEP was developed during the first semester of kindergarten, and he was eligible for special education services under the category of specific learning disabilities. Assessments of intellectual skills revealed that Evan scored below the average range (IQ=86) on the Differential Abilities Scale-II (DAS-II; Elliott, 2007), and within the normal range (IQ=96) on Naglieri Nonverbal Ability Test, Second Edition (NNAT-2; Naglieri, 2007). According to his parents' report, his pediatrician also mentioned Dyslexia and a possibility Attention Deficit Hyperactivity Disorder. At the beginning of the study, Evan could count up to 23. He could write the first two letters in his name. He could identify most letters, and was just beginning to match sounds to letters. Evan had difficulty paying attention in large and small group activities. He was placed in a collaborative kindergarten class.

Prior to the intervention, students were given chance to play games using the iPad. The researcher observed the students and screened for the following prerequisite skills:

- Visual ability to see the pictures and words displayed on the iPad;
- The ability to hear the directions;
- The ability to verbally imitate target phonemes;
- The ability to follow a one-step direction;
- The ability to operate the iPad independently by touching the screen with index finger;

- The ability to wait for 5s;
- The ability to attend to a teacher-selected task for at least 10 minutes.

Based on the results of the observation and the consultation of the teachers, some of the prerequisite skills (i.e., waiting for 5s and operating an iPad) were taught during the history and wait training. Reinforcers were identified by interviewing the teachers and observing the students.

Two pre-intervention assessments were conducted to get a general profile of the students' cognitive and reading abilities. One was the Peabody Picture Vocabulary Test III (PPVT-III; Dunn & Dunn, 1997), and the other was Test of Early Reading Ability (TERA-3; Reid, Hresko & Hammill, 2001). Table 6 summarizes the students' characteristics and their performance on the pre-intervention tests.

Settings and Arrangements

The study was conducted throughout the 2011-2012 school year in a rural Title I primary school in a southeastern state of U.S. The school served 807 students from Pre-K to 2nd grade, of which, 1% were Asian, 5% were Hispanic, 31% were African American, and 60% were Caucasian. Two sessions were conducted every day, five days a week, and each session lasted for about 6 min. Most sessions were conducted in a 1:1 instructional arrangement in an empty resource room in the school. A few sessions were conducted in an unoccupied conference room when the resource room was in use. Distractions were kept to a minimum as much as possible.

The resource room was as big as a regular classroom (25 ft x 25 ft). It included a teacher's desk, two child-sized round tables, a kidney shaped table, several child-sized chairs, and bookshelves along the wall. The conference room was 16 ft x 10 ft in size. It included 4

Table 6

Students' Characteristics

Student	Age	Gender	Ethnicity	Placement	Eligibility Category	Others	PPVT III	TERA-3			
								Alphabet	Conventions	Meaning	Over all
Sarah	5-1	Female	African American	Collaborative Kindergarten	SDD	--	79	SS 7 Below Average	SS 6 Below Average	SS 9 Average	SS 83
Zach	6-3	Male	African American	Collaborative Kindergarten	SDD	Repeat K	93	SS 5 Poor	SS 5 Poor	SS 6 Below Average	SS 70
Lucy	8-8	Female	Caucasian	Collaborative 2nd grade & Separate class for speech	SDD & Reading disabilities	Hearing aid & glasses	71	SS 1 Very Poor	SS 2 Very Poor	SS 1 Very Poor	SS 43
Evan	5-8	Male	Caucasian	Collaborative Kindergarten	SLD	Hypera -ctive	79	SS 4 Poor	SS 5 Poor	SS 9 Average	SS 74

Note: SDD = Significant Developmental Delays, SLD = Specific Learning Disabilities, SS = Standard Score large tables in the middle and several adult-sized chairs around the tables. It also had a Smart Board and a white board on the wall, but those were not intended for the students to use.

The student was brought to the room by the researcher. In the resource room, the student was seated next to the round table at a corner which was not used by the resource room teacher. In the conference room, the student could choose any place to sit. During the intervention sessions, probes, and generalization across position probes, the student sat facing the iPad, which was located on a table, and the researcher sat beside the student to observe and to provide technical support if necessary. During the screening, pre-intervention assessments, and the generalization across mode probes, the student sat diagonally across the table from the researcher.

Materials and Equipment

Pre-intervention materials. During the pre-intervention assessments, the PPVT-III Kit and the TERA-3 Kit were used.

The Peabody Picture Vocabulary Test III – PPVT III. The PPVT-III is an individually administered norm-referenced assessment of receptive vocabulary of standard English, and it can be used to estimate the verbal intelligence of people from 2-6 to 90+ years of age. PPVT III takes 10-15 min to administer. It includes 17 sets, and with 12 items in each set. Before the start of test, training is conducted, and the student is required to correctly respond to at least two training words. During the assessment, no prompt or corrective feedback is given. The assessment ends when the student makes eight or more incorrect responses in one set.

The Test of Early Reading Ability – TERA-3. The TERA-3 is a norm-referenced assessment that measures the early developing reading skills of children from preschool to 2nd grade. It includes three subtests, which assess young children’s knowledge of alphabet and letter-sound correspondence, their familiarity with conventions of printed material, and their abilities to understand the meaning of print. The length of the session varies from 15 min to 45 min. There are no specific time limits. The student gets 1 point for each correct response and 0 points for incorrect or no response after 15s. The subtest continues until the student misses three items consecutively. Some verbal encouragements are given to the student during testing, but no comments about the accuracy can be delivered.

Screening materials. Target phonemes were selected using 5 in. × 8 in. index cards. The screening included 21 initial phonemes, and each phoneme was randomly presented three times. On each card, there were four pictures that were printed in color. The picture that started with the target phoneme was placed in the middle of the top row, and three choices were placed horizontally on the bottom row. The student was asked to point to one picture from the bottom row that started with the same target phoneme as the picture on the top row.

Wait and history training materials. During phase I, 5 in. × 8 in. index cards were used to teach students Chinese words. On each index card, the top row had a picture of an object, and there were three Chinese words listed horizontally on the bottom row. When the student could wait for 5s for the prompt, phase II started, and the iPad application "Santa's Helper" was introduced. This application was developed by the researcher. The student was asked to help Santa put different toys into different boxes. For example, Santa said, "This is a teddy bear. Which box should I use? Yellow box, red box, blue box." The student was expected to wait 5s for the researcher to tell him/her which box to point to.

Probe, intervention, and generalization across position materials. An interactive iPad application was developed by the researcher for the study. During the developing process, the researcher consulted with media experts, classroom teachers, and university professors to get their opinions regarding technical aspects and ease of use. Feedback was gathered and modifications were made accordingly. The iPad application was named “Touch Sound”. Major screen shots of the application are presented in Figure 1. 0-5s CTD procedures were embedded in the application.

On the screen, a picture of common object that started with the target phoneme was placed in the middle of the top row, and three choices were placed horizontally on the bottom row to help students follow along with task directions. The student was asked by the application to touch one choice that started with the same target phoneme as the picture on the top row. These pictures were imported from Google images.

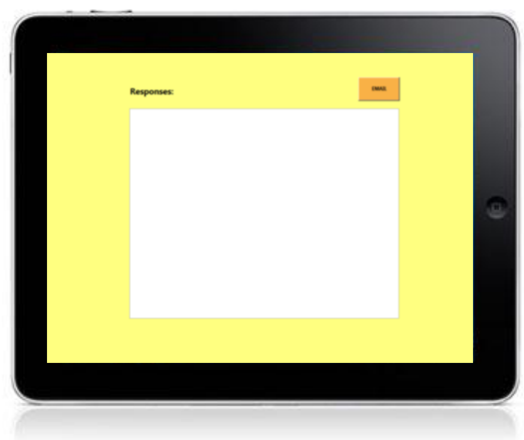
Materials for generalization across materials. During the generalization across materials sessions, each student was provided a pencil and an 8.5 in. x 5.5 in. worksheet. The worksheet contained 18 items, which were printed in color. Each target phoneme was randomly presented three times. For each item, on the first row was a picture that started with the target phoneme, and on the second row was three choices of pictures of words, one of which began with the same target phoneme. Each picture was named and the student was asked to circle the word that began with the same phoneme as the word on the first row.

Equipment. The equipment used to develop the intervention application was a MacBook. The software that was used to develop the intervention application is LiveCode®. LiveCode® uses natural programming language to develop applications, and allows the incorporation of sound, text, pictures, and videos. It is compatible with the iPad. The audio directions were recorded using Audacity 11.3 Beta with the MacBook built-in microphone. During the intervention sessions and probes, a 16 GB iPad 2 was used to present the tasks.

