EFFICACY OF COMPUTER-ASSISTED INSTRUCTION WITH CROSS-AGE PEER MEDIATED TUTORING FOR DEVELOPING PHONEME AWARENESS IN CHILDREN AT-RISK FOR READING DISABILITIES

by

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Abstract

Previous research has demonstrated that instruction in phoneme awareness, computer-assisted instruction and cross-age peer tutoring can all effective methods for teaching phoneme awareness to struggling readers. This study investigated the efficacy of computer-assisted instruction in phonological awareness and cross-age peer tutoring (CAIPT) in improving phonological awareness of primary grade students at-risk for reading disabilities. Eighty-seven children ranging in age from 65 to 119 months (M = 89.45; SD = 11.7) were assigned using a stratified random procedure to one of two conditions: (1) cross-age peer tutoring in combination with computer-assisted phonological awareness instruction (CAIPT); and (2) phonological awareness instruction (PAI). Tutees and tutors in the CAIPT groups were age matched to pairs of children in the PAI control groups. Children in the two CAIPT groups were poor readers (i.e., standard scores ≤ 80 on the Letter-Word Identification subtest on the Woodcock Johnson Achievement Battery – Third Edition). The treatment groups received 20 minutes of CAIPT instruction five times a week for 3 weeks. The control groups participated in 20 minutes of phonological awareness and literacy activities taught daily for 3 weeks. Quantitative and qualitative analyses were conducted in order to compare the performance of the CAIPT treatment and PAI control groups on phonological processing. Profile analyses demonstrated that the phonological processing performance for the CAIPT treatment and PAI control groups had identical parallel and flat profiles. Qualitative analyses of the data revealed that CAIPT fosters collaboration and communication between learners by providing an interactive and entertaining environment for learners.

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Chapter 1
Introduction

Learning to read an alphabetic script is a complex process based on incidental learning and formal acquisition of abilities and skills (Mioduser, Tur-Kaspa, & Leitner, 2000). English speaking children who are learning to read utilize their awareness of English phonemes and their knowledge of English orthography to decode text (Jorm & Share, 1983; Siegel, 1993; Stanovich, 1988; Wagner & Torgesen, 1987). Phoneme awareness and orthographic knowledge are critical components of the reading process in beginning readers (Adams, 1990; Rack, Snowling & Olson, 1992; Vellutino, 1991). Phoneme awareness (PA) refers here to a child's understanding that spoken words consist of phonemes and that phonemes can be manipulated to make new words. A substantial body of research has demonstrated that young children's performance on phonological tasks is a good predictor of decoding and word recognition abilities (Adams, 1990; Bradley & Bryant, 1983; Stanovich, 1986, 1988, 1991; Stanovich & Siegel, 1994; Sulzby, 1983; Wagner & Torgesen, 1987). Moreover, studies also show that older children with reading disabilities have a deficit in some aspect of phonological processing (Stanovich & Siegel, 1994; Torgesen & Wagner, 1998) and that training in phoneme awareness and orthographic knowledge improves phoneme awareness, word recognition and reading comprehension of both good and poor readers (see Bus & van Ijzendoorn, 1999; Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh, & Shanahan, 2001 for reviews).

Findings from a meta-analysis of reading intervention research conducted by the National Reading Panel in the United States (Ehri et al., 2001) suggest that the magnitude of treatment effects on measures of phoneme awareness are greater when instruction is provided in small groups (n = 2-7, ES = 1.38), compared to one-to-one tutoring (ES = 0.60) or classroom instruction (ES = 0.67). Similarly, treatment effects on measures of word recognition are, on average greater, when PA instruction is presented in small groups (n = 2-7, ES = 0.81) compared to one-to-one tutoring (ES = 0.45) and classroom instruction (ES = 0.35). These findings suggest that small group instruction (i.e., from two to seven students) effectively increases overall reading ability of children with reading disabilities.

Another important finding from the National Reading Panel meta-analysis is that PA can be effectively taught by classroom teachers. However, when planning PA instruction, teachers need to assess the phonological abilities of children in their classrooms and tailor instruction to meet children's specific needs. This recommendation, although sound in nature, presents a challenge for teachers in classrooms where children's learning needs are diverse and when children's phonological abilities are varied.

One way that teachers are encouraged by administrators and consultants in school districts to meet this diversity in instructional needs of students is by incorporating the use of computers to individualize instruction. The Government of Canada facilitates the implementation of school programs such as SchoolNet (http://www.schoolnet.ca/) and Community Access Point (http://cap.ic.gc.ca/) that provide students with access to computers, Internet, computer support and training. According to Networked Canada, a recent document published by Statistics Canada (1999), the ratio of computers to students in classrooms is 1: 9 for elementary grade students, 1: 8 for intermediate grade students and 1:7 for secondary grade students. Studies show that computer-assisted instruction (CAI) is an effective means of increasing the phoneme awareness of children at-risk for reading disabilities (Blok, Oostdam, Otter, & Overmaat, 2002). Whether CAI can be effectively delivered in small groups is unclear.