Title Screen

Direction Screen

End Screen



Data Screen

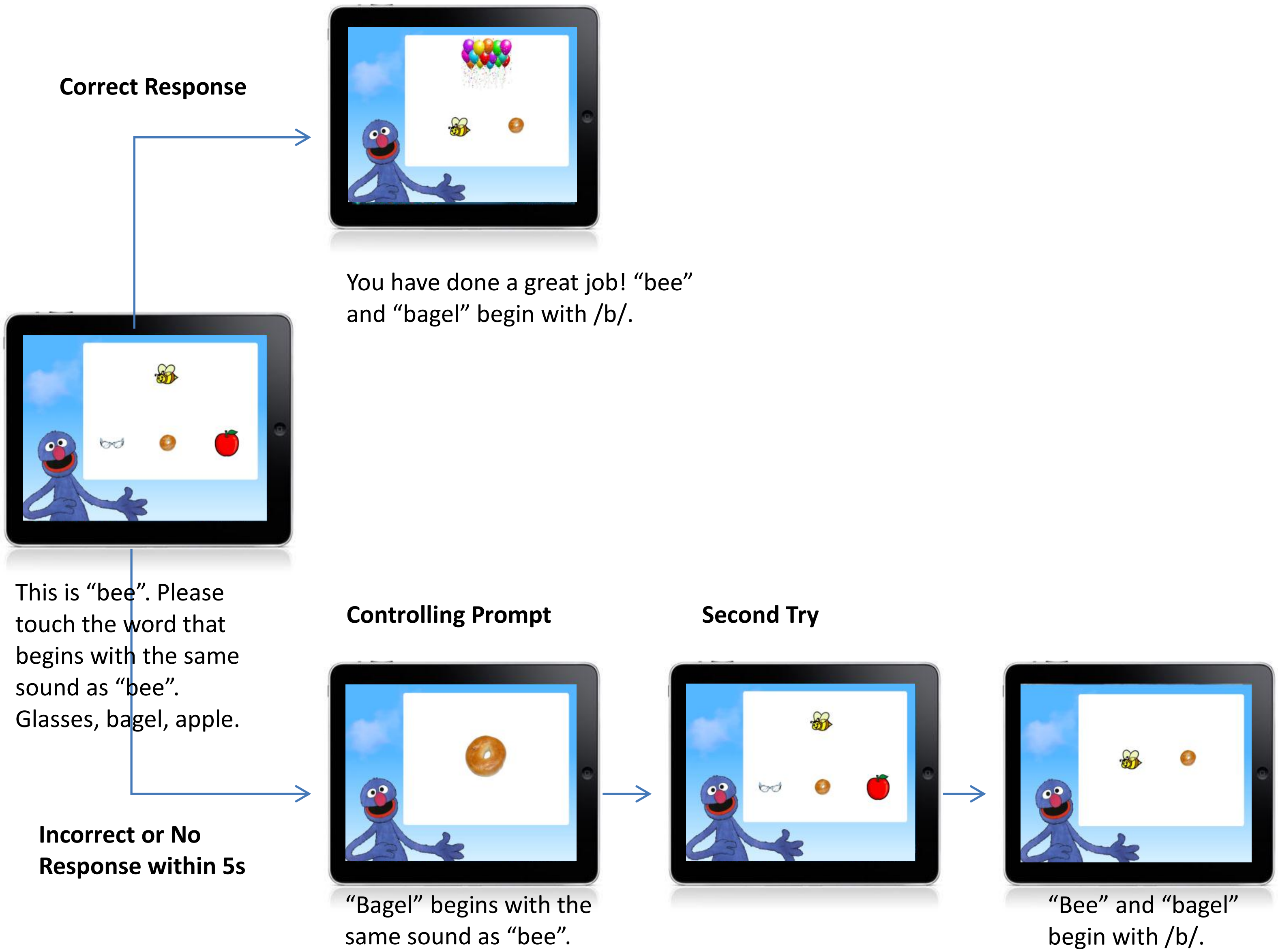


Figure 1. Major screens of the iPad application.

Response Definitions and Recording Procedures

The target behavior was defined as the student receptively touching the word that had the same initial phoneme as the given word. The dependent variable was the percent of unprompted correct receptive identification responses for the target phonemes for each session.

The intervention program involved 0-5s CTD procedures. Five potential responses were recorded during the intervention.

1) An unprompted correct was a correct response before the prompt, where the student touched the correct answer within 5s after the task direction was given, and before the prompt was shown. The student would receive a descriptive verbal praise from the iPad application for every unprompted correct.

2) An unprompted incorrect was defined as an incorrect response before the prompt. The incorrect response would lead the student to a prompt slide, in which only the correct answer was present. The correct answer would be read by the iPad application, and then the student would be redirected to the original question to have a second try.
3) A prompted correct was a correct response within 5s after the prompt was shown.
4) A prompted incorrect was an incorrect response within 5s after the prompt.
5) A no response error was recorded when the student did not touch any answer within 5s after the prompt.

When a prompted incorrect or a no response error occurred, the student was led to a new slide showing the original word and the correct answer. For example, the slide showed “cat” and “cup”, and a verbal prompt was given (e.g., “Cat” and “cup” begin with /k/.)

During the probes, probes for generalization, and maintenance, a correct response was recorded if the student chose the correct answer within 5s after the task direction. An incorrect response was recorded if the student chose an answer other than the correct answer within 5s after the task direction. A no response was recorded if the student did not choose any answer within 5s after the task direction. The student's responses were recorded automatically by the iPad application. Only unprompted correct responses were counted toward criterion.

Experimental Design

A multiple probe design across three sets of phonemes (Gast & Ledford, 2010) replicated with four students was used to evaluate the effectiveness of using an iPad application and 0-5s CTD procedures to teach PA skills to young children with disabilities. In order to evaluate the experiment control, intervention for the next set of target phonemes did not begin until the student had reached criterion on the previous set. The student's performance on each set of target phonemes improved only under the intervention condition, and remained at a stable baseline level before the student received intervention. The threats to internal validity (history and maturation) were controlled with the staggered introduction of intervention. The threats to instrumentation were controlled by collecting observer reliability data. The external validity was addressed by the replication of the results among the four students.

Experimental conditions were implemented in the following manner for each student: (1) pre-intervention assessment, (2) screening, (3) wait/history training, (4) generalization probe 1, (5) probe 1, (6) iPad intervention for set 1, (7) generalization probe 2, (8) probe 2, (9) iPad intervention for set 2, (10) generalization probe 3, (11) probe 3, (12) iPad intervention for set 3, (13) generalization probe 4, (14) probe 4, and (15) maintenance probe.

Data were collected and graphed daily. Decisions to maintain or change a condition were made according to the visual analysis guidelines (Gast & Spriggs, 2010). Within each condition, the trend, level, and length were analyzed. A split-middle method was used to determine the data trend. The level stability was determined if 80% of the data points fell within a 20% of range of median data point. Between two adjacent conditions, data were compared by changing in level and trend.

General Procedures

The study consisted of (1) a pre-intervention assessment condition, (2) a screening condition, (3) a wait/history training condition, (4) an iPad application with CTD procedures intervention condition, (5) a probe condition, (6) a generalization probe condition, and (7) a maintenance probe condition. All the sessions were conducted in a 1:1 instructional arrangement.

The pre-intervention assessments and screening were conducted before the study started. Wait/history training was provided before the intervention to teach the students prerequisite skills and to practice how to operate an iPad. During the intervention, two 6-trial sessions occurred each day, five days a week. The maximum length of each session was 6 min, with at least 30 min between the two sessions. The intervention for one set of target phonemes stopped when the student reached 100% correct responses for three consecutive sessions, and then the next set was introduced to the intervention. The probes and generalization probes were conducted before the intervention started, and when the student reached the criterion on each set. Maintenance data were collected after the intervention was completed.

Instructional Procedures

Pre-intervention assessment procedures. The purpose of this phase was to establish a general profile of the language and literacy performance of each student. The two assessments, PPVT III and TERA-3, were administered according to their examiner’s manuals after the student’s attention was secured by a general attentional cue (i.e., “Time to work”). Each student was tested individually on these two assessments.

Screening. Each student was tested on 21 initial phonemes written in 5 in.×8 in. index cards. After the student's attention was secured by a general attentional cue (i.e., "Time to work"), the researcher read the task direction (i.e., This is "bus". Please point to the picture that starts with the same sound as "bus". Bee, cup, watch.). The student was given 5s to respond. Correct responses were recorded when the student pointed to the correct picture of word or verbally stated the correct word within 5s after the ask direction. Incorrect responses were recorded when the student pointed to an incorrect picture of word, stated an incorrect word, or gave no response within 5s after the task direction. Each target phoneme was randomly presented three times in each session, with different words, for a total of 63 trials in each session. Each student was allowed to take two to three short breaks during each session, and they were allowed to play games on iPad during the breaks. Three sessions were conducted over three consecutive days. The target phonemes were defined as phonemes that a student made no more than 33.33% correct responses over three consecutive sessions. Six target phonemes were identified for each student. The identified target phonemes were divided into three sets based on difficulty. Because not all initial phonemes could also be used as the end sound, only three phonemes were identified for each student to be used for generalization across position probes. Table 7 shows the target phonemes and generalization across position phonemes for each student.

Wait/History training. There were two phases of this condition. During phase I, 5 in.×8 in. index cards were used to teach students Chinese words. The purpose of phase I was to teach the student to wait for 5s. After the researcher gained the student's attention by a general attentional cue, i.e. "It's time to work.", the researcher gave the direction, "We are going to learn some Chinese today. You do not know the answer, so you need to wait for me to tell you which word to point to." "This is orange. How do you say 'orange' in Chinese? Pingguo, xiangjiao,

Table 7

Target Phonemes for Instruction and Generalization across Positions

	Target Phonemes	Generalization across Position
Sarah	/b/, /k/, /f/, /g/, /l/, /m/	/k/, /l/, /f/
Zach	/k/, /dʒ/, /θ/, /p/, /l/, /z/	/k/, /l/, /p/
Lucy	/k/, /dʒ/, /g/, /t/, /l/, /p/	/k/, /l/, /p/
Evan	/k/, /p/, /l/, /m/, /t/, /w/	/k/, /l/, /p/

juzi.". During the 0s delay sessions, the researcher gave the prompt immediately by pointing to the correct answer and verbally stating the word, "Juzi". Then the researcher repeated the task direction, and the student was given 5s to respond. If the student pointed to the correct response or verbally repeated the correct response within 5s, he/she would receive descriptive social praise from the researcher, i.e., "Excellent!" "Great job!". If the student did not point to or verbally state the correct response within 5s, the researcher would physically guide him/her to point. The waiting time was gradually increased, and the criterion to add 1s was when the student made three consecutive prompted corrects in one session. If the student failed to wait for the prompt and made an unprompted incorrect, the researcher reminded the student, "Wait if you don't know, and I will tell you." There were 10 trials in each session, and one session was conducted each day. When the student made three consecutive prompted corrects after 5s the task direction was given in one session, training on phase II was started.

The purpose of phase II was to help the student become familiar with operating an iPad. The task analysis (TA) is presented in Table 8, and it is identical to the TA in the intervention condition. During phase II, students worked on the iPad application “Santa’s Helper”. After the student’s attention was secured by a general attention cue, i.e. “It’s time to work.”, the researcher put the iPad on the table in front of the student. On the screen, a smiling face was shown, and the student was asked to touch the smiling face to start. When the student touched the smiling face, the next screen appeared. On this screen Santa delivered the direction and asked the student to help him put toys into different boxes. For example, “This is a train. Which box should I use? Yellow box, red box, blue box.” The student needed to wait 5s for Santa to tell him/her which box to touch. If the student touched any box within the 5s, the application would say “Stop! You need to wait.” If the student made a prompted correct, he/she would receive a praise from Santa, i.e. “Great job!” If the student made a prompted incorrect, the application would show the correct answer. If the student did not touch any box after the prompt was given, the researcher would verbally prompt the student to touch the correct answer. There were five trials in a session, and two sessions were conducted each day. The wait/history training continued until the student could independently perform each step of the task analysis at 100% accuracy for three consecutive sessions. A sample data recording sheet is shown in Appendix D.

Probe procedures. A probe session was conducted with every student prior to the introduction of intervention, and following the session during which each student reached the predetermined criteria (i.e. 100% accuracy for three consecutive sessions) for one set of target phonemes. Each probe session consisted of 18 trials. The six phonemes for each student were intermixed and randomly presented three times with different words. At least three sessions were conducted over three days or until the data were stable.

Table 8

Task Analysis of the iPad Application Operation

Step	iPad Screen	Narration in the Program	Student's Behaviors
1	Title Screen	"Please touch the smiling face to start."	1. Look at the screen. 2. Touch the smiling face on the screen with index finger.
2	Direction Screen	"Ho! Ho! Ho! Ho! Christmas is coming. I need your help to sort some toys. You do not know which box to use, so please wait for me to tell you. Please touch the arrow when you are ready to work."	1. Listen to the direction. 2. Touch the arrow with index finger to start.
3-6	Presentation of the 4 items	"This is a teddy bear. Which box should I use? Yellow box, pink box, green box?" "I will use pink box."	1. Listen to the narration in the program. 2. Wait for the prompt. 3. Touch the picture with index finger.

Probes were delivered through the iPad application. At the beginning of the probe session, the researcher gained the student's attention by giving a general attentional cue (e.g., "Let's start to work."). When the student's attention was secured, the researcher presented the iPad in front of him/her, and loaded the application. The student touched the smiling face to start the probe. During the probe, on each screen the student saw one item (i.e., the picture of a word that begins with the target phoneme) and three choices. The iPad application read the four words and the task direction (e.g., "This is bee. Please touch the word begins with the same sound as bee. Cat, bagel, flower."). The student was given 5s to respond. General verbal praise was given by the iPad application for each correct response. If the student responded incorrectly or did not respond during the 5s, he or she would be shown the next phoneme. The inter-trial interval was

2s. No prompts were provided during the probes. The student's responses were automatically recorded by the iPad application.

Generalization assessment procedures. Generalization assessments were conducted individually before the intervention started and every time after the student reached the criterion on one set of target phonemes. Generalization assessments evaluated if the student could generalize the skills across materials, and if students could correctly isolate these trained phonemes when they appeared at the end position in words.

Generalization across materials. During the generalization across materials assessment, a general attention cue was given (e.g. "It's time to work."), and then the student was given a worksheet and a pencil. The worksheet was printed in color on a piece of 8.5 in. x 5.5 in. white paper. The six target initial phonemes were randomly presented three times with different words on the worksheet. For each item, the first row was a picture of a word that began with the target phoneme, and the second row was three pictures of words placed horizontally. The researcher read each word, and asked the student to circle the picture of the word on the second row that started with the same sound as the given word on the first row. The student was given 5s to respond. A general verbal praise was delivered for each correct response. An incorrect response or no response was ignored. The inter-trial interval was 2s. The total length of each generalization assessment was no more than 15 min. At the end of the probe, the student received a general verbal praise (e.g., "Good job!") from the researcher for attending. No prompts were provided during the probes. A sample worksheet is shown in Appendix E.

Generalization across positions. The procedures to evaluate the transfer of the target behavior across positions were the same as the probes. Words that contain the target phonemes as their final phonemes were selected. Instead of isolating the initial phonemes, the student was asked to isolate the final phonemes. Each session consisted of nine trials, and each phoneme was randomly presented three times with different words. At the beginning of a session, the researcher gained the student's attention, and loaded the iPad program for him/her. The presentation of the task was the same as the probes, and the student was asked to select a picture of a word at the bottom row of the screen that had the same final sound as the word given at the top row of the screen. The student was given 5s to respond. The inter-trial interval was 2s. No prompts were provided during the probes. A correct response was reinforced using a general verbal praise delivered by the application (e.g., Excellent!). An incorrect response or no response within 5s was ignored, and the student was lead to the next item. At the end of the probe, the student received a general verbal praise for attending. The student's responses were recorded by the iPad application.

Intervention procedures. At the beginning of each intervention session, the researcher briefly introduced the expectations for the student (i.e., touch the correct answer after the task direction, and wait for a prompt if he/she does not know the answer). Then the researcher gave a general attentional cue (e.g., "Let's start."), and loaded the application on iPad. The application asked the student to touch the smiling face when he/she was ready to work. By touching the smiling face on the screen, the student's attention was obtained, and he/she was led to the direction page. On the direction page, a cartoon character stated the task expectation, and presented the student an example. After that, the cartoon character asked the student to touch the arrow button to start the instruction.

The first screen contained four pictures of words, with one picture of a word that started with the target phoneme placed at the top row and three pictures of words placed horizontally at the bottom row (i.e., a word that started with the same target phoneme as the word on the top row, and two distractors that were common objects for the student to recognize). Different words that begin with the target phonemes and different pictures that depict the words were used from trial to trial to facilitate generalization. The iPad application read the task direction. For example, “This is kite. Please touch the word that begins with the same sound as kite. kitchen, bee, ice.” During the 0s delay sessions, the application immediately showed the controlling prompt, on which only the correct answer was presented, and the application said, for example, “kitchen begins with the same sound as kite.” The third screen was the same as the first screen, and the student was asked to have a second try. The student received a general verbal praise at the end of each session. The student was moved from 0s delay sessions to 5s delay sessions when he/she reached 100% prompted corrects in one session.

Subsequent sessions were conducted using 5s delay until the student reached the criterion of 100% unprompted corrects over three consecutive sessions. After the application delivered the task direction, the student was given 5s to respond before the prompt was provided. Every correct response before the prompt led the student to a new screen, on which the pictures of the two words that began with the same target phonemes were presented, and a descriptive verbal praise was given (e.g., “Nice job! Cat and cup begin with /k/.”). An incorrect response or no response before the prompt resulted in the prompt screen. On the prompt screen, only the picture of the correct answer was shown, and the application said, for example “Cat begins with the same sound as cup.” After that the student was redirected to the original screen to answer the question again. An incorrect response or no response after the prompt led the student to the prompt screen again, and at the same time, a verbal prompt was delivered by the application (e.g. “Cat and cup begin with /k/.”).

The iPad application recorded each student's performance automatically. Each instructional session included six trials, three trials for each target phoneme. The student received two intervention sessions every day. Five different sessions were developed for each set of target phonemes, and the student never had the same session over two consecutive days. Throughout the intervention, the researcher sat beside the student to observe, and did not provide any additional help except technical assistance. At the end of each intervention session, the student was allowed to play games on the iPad for 10 min as a reinforcer.

Maintenance assessment procedures. Maintenance data were collected four weeks and seven weeks after the intervention. The maintenance assessments were delivered through the iPad application. The format and procedures were identical to the probe sessions.

Reliability

Twenty-five percent of sessions across intervention, probe, and generalization across position sessions, were planned to be videotaped for collecting the reliability data, with at least one collection in each condition for all students. Two graduate students were trained to be observers. The training sessions for the two observers were conducted at the researcher's office or home separately. At first, the observer explored with the intervention and probes on the iPad. Then the researcher explained the response definitions and consequences (See Appendix F) to the observer. Finally, the researcher and the observer watched several video tapes together and coded separately. The data from the researcher and those from the observer were compared, and the training session was finished until the researcher and the observer reached 100% agreement.