CAI is individualized, interactive, and guided in its nature (Steinberg, 1991). *Individualized* refers to the ability of the computer to tailor the instruction towards the individual's specific learning needs. *Interactive* refers to the notion that the flow of information is transmitted from the computer to the student. Three levels of CAI, based on the interaction between the student and the computer, are: drill and practice, tutorial, and dialogue. CAI is *guided in nature* because a computer presents learning material in graduated steps, based on the accuracy of student's response. Behaviourist principles of repetition, sequencing, and reinforcement are used in CAI. Expected performance is calculated from student responses and the conditions under which these responses occur. Student actual performance is also monitored by the computer.

In a review of forty-two studies of CAI and reading outcomes, Blok et al. (2002) report that CAI improves phonological awareness, word recognition, and oral reading fluency of young, beginning readers who speak English as a first language (ES = 0.50). Studies show that CAI results in gains in phonological awareness and word recognition skills for normally developing readers (e.g. Barron, Golden, Seldon, Tait, Marmurek, & Haines, 1992; Foster, Erickson, Foster, Brinkman, & Torgesen, 1994; Reitsma & Wesseling, 1998) and for children who are at-risk for reading disabilities (e.g. Barker &

Torgesen, 1995; Kerstholt, Van Bor, & Schreuder, 1994; Mitchell & Fox, 2001; Wise, Ring, & Olson, 1999). Moreover, studies also show that CAI improves the acquisition of specific orthographic knowledge and decoding skills (Roth & Beck, 1987; Wise, Olson, & Ring, 1998, 2000) and reading speed and accuracy (Jones, Torgesen, & Sexton, 1987) of developing readers. CAI to improve reading skills is effective primarily because student progress is individually paced and students are provided with speech feedback to help them identify words in isolation and in connected text (Van Daal & Reitsma, 1993, 2000; Wise & Olson, 1995, 1998; Wise et al., 2000). Although research has clearly demonstrated that CAI is an effective means for providing PA instruction, whether groups of children of varying age benefit from CAI in PA to the same degree is unclear. To date, few studies have investigated the role of age on the treatment efficacy of CAI in PA for children at risk for reading disabilities. In the present study, this issue is addressed by investigating the response of primary grade children of varying age to CAI in PA.

A related issue concerns whether CAI in PA, designed for individualized instruction, is also effective in a peer-tutoring context. Studies show that cross age peer mediated tutoring in small groups (n = 2-6) improves children's reading skills (Elbaum, Vaughn, Hughes, & Moody, 2000; Mathes & Fuchs, 1994). Cross-age mediated peer tutoring involves direct instruction; academic stimuli are presented to a younger child by an older child and immediate feedback, in the form of praise or correction, is provided (Maheady, Harper, & Malette, 1991). Cross-age peer tutors have been used successfully in a variety of settings to improve academic achievement of school-aged children of varying age (Chun & Winter, 1999; Nugent, 2001; Simmons, 1995) and ability (Fuchs, Fuchs, Mathes, & Simmons, 1997; Fuchs, Fuchs, Mathes, & Martinez, 2002). Moreover, cross-age peer tutoring increases both tutor and tutee achievement across domains, i.e. reading, math, computer literacy (Bierne-Smith, 1991; Cohen, Kulik, & Kulik, 1982; East, 1976; Sassi, 1990; Wasik & Slavin, 1993). Children with reading disabilities benefit from instruction when they tutor younger students and when they are tutored by older, more able students (Juel, 1991; Nugent, 2001; Schneider & Barone, 1997; Taylor, Hanson, Justice-Swanson, & Watts, 1997). Reading performance of students who participate in peer mediated tutoring improves (Barbetta, Miller, Peters, Heron, & Cochran, 1991; Topping & Ehly, 1998) as well as student attitudes towards school, self-worth, and social standing (Franka, Kerr, Reitz, & Lambert, 1990; Trapani & Gettinger, 1989). Wetzel (1999) suggests that when tutors send frequent and repeated messages to their tutees about the significance of academic achievement, the tutored students are more likely to internalize these values and follow positive academic goals.

Studies of computer technology in a classroom environment show that two students working together on one computer express enjoyment from this collaborative process (e.g. Sandholtz, Ringstaff, & Dwyer, 1997; Tierney, 1996; Tsoneva & Lazarova, 1988). Other direct benefits of CAI are increased sharing of information and critical thinking among students in a classroom (Sandholtz, et al., 1997). Scott, Mandryk, and Inkpen (2003) report that when a shared computer display is used during CAI, children engage in collaborative behaviour similar to that observed when children interact during paper-based activities. However, whether CAI in PA promotes and maintains collaborative behaviour among children at-risk for reading disabilities is less clear.