The inter-observer reliability was calculated by the point-by-point method in which the number of agreement is divided by the number of agreement plus disagreement, multiplied by 100 (Cooper, Heron, & Heward, 2007). The procedural reliability data were collected on the operation of the intervention program. It was collected simultaneously with the dependent variable reliability. The procedural reliability was calculated by dividing the number of correct behaviors performed by the number of planned behaviors, multiplied by 100 (Billingsley, White, & Munson, 1980). Criterion for continuation of the program was 90% agreement on each behavior.

Social Validity

Social validity data were collected using a questionnaire format to evaluate the teachers' opinions on the intervention after the intervention was completed. Some open-ended questions were developed. The questionnaire is presented in Appendix G. Students were also interviewed informally during and after the intervention to learn their perceptions.

CHAPTER 4

RESULTS

The purpose of this study was to evaluate the effectiveness of using an iPad application with 0-5s CTD procedures to teach young children with disabilities to receptively identify initial phonemes. At the same time, the researcher wanted to find out if the target skills would be generalized across materials, if the skills would be generalized across positions (i.e., when they became the end phonemes), and if the skills would be maintained after the intervention was completed. The findings add to the existent literature on teaching PA skills to young children with disabilities, using CTD procedures in computer-assisted academic instruction, and incorporating tablet computers within daily instruction. The results of each student's performance on the target skills are discussed below. Efficiency data are calculated. The reliability data and social validity are reported.

Reliability

Inter-observer reliability data on the dependent measure and procedural fidelity data were collected simultaneously for 31% of all sessions across probe, intervention, and generalization across position sessions for the four students. Procedural fidelity was collected on the researcher's behaviors and iPad application functions. Elements assessed included if the student's attention was secured, if the task direction was presented, if the student was given 5s to respond, and if correct prompt or praise was delivered. Table 9 presents the detailed results. The overall inter-observer agreement (IOA) equaled 100% across all the sessions collected and across all four students. The mean procedural fidelity was 97.8%, with a range from 92% to 100%.

Table 9

Reliability Data

	Probe			Intervention			Generalization across Position			Total		
	% of sessions collected	IOA	Procedure Fidelity	% of sessions collected	IOA	Procedure Fidelity	% of sessions collected	IOA	Procedure Fidelity	% of sessions collected	IOA	Procedure Fidelity
S	38%	100%	100%	23%	100%	100%	50%	100%	96%	36%	100%	98.7%
Z	27%	100%	97.5%	27%	100%	98%	25%	100%	100%	26%	100%	98.3%
L	33%	100%	100%	28%	100%	100%	25%	100%	100%	29%	100%	100%
E	40%	100%	97%	27%	100%	93%	25%	100%	92%	31%	100%	94%
Total	34.5%	100%	98.6%	26.3%	100%	97.8%	31.3%	100%	97%	31%	100%	97.8%

The major errors occurred when the researcher prompted the student during the sessions to gain their attention.

Research Questions and Data Analysis

Research question #1. The first research question evaluated the effects of using the iPad application with 0-5s CTD procedures to teach young children with disabilities to receptively isolate initial target phonemes. The intervention was introduced in a staggered manner when the student reached criterion on the previous set of target phonemes. Each student's performance remained at a stable or decelerating trend before the introduction of the intervention, and improved after the iPad application was introduced. Direct intra-subject and inter-subject replications were obtained. Figures 2 to 5 present data on the mean percentage of correct responses of each student across three sets of target phonemes under the probe and intervention conditions. The percentage of prompted corrects is represented by open triangles (△) and the percentage of unprompted corrects is represented by closed diamonds (♦).

Sarah. Sarah reached the criterion for all sets after the introduction of intervention. Her performance is depicted in Figure 2. She demonstrated a mean percent of correct responses of 28.47% before intervention, which was under the chance level (i.e., 33.33%). Visual analysis reveals a change in level and an accelerating trend after the introduction of intervention. Sarah spent 22, 15, and 18 instructional sessions to reach criterion for sets 1, 2, and 3, respectively. The mean percentage of correct was 89.35% during the post-intervention probes.

Zach. Zach learned all his target phonemes after the intervention. Figure 3 presents his performance on the target phonemes during the probe and intervention sessions. Probe data before intervention indicate an average of 35.1% accuracy (ranging from 25% to 41.67) on

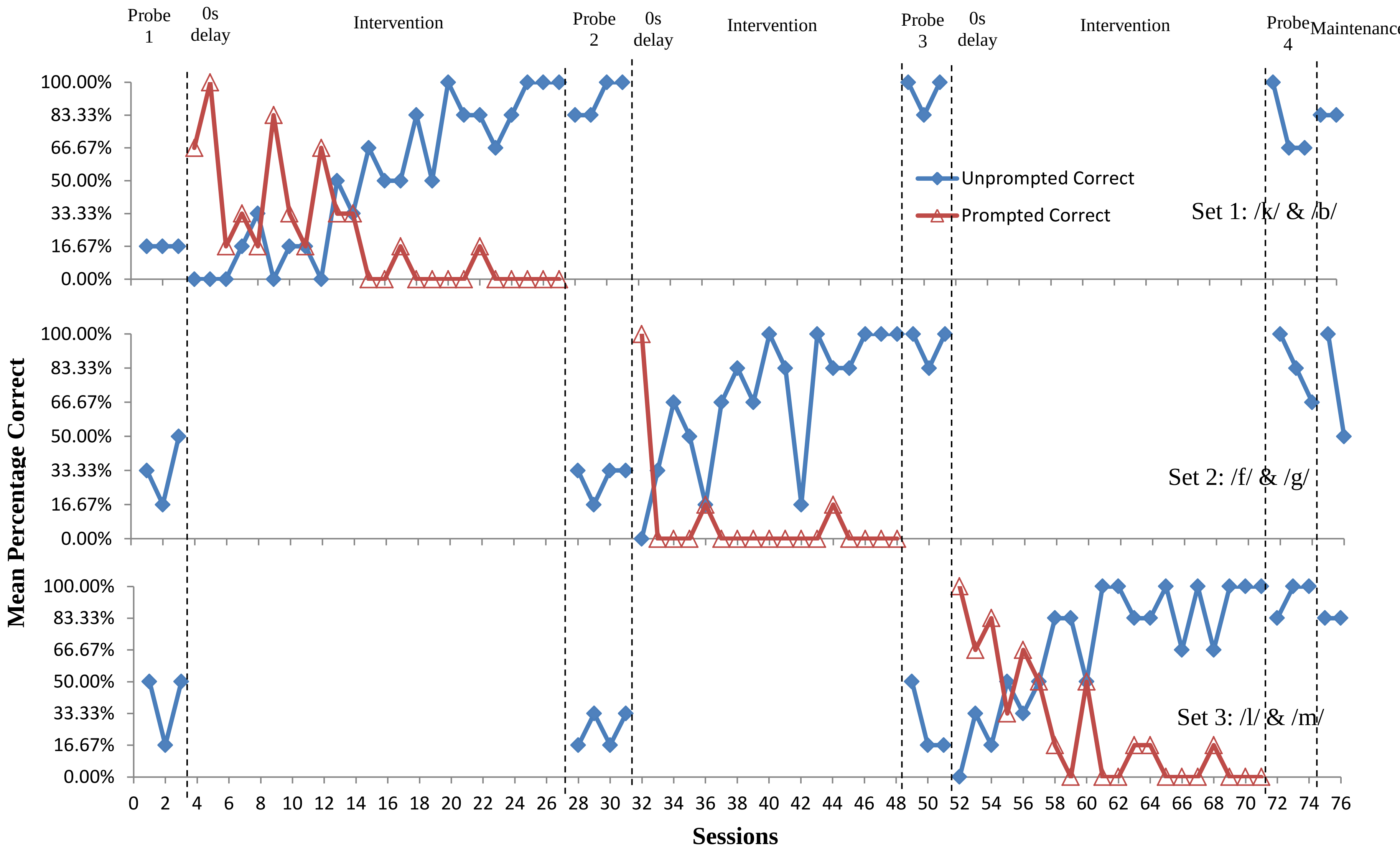


Figure 2. Mean percentage of correct for Sarah.

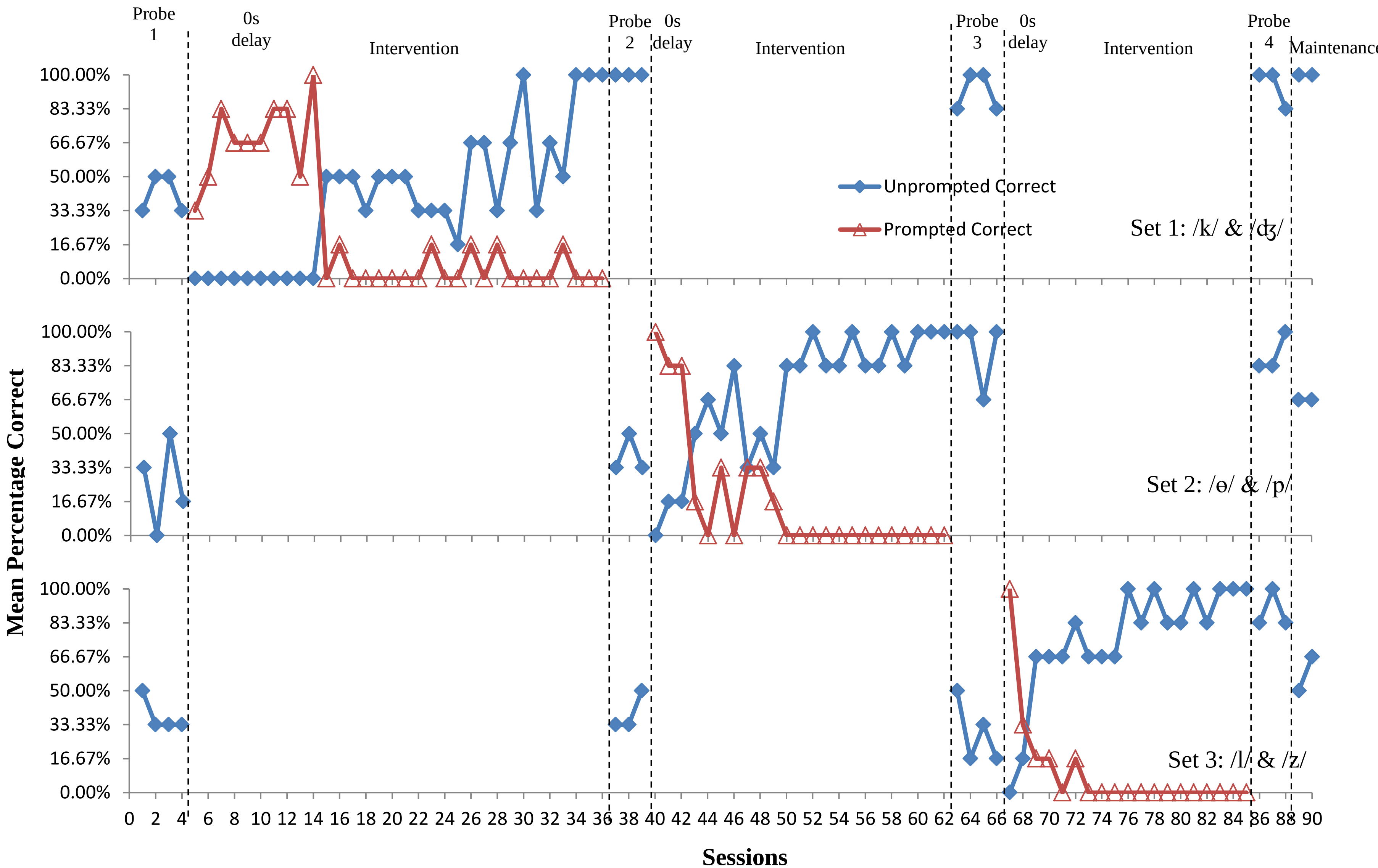


Figure 3. Mean percentage of correct for Zach.

untaught phonemes. This number was above the chance level which meant Zach knew some of the target phonemes before intervention. However, he had never had 100% accuracy on any of the target phonemes before intervention.

At the beginning of the intervention, Zach was not responsive to the intervention at all. It took him 10 sessions to get 100% prompted correct during the 0s delay sessions. His performance had remained at the low baseline level for 11 sessions after he was moved to 5s delay sessions. He sat on the chair, but he just randomly touched a picture of choice after the task direction was delivered without paying attention. The researcher discussed Zach's situation with his teacher, and his teacher mentioned he had the same attention issues in class.

Beginning with session 26, the researcher modified the research procedures to improve Zach's attention on task. Instead of letting Zach play games on the iPad when he finished a session, the researcher asked him to rate if he had paid attention during the intervention after he finished a session, and he only could play games if the researcher and Zach both agreed he had been focused on the task. Zach's performance improved dramatically after the implementation of the attention management system, and he reached the criterion for set 1 after 9 sessions. The attention management system was removed from session 42 when attention was no longer a problem for Zach.

For sets 2 and 3, it took Zach 21 and 17 sessions to reach the criterion, respectively. Visual analysis shows a change in level with an accelerating trend across all three sets of target phonemes. The mean percentage of correct responses increased to 92.52% for post-intervention probes.

Lucy. Pre-intervention data revealed an average of 36.13% accuracy (ranging from 22.22% to 55.56%) for untaught phonemes. Like Zach, Lucy correctly identified some of the target phonemes before intervention, but she also had never reached 100% accuracy for any single phoneme. Figure 4 displays Lucy's data. After the introduction of intervention, Lucy's performance on the target phonemes demonstrated a change of level, and the trend was changed from decelerating or zero celeration to accelerating. Lucy reached to the criterion in 24, 19, and 19 sessions for sets 1, 2, and 3, respectively. The mean percentage of correct responses was 93.54% in probes after the intervention.

Evan. Evan's data, shown in Figure 5, demonstrate a positive change in the percentage of correct responses with the introduction of the intervention. Though the mean percentage of correct responses was 35.24% during pre-intervention probes, he had never reached 100% accuracy for any phoneme before intervention. The introduction of the iPad application resulted in a change of level, and an accelerating trend in the percentage of correct responses. Evan's performance was not consistent in that he exhibited some noncompliant behaviors during the intervention. He would say things like, "I do not want to do the same one." or "I only do one session today." The researcher discussed the situation with his teacher, and his teacher insisted he needed to continue the intervention, and suggested if he behaved well during intervention, he could get an extra treat when he came back to class. Once this procedure was in place in session 15, the number of his noncompliant behaviors dramatically decreased, and his performance with the application improved. Evan spent 22, 30, and 17 sessions to get to the criterion for sets 1, 2, and 3, respectively. His average correct responses improved to 89.81% during the post-intervention probes.

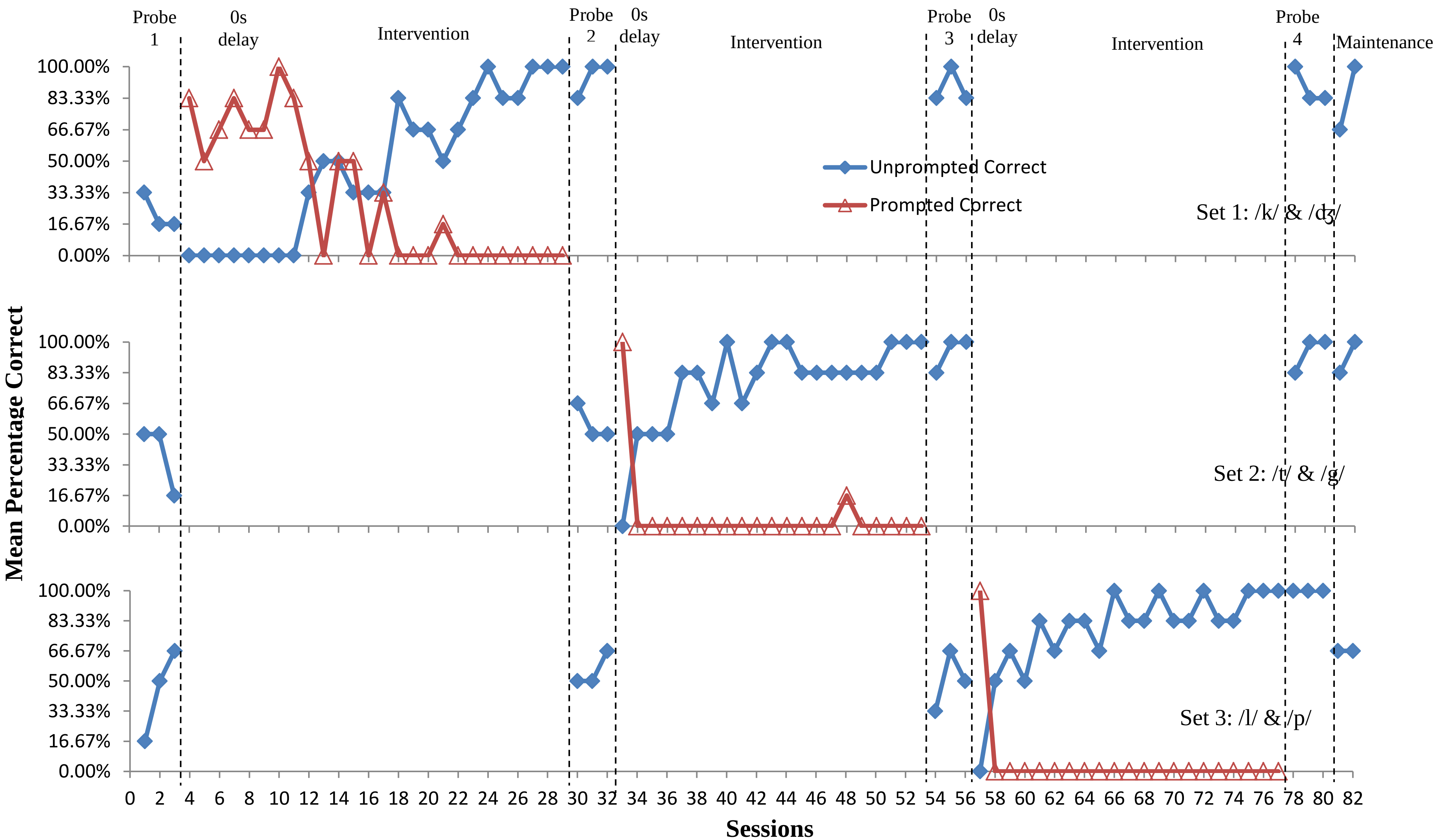


Figure 4. Mean percentage of correct for Lucy.