In summary, research shows that instruction in phoneme awareness, computer-assisted instruction and cross-age peer tutoring are all effective methods for teaching phoneme awareness to struggling readers. It seems reasonable to predict, therefore, that a combination of computer-assisted instruction in phonological awareness and cross-age peer tutoring (CAIPT) is an effective instructional approach to improve the reading performance of children at-risk for reading disabilities. Whether CAIPT can improve the reading ability of children at-risk for reading disabilities to within age- or classroom-level expectations is far less certain. The primary goal of this study is to investigate whether CAIPT instruction is effective for a sample of children at-risk for reading disabilities in the primary grades (K-3).

Purposes

This study has three purposes.

1. To examine whether participation in computer-assisted instruction with cross-age peer mediated tutoring improves the phonological processing of primary grade children at-risk for reading disabilities.
2. To examine whether participation in computer-assisted instruction with cross-age peer mediated tutoring improves the phonological processing of primary grade children at-risk for reading disabilities to within age-level expectations.
3. To examine whether computer-assisted instruction with cross-age peer mediated tutoring is a socially valid method of providing instruction to improve phonological processing among primary grade children at-risk for reading disabilities.

To conclude, the study of efficacy of CAIPT to support the learning of at-risk readers requires further investigation. The goal of this study is to examine whether cross age peer tutoring contributes to the efficacy of computer assisted instruction to improve phoneme awareness and orthographic knowledge of young, primary grade children at-risk for developing reading disabilities.

Chapter 2
Literature Review

This study uses the framework of a socio-cultural perspective based on the ideas of Vygotsky and Galperin, situated learning theory, and cognitive apprenticeship theory. These provide a rationale to understand the collaborative process of cognitive, social, and emotional interchange between participants in the shared act of learning. Three domains of research are important to this study – early reading development, effectiveness of one-to-one tutoring, and effectiveness of computer-assisted instruction. The study reported here investigates if cross-age mediated peer tutoring in combination with computer-assisted instruction in phonological awareness will be an effective instructional method for elementary grade students. This review of literature is divided into three sections. In part A, the theoretical framework for the present study is reviewed. In part B, the research framework is reviewed. In part C, the research basis of the software program that compliments phonological awareness instruction and is used in this study is reviewed.

Part A: Theoretical Framework

The rationale for using tutors in computer-assisted training in phonological awareness is supported by the principles of socio-cultural theory, mental actions theory, situated learning theory, and cognitive apprenticeship theory.

Socio-Cultural Theory

Socio-cultural theory, originating from the work of Vygotsky, stipulates that cognitive development is a product of social interactions with the people in the individual's world and the tools provided by the culture that support an individual's thinking (Vygotsky, 1978). Vygotsky suggests that all individual's cognitive functions are first experienced in an interpsychological plane before they are appropriated on an intrapsychological plane (Crook, 1994). Learning on the interpsychological plane involves different supports which students receive to aid their learning from more culturally knowledgeable and experienced people, such as teachers, experts, and peers (McLoughlin, 1999). This process is known as *scaffolding* (Bruner, 1975). Knowledge is considered to be mutually constructed between the student and more skilled peers or adults involved in the process of cognitive change (Newman, Griffin, & Cole, 1989). Hence, meaning is constructed as a joint activity rather than simply being transmitted. Since this process is mediated by historically and culturally based concepts and content knowledge, learning is inherently social (Bakhtin, 1981) and language is the primary tool for "learning, meaning construction, and cultural transmission and transformation" (Lee & Smagorinsky, 2000, p. 2). In order to understand higher cognitive development, it is necessary to understand the existing interrelationships between thoughts and language.

An essential component of socio-cultural theory is what Vygotsky referred to as the *zone of proximal development*. The zone of proximal development is the distance between the individual's capacity to solve problems on his/her own and the individual's capacity to solve problems in collaboration with more advanced individuals. Therefore, an individual's learning capacity is not predetermined; it is a constantly changing range of opportunities reliant on the individual's previous knowledge, the nature of the task to be learned, the structure of the learning activity and lastly the quality of the interpersonal interactions between the student and the more advanced individual (Lee & Smagorinsky, 2000).

The present study is designed to enable peer tutors to move their younger counterparts through the zone of proximal development by providing support in the form of verbal prompts, praise, and discussion. According to Vygotsky, language is critical for cognitive development. Young children communicate by using private speech in order to regulate their behaviour and thinking. As they mature, they start using inner speech in order to accomplish complex cognitive actions. Since language is essential in forming thought and there is a correspondence between thought and speech, the interactions between tutors and tutees encourage students' intellectual development. Also, all participating students engage in a shared act of learning in a shared experience environment, resulting in a collaborative process of cognitive, social, and emotional interchange.