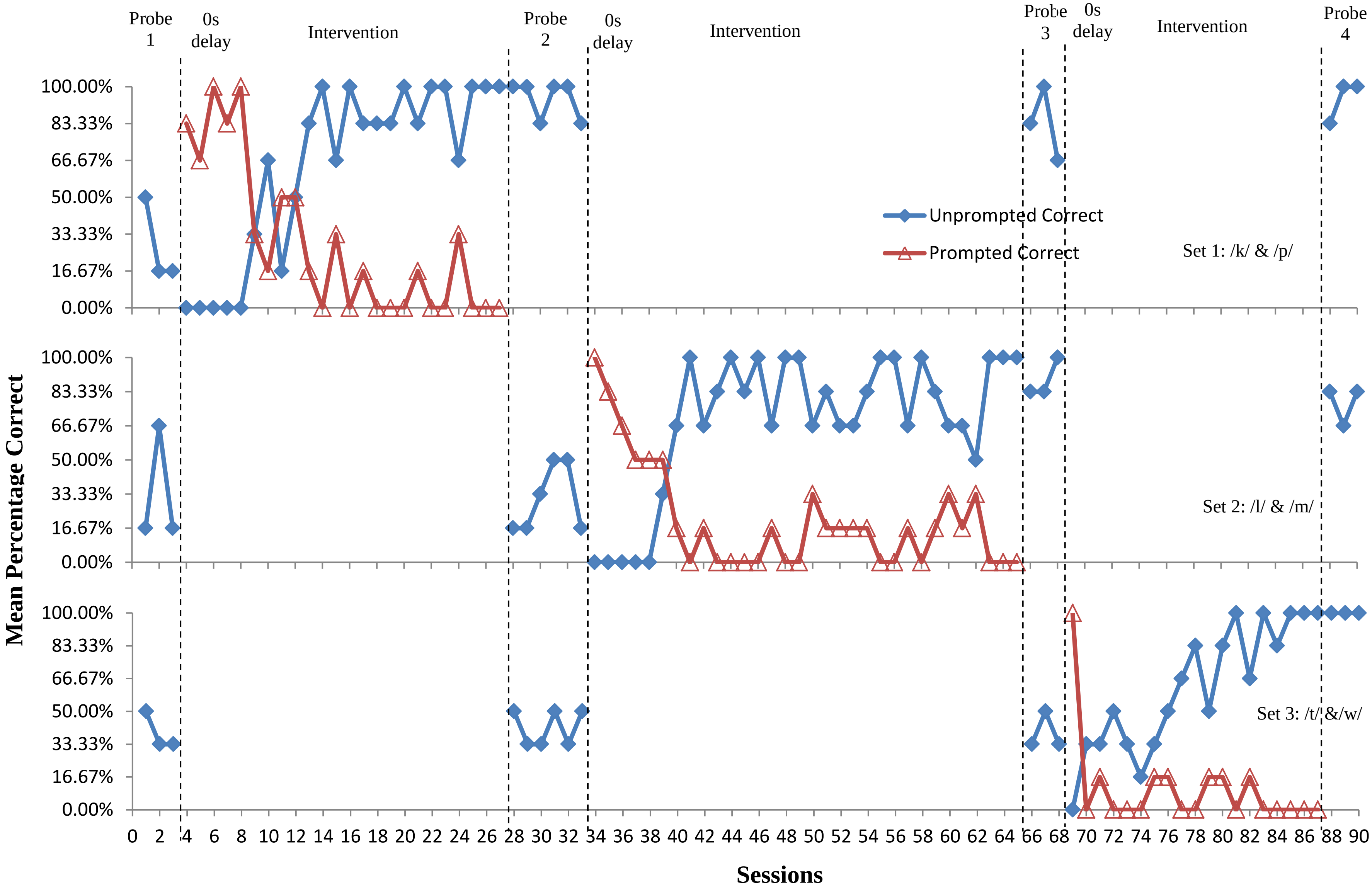


Figure 5. Mean percentage of correct for Evan.

Research question #2.

Generalization across materials. The students were evaluated to determine whether they would generalize the target behaviors when the task was delivered using paper and pencil. Table 10 summarizes the percentage of correct responses of the receptive identification of initial target phonemes when the task was presented on a worksheet. The results suggest that all four students improved their performance after the intervention was completed. Sarah generalized the skills across materials with 100% accuracy on sets 1 and 3 and with 83.33% accuracy on set 2. Zach

Table 10

Mean Percent Correct of Generalization across Materials

Student	Set	Probe 1	Probe 2	Probe 3	Probe 4
Sarah	1	50	**100**	**83.33**	**100**
	2	33.33	50	**66.67**	**83.33**
	3	33.33	33.33	33.33	**100**
Zach	1	0	**66.67**	**100**	**83.33**
	2	0	16.67	**83.33**	**100**
	3	0	33.33	0	**100**
Lucy	1	0	**66.67**	**83.33**	**83.33**
	2	16.67	33.33	**66.67**	**83.33**
	3	16.67	33.33	16.67	**100**
Evan	1	16.67	**66.67**	**83.33**	**83.33**
	2	16.67	33.33	**83.33**	**100**
	3	33.33	50	33.33	**100**

Note: Data in bold were collected after the intervention.

and Evan showed 100% correct responses on sets 2 and 3, and 83.33% correct responses on set 1. Lucy demonstrated 100% accuracy on set 3, and 83.33% accuracy on sets 1 and 2.

Generalization across positions. The researcher examined whether the students could generalize the target behaviors across positions. Specifically, the researcher wanted to know if the student could receptively identify the target phonemes when they appeared at the end of the words. Table 11 presents the data on the mean percentage of correct responses. Zach was the only student who showed progress in all three target phonemes. He got 100% accuracy on target phoneme /k/ after intervention, and his performance on target phonemes /l/ and /p/ improved from 0% to 33%. Sarah showed improvement on only one target phoneme /p/, and the other target phonemes remained at a low level of accuracy. Evan maintained at the same low level of accuracy after intervention for two target phonemes (i.e., /k/ & /p/), and for the other one (/l/), his performance decreased from 33% to 0%. Lucy was the student who regressed most. She performed at 100% accuracy level on /k/ and at 67% accuracy on /l/ before intervention. However, after intervention, the accuracy level dropped to 33% and 0%, respectively. Her performance on /p/ remained at 0% accuracy.

Research question #3. Maintenance data were collected four and seven weeks after the intervention was ended for three of the four students. Evan completed the intervention towards the end of the school year, so there was no time to conduct maintenance probes for him. Figures 2-4 also include data for Sarah, Zach and Lucy's performance during the maintenance probe sessions.

Sarah. Sarah's performance on set 2 remained at 100% accuracy level, and her performance on set 1 and 3 decreased to 83.33% accuracy level at the 4-week follow-up session. During the 7-week follow-up session, her performance on sets 1 and 3 maintained at the 83.33% accuracy level. However, her performance of set 2 dropped to 50% accuracy level.

Table 11

Mean Percent Correct of Generalization across Positions

Student	Target Phoneme	Gen. Probe 1	Gen. Probe 2	Gen. Probe 3	Gen. Probe 4
Sarah	/k/	0	**33**	**33**	**0**
	/l/	33	67	**100**	**33**
	/f/	0	33	0	**33**
Zach	/k/	33	**67**	**67**	**100**
	/l/	0	33	**33**	**33**
	/p/	0	67	33	**33**
Lucy	/k/	100	**67**	**67**	**33**
	/l/	67	0	**33**	**0**
	/p/	0	33	0	**0**
Evan	/k/	67	**33**	**67**	**67**
	/l/	33	33	**33**	**0**
	/p/	33	67	33	**33**

Note: Data in bold were collected after the intervention.

Zach. Zach's performance on set 1 maintained at 100% accuracy level during 4-week and 7-week follow-up sessions. However, his performance on set 2 decreased to 66.67% accuracy level at both 4-week and 7-week follow-up sessions. His performance on set 3 was only at 50% accuracy level at 4-week follow-up session, and was at 66.67% accuracy level at the 7-week follow-up session.

Lucy. During the 4-week maintenance probe, Lucy' performance on all three sets of target phonemes decreased, with an accuracy of 50%, 66.67% and 66.67%, respectively. During the 7-week maintenance probe, her performance of accuracy in sets 1 and 2 increased to 83.33%, and her performance on set 3 remained at 66.67% accuracy.

Efficiency Data

Efficiency of intervention was evaluated via the number of instructional sessions to criterion for each set of target phonemes. Table 12 summarizes the efficiency data. The total instructional sessions needed to reach criterion for all three sets of target phonemes ranged from 61 sessions to 69 sessions. The number of sessions to criterion for each set of target phonemes ranged from 17 sessions to 30 sessions. All students reached criterion quicker with set 3 than with set 1. The length of each instructional session ranged from 3m 58s to 5m 09s, so the total instructional time for each student to master all three sets of target phonemes was about five hours.