Mental Actions Theory

Galperin's (1985) theory of mental actions further elaborates Vygotsky's theory. According to Galperin, progress within an individual's zone of proximal development can be enhanced not only by social interaction but also by the use of special instructional techniques (Galperin, 1985). Each activity involves three main functional components: orientation, execution, control and correction. As individuals learn, they move through a progression of mental actions that result in transfer of responsibility from the expert to the novice. During orientation, the learner becomes oriented into the activity whilst the expert introduces the framework of the activity. Execution involves sharing the activity between the novice and the expert. During control and execution, the expert controls the proper execution of the activity until the learner can perform the activity individually. This transitional process is mediated by materialization and private speech.

Materialization refers to the use of objects and physical actions and their representations of the concepts to be learned. It focuses individual's attention on what is to be learned and the process of appropriating the mental action. At the outset of learning, materialization is needed. It helps the individual to concentrate on a critical aspect of the concept that is to be internalized. The use of materialization helps develop new mental actions and leads to cognitive functioning of the novices without expert assistance and support.

In order for materialization to have beneficial effect, it must be accompanied by outer or inner speech. The use of verbalization is a key in the learning process since it encourages the learner to express the learning and connection-making process to him/herself and others. Galperin's theory of mental actions stipulates that learning progresses from physical toward mental action with help by outer or inner speech.

In the present study, peer tutors provide the necessary scaffolding to the tutees by following the formation of their mental actions. First, the tutees become oriented toward the activity and receive the necessary clarifications concerning the objective to which the cognitive action relates as tutors introduce the framework of the activity. Tutees become initially familiarized with the required cognitive action and the conditions under which it should be carried out. Thus, the tutees form an outline of the action's orienting basis (Talyzina, 1981).

The social interaction between the tutors and the tutees is reinforced, especially during orientation since computer-based activities give the tutee a possibility to ask questions and find answers to questions. In computer-based environments, the ability to teach students how to ask questions and look for answers versus giving them the answers is considered critical (Tsoneva & Lazarova, 1988). During the execution, the tutors will share the activity with the tutees by allowing them to assimilate the action's content and control over the execution of each component of the action. In control and correction, tutors withdraw scaffolding support since the activity is completely internalized by the tutees and control for its proper execution. Moreover, materialization during the formation of each mental action is accomplished with tutors' guiding of tutees learning by helping them to select activities that are relevant to their learning level and to organize them coherently. Also, tutors provide prompting and reinforced interaction whilst assisting tutees in integrating new knowledge with their previous knowledge.

Situated Learning Theory

Situated learning theory (Lave & Wenger, 1990) and the principle of cognitive apprenticeship (Collins, Brown, & Newman, 1989) further develop Vygotsky and Galperin's views about the acquisition of knowledge. According to Lave and Wenger (1990) learning occurs as a function of the activity, context and culture in which it occurs and therefore is situated. The fundamental component of situated learning is social interaction. In the process of learning, learners are involved in a "community of practice" which posseses certain behaviour and knowledge that has to be learned. As novices enter the "community of practice" they are positioned at its periphery. When they become more active and engaged within the community and its culture, the novices move from the periphery towards the center and assume the roles of experts. The process is referred to as "legitimate peripheral participation."

Cognitive Apprenticeship Theory

According to the situated learning theory, learners can often master complex and difficult concepts through cognitive apprenticeship (Collins et al., 1989). Cognitive apprenticeship is an instructional method synthesizing formal schooling and traditional apprenticeship. It makes the thinking processes involved in a learning activity visible to the students and the teacher. Brown, Collins and Duguid (1989) emphasize that cognitive apprenticeship "supports learning in a domain by enabling students to acquire, develop and use cognitive tools in authentic domain activity. Learning, both outside and inside school, advances through collaborative social interaction and the social construction of knowledge"(p. 39).

When using cognitive apprenticeship the teacher guides student learning by using modelling, coaching, scaffolding, and fading, thus creating a shared problem-solving environment. Firstly, the teacher is responsible for modelling the required action, next for coaching and scaffolding the students as they gradually become more proficient in their skills. When this is accomplished, the teacher starts to fade out his/her support by shifting more control to the learner. More advanced peers or knowledgeable adults can successfully use cognitive apprenticeship instructional methods in supporting learners.

The basic methods of cognitive apprenticeship have been adopted in teaching reading (Palinscar & Brown, 1986).

In the present study tutors are responsible for the sequencing of the activities so that tutees are provided with opportunities to build a conceptual model of each activity. They are required to describe the steps that they follow