Table 12

A Summary of Efficiency Data

Student	Set	# of Sessions to Criterion
Sarah	1	24
	2	17
	3	20
	Total	61
	Mean	20.33
Zach	1	30
	2	21
	3	17
	Total	68
	Mean	22.67
Lucy	1	24
	2	19
	3	19
	Total	62
	Mean	20.67
Evan	1	22
	2	30
	3	17
	Total	69
	Mean	23

Social Validity

Social validity was evaluated through a teacher-completed questionnaire and informal interview of the students. The social validity questionnaire contained five questions that were related to the teachers' opinions on the goals, outcomes, inclusion of iPad, and suggestions for future studies. Teachers who worked directly with the students on a daily basis completed the questionnaire at the conclusion of the intervention. The data were analyzed using content analysis. The findings indicated that all three teachers (Two students had the same teacher.) believed that it was a developmentally appropriate goal for their students, the students became more confident in reading related activities, and the students became more focused during learning activities in class. The teachers also reported that they would like to incorporate the iPad application into their daily activities to assist students in learning initial sounds. They suggested that they could use it as a center activity.

The informal interview of students revealed all four students enjoyed using the iPad application. Lucy said she liked to work on the iPad application because the cartoon character would tell her the answer. Sarah indicated the work on the iPad application had taught her to find two words that started with the same sounds, and helped her when she went back to her classroom. Evan said it was a fun game. All students were really motivated because they knew that they could play games on the iPad when they finished a session.

CHAPTER 5

DISCUSSION

A multiple probe design across three sets of target phonemes replicated with four students was used to determine the effects of using an iPad application to teach young children with disabilities to receptively identify initial phonemes. The iPad application, which incorporated 0-5s CTD procedures, was designed and developed by the researcher based on the students' needs. During the intervention, students worked on the iPad and the percentage of unprompted receptive correct identification of initial phonemes was recorded. The results indicated that students with disabilities could benefit from the intervention, and most of the skills were generalized and somewhat maintained after intervention.

This chapter provides an overview of the results, followed by how the study will expand the existing literature on using CTD procedures within CAI to teach PA skills to young children with disabilities. The chapter concludes with a discussion of the limitations of the current research and recommendations for future research in related areas.

Discussion Related to Research Questions

Question #1. All four students improved their performance on target phonemes using the iPad application. Prior to the intervention, they all demonstrated low levels and stability in the mean percentage of correct responses. After the intervention, they had all reached 100% correct responses for all three sets of target phonemes. However, there were some issues that need to be discussed. First, although all four students completed the wait/history training, and at the beginning of each instructional session the researcher reminded them to wait for the prompt if they did not know the answer, Lucy and Zach still took 7 and 10 sessions, respectively, to reach the criterion of 100% prompted corrects during the 0s delay sessions for set 1. The possible reason might be because the two students did not really understand CTD procedures at the beginning, and they needed some time to figure it out by themselves. Both Lucy and Zach reached 100% prompted correct during 0s delay sessions for sets 2 and 3 with only one session.

Second, the visual analysis of data reveals that the students' improvement on the target phonemes was not consistent. For example, Zach reached 100% unprompted correct in session 30 during set 1 intervention, but his performance decreased to 33.33% accuracy in session 31. Similar situations happened with Sarah, Lucy and Evan as well. One reason might be because the students were inattentive. For example, Evan's noncompliant behaviors from time to time affected his performance. An alternative might be because the difficulty level of the words used in different sessions varied. There were five similar applications developed for each set of target phonemes, and completely different words were used in the five applications to foster generalization. Some words might be more familiar to the students compared to others, for example, "library" may have been a more familiar word than "lobster" to the students. Some words were also phonologically easier than other words. For example, "dog" was an easier word compared to "dinosaur".

Third, the students made a lot of unprompted incorrect responses during the instruction. Lucy and Zach seldom waited for the prompt during sets 2 and 3 instruction. They were the two oldest students, and they had been exposed to PA skills longer than the other two students. One possible reason might be that they were confident about their performance, so they believed that they knew the answer. The other possible reason might be that 5s was too long for them to wait.

Through observation, the researcher noticed that Zach was rushing to finish so he could play games.

In conclusion, though problems existed, all four students demonstrated an increase in level and an accelerating trend after the introduction of the iPad application. The findings are consistent with existing literature: students with disabilities can improve their PA skills with the appropriate training; computer-assisted instruction can help them learn the PA skills; and CTD procedures can be successfully embedded within computer-assisted academic instruction.

Question #2. The second question examined whether the skills learned through the iPad application were generalized across materials and across positions. The findings indicate that all four students demonstrated improvement in the generalization across materials probes, with 100% accuracy on most sets of target phonemes after intervention. However, the results of the generalization across positions probes were mixed. Zach was the only student who demonstrated improvement after instruction. Sarah and Evan’s performance were inconsistent. Lucy showed a decelerating trend in her performance. This finding is not surprising because identifying initial sounds is a completely different skill compared to identifying end sounds. Previous studies also have demonstrated that the discrimination of consonants in the end position is a more difficult task than the discrimination of consonants in the onset position (Kochetov, 2004; Redford & Diehl, 1999). Thus, training on one kind of PA skills would not automatically lead to improvement on another kind (O’Connor et. al., 1993).

Question #3. The third question evaluated whether the skills learned would be maintained four and seven weeks after the intervention was finished. Due to the limitation of time, data were collected on only three of the four students (i.e., Sarah, Zach, and Lucy). The results were inconsistent. The findings indicated that during the 4-week follow-up probe, Sarah’s performance was largely maintained, with the accuracy level on all three sets of target phonemes at or above 83.33%; Zach only maintained his performance on set 1 at 100% correct responses, and his performance on sets 2 and 3 decreased to 66.67% and 50%, respectively. Lucy's performance decreased to 66.67%, 83.33%, and 66.67%, on sets 1, 2, and 3, respectively. During the 7-week follow-up probe, Sarah maintained her performance on sets 1 and 3, but her performance on set 2 decreased to 50% correct responses. Zach's performance maintained for sets 1 and 2, and his performance on set 3 increased to 66.67%. Lucy's performance on set 3 remained at 66.67% accuracy level, and she increased her accuracy level on sets 1 and 2 to 100%. The improvement on the second follow-up probe might be because they received instruction on the target phonemes in class during the three weeks between the two maintenance probes, or because they did not pay attention to the task at the first follow-up probe.

Relationships to Existing Literature

The results of this study indicate a positive change of all students' performance on the trained target phonemes, and the skills were generalized across materials. Though the results on generalization across positions and maintenance were mixed, this current study extends existing literature on PA training for young children with disabilities, computer-assisted PA instruction, and the use of CTD procedures in computer-assisted academic instruction.

First, three of the students in the study (i.e., Sarah, Zach, and Lucy) were eligible for special education services under the category of significant developmental delays, and they were below the average in intellectual functioning. They all improved their PA skills after the intervention. The results of the three students add to the limited literature that investigates the effectiveness of PA intervention for young children with significant developmental delays.

Second, most of the existing studies related to using CAI to teach PA skills used a group pretest-posttest experimental design. For students with disabilities, a group design is not sensitive enough to detect individual differences. This investigation used a single subject multiple probe design, in which each student served as his/her own control, and his/her performance before intervention was compared to the performance after intervention (Gast & Ledford, 2010).

Third, in the review of the current literature, there were only three studies which used CTD procedures in computer-assisted academic instruction for young children with disabilities. The current investigation expands the literature by embedding 0-5s CTD procedures in the iPad application.

Limitations of the Research

There are several limitations in this study. First, the intervention was conducted in a conference room or an unoccupied resource room. Neither of them were the students' natural environment. In the natural environment, for example, in the classroom, the students seldom got the one-on-one attention, so one cannot assume the intervention would be effective in the natural classroom environment with typical distractors.

Second, the researcher tried to include only common words during the intervention. However, it was not an easy task to find different words that started with the same phoneme and also had a picture, and the researcher failed to screen the selected words before the intervention. As a result, some uncommon words or more phonologically difficult words were used in the iPad application. This may have caused the inconsistent performance of the students from session to session. In the future, researchers should evaluate the familiarity and difficulty level of each word before the development of the iPad application.

Third, at the beginning of the intervention, after the researcher had identified the target phonemes for each student, a letter was sent to their teachers asking them not to provide direct instruction on these target phonemes. However, it was impossible to eliminate their learning opportunities on these phonemes in class or at home completely. Thus, the internal validity of the study may be weakened.

Fourth, the study only involved four students. Even though they all have mastered their target phonemes, the external validity was limited. More studies are needed to be conducted with students of different characteristics to strengthen the external validity.

Fifth, the researcher did not have any contact with any of the students before the intervention, and only met them during the intervention. It took a while for the students to get familiar with the researcher, and to feel comfortable working with her. This might explain why there was a learning curve after the introduction of the intervention, especially for set 1 of their target phonemes.

Sixth, during the intervention, Lucy wore her hearing aid every day at the beginning of the study, but she stopped wearing it later due to ear infection. The researcher could not get more information about when she started to wear hearing aid, how it helped her, and how it affected her understanding of phonemes. With this information, the researcher might be able to better interpret Lucy's performance. In addition, though Evan maintained his performance on sets 1 and 2 during probe 4, the results of the study would be strengthened if the researcher had the time to collect his maintenance data after the intervention was completed.

Finally, this study heavily relied on technology, and the teachers were interested in using the application in their own classes. However, at the current stage, it is impossible for each student to get his/her own iPad. Thus, some students who may benefit from the intervention may not get the supports needed due to the limited access of technology.

Recommendations for Future Research

The results of this study supported the use of an iPad application with 0-5s CTD procedures to teach students with disabilities to receptively identify initial phonemes. However, it is difficult to determine the effects of using the iPad application for instruction with only one study. Future studies are needed to evaluate the use of the iPad application with different populations.

In the current study, the students failed to generalize the skills across positions because the discrimination of the end phoneme is a more difficult task. It will be interesting to see if students will generalize the skills to phonemes at onset position when they are trained to identify end sounds using a similar iPad application.

During the intervention, the students were exposed to a large amount of vocabulary in a relatively short period of time. Future studies can be conducted with English language learners to examine how many words they will gain besides learning the target phonemes.

One of the concerns of parents and teachers about young children using technology is that they are learning in front of the computer, and they will not have opportunities to develop their social skills. Research has shown that collaborative use of computers can facilitate social interactions between young children, like sharing and turn-taking (Fitzpatrick and Hardman 2000; Muller and Perlmutter 1985). Future studies can incorporate peer-tutoring with the use of the iPad application, and record the interactions between the students.

In the current study, Zach and Lucy could not wait patiently for 5s for a prompt. If the application can address students' individual needs, and allow the researcher to select the time delay intervals based in the students' needs, the results might be better.

The current investigation did not evaluate the effects of PA training on early reading development. Future research should include this piece, and evaluate the students' reading skills right after the intervention, and one year after the intervention to see if the students really learn and maintain the skills.

Finally, iPad is a new piece of technology. Students in the current study were very excited to work on the iPad. Being able to play games on iPad after intervention was a great motivation for them. Future research could examine the effects of motivation on learning when using iPad for instruction.

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Appendix A

Morgan County Primary School Approval Form

MORGAN COUNTY PRIMARY SCHOOL

993 East Avenue ◆ Madison, GA 30650 ◆ Phone: 706-342-3475 ◆ Fax: 706-342-9184

"Together, we will learn."

Zhen Chai
The University of Georgia
College of Education
Department of Communication Sciences and Special Education
516 Aderhold Hall
Athens, GA 30602-7153
July 14, 2011

Dear Zhen Chai,

Your request to conduct research in MCPS, as part of your doctoral degree program requirements at The University of Georgia, has been reviewed. Specifically, consideration was given to the description of your research project, project population, instructional interventions, evaluation instruments, and your plans for submission of the final report to the university.

It is my understanding that you will collect data from students to evaluate the effectiveness of using an iPad application with a constant time delay procedure to teach phonological awareness skills to young children with mild to moderate intellectual disabilities or developmental delays in the area of cognition. Please note that all information obtained from students must be completely anonymous and must not be identifiable by individual or by school. Pseudonyms must be used in all written reports.

After considering all of the aforementioned information, it appears that your research request meets the requirements of Morgan County Board of Education policy, Solicitation of Information JKA. Therefore, I approve your request to conduct the research in MCPS as described in your proposal. I hope your research project goes well, and that the information you obtain will be beneficial to you and to our students.

Sincerely yours,

Betsy Sh

Dr. Betsy T. Short
Principal

cc: Dr. Ralph Bennett, Superintendent

Accredited by the Southern Association of Colleges and Schools
Website: www.morgan.k12.ga.us/mcps

Appendix B

Parental Permission Form

PARENTAL PERMISSION FORM

I agree to allow my child, ____________________, to take part in a research study titled, "Using iPad to Teach Phonological Awareness Skills to Young Children with Mild to Moderate Intellectual Disabilities," which is being conducted by Ms. Zhen Chai, from the Department of Communication Sciences and Special Education at the University of Georgia under the direction of Dr. Cynthia Vail. My child's participation is voluntary which means I do not have to allow my child to be in this study if I do not want to. My child can refuse to participate or stop taking part at any time without giving any reason, and without penalty or loss of benefits to which she/he is otherwise entitled. I can ask to have the information that can be identified as my child's returned to me, removed from the research records, or destroyed.

- The reason for the study is to find out if using iPad helps young children learn phonological awareness skills.

- Children who take part may improve their phonological awareness skills. The researcher also hopes to learn something that may help other children learn reading better in the future.

- If I allow my child to take part, my child will be asked to isolate some initial letter sounds on an iPad while the researcher watches. The researcher will ask my child to do these activities once a day for 20 minutes, five days a week for about three to four weeks. This activity will take place during free study time and will not interfere with daily classroom instruction. If I do not want my child to take part then she/he will be allowed to study as usual.

- The research is not expected to cause any harm or discomfort. My child can quit at any time. My child's grade will not be affected if my child decides not to participate or to stop taking part.

- Any individually-identifiable information collected about my child will be kept confidential unless otherwise required by law. My child's identity will be coded, and all data will be kept in a secured location.

- The researcher will answer any questions about the research now, or during the course of the project, and can be reached by telephone at 706.206.2429 or email at zhench@uga.edu. I may also contact the professor supervising the research, Dr. Cynthia Vail, at 706.540.7403 or cvail@uga.edu.

- I understand the study procedures described above. My questions have been answered to my satisfaction, and I agree to allow my child to take part in this study. I have been given a copy of this form to keep.

_______________	_______________	_______
Name of Researcher	Signature	Date
_______________	_______________	_______
Name of Parent	Signature	Date

University of Georgia
Institutional Review Board
Approved: 7-29-11
Expires 7-28-12

Please sign both copies, keep one and return one to the researcher.

Additional questions or problems regarding your child's rights as a research participant should be addressed to The Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center,
Athens, Georgia 30602; Telephone (706) 542-3199; E-Mail irb@uga.edu.

Appendix C

Child Assent Form

Child Assent Script/Form

I want to see if you would be willing to help us with a research project about using iPad to learn letter sounds. You will work on the iPad, and answer the questions that the iPad asks. I just want to know if iPad can help children learn letter sounds.

If you decide to do the project with me, your answers will be kept just between you and me. I may not be able to keep this promise if you tell me that you or another child is being hurt in some way, or if a judge asks me for some information. If that were happening, I would tell someone to help keep you or the other child safe. If you do not like to work on the iPad any more, you can also decide to stop at any time.

Do you have any questions? Would you be willing to do the project with us?

University of Georgia
Institutional Review Board
Approved: 7-29-11
Expires 7-28-12

Appendix D

Data Collection Sheet for History Training

Student: ___________________________ Date: _______________________

Trial	Step	Task Analysis	Session 1		Session 2	
1	1	Look at the screen.	I	P	I	P
	2	Touch the smiling face on the screen with index finger.	I	P	I	P
	3	Listen to the direction.	I	P	I	P
	4	Touch the arrow with index finger to start.	I	P	I	P
	5	Listen to the narration in the program.	I	P	I	P
	6	Wait for the prompt.	I	P	I	P
	7	Touch the picture with index finger.	I	P	I	P
2	5	Listen to the narration in the program.	I	P	I	P
	6	Wait for the prompt.	I	P	I	P
	7	Touch the picture with index finger.	I	P	I	P
3	5	Listen to the narration in the program.	I	P	I	P
	6	Wait for the prompt.	I	P	I	P
	7	Touch the picture with index finger.	I	P	I	P
4	5	Listen to the narration in the program.	I	P	I	P
	6	Wait for the prompt.	I	P	I	P
	7	Touch the picture with index finger.	I	P	I	P
5	5	Listen to the narration in the program.	I	P	I	P
	6	Wait for the prompt.	I	P	I	P
	7	Touch the picture with index finger.	I	P	I	P

** I = Independent
P= Prompted

Appendix E

Data Collection Form for Gen. across Materials

Student name: Date:

Appendix F

Response Definitions and Consequences in the iPad Application

Behavior	Definition	Consequences during Instruction	Consequences during Probe
unprompted correct	correct response before the prompt, so the student touches the correct answer after the task direction but before the prompt is shown.	Student will receive a descriptive verbal praise for every unprompted correct, and then will be shown the next item.	Student will receive a descriptive verbal praise for every unprompted correct, and then will be shown the next item.
unprompted incorrect	incorrect response before the prompt	Student will be shown the prompt page, in which only the correct answer will be present. The correct answer will be read by the iPad, and then the student will be redirected to the original question to have a second try.	Student will be shown the next item.
prompted correct	correct response within 5s after the prompt is shown	Student will be lead to the end page, which shows the two words that begin with the same sound.	________________
prompted incorrect	an incorrect response within 5s after the prompt	Student will be lead to the end page, which shows the two words that begin with the same sound.	________________
no response error	Student does not point to any answer within 5s after the prompt.	Student will be lead to the end page, which shows the two words that begin with the same sound.	________________

Appendix G

Social Validity Questionnaire

1. What do you think about the goals of the intervention?

2. If this application becomes available, how might you incorporate it into your instructional practices?

3. Please describe any changes in the student's ability to identify initial phonemes that may be attributed to this intervention.

4. Please describe any other ways that the student benefitted from this intervention.

5. What do you suggest to modify the current intervention in the future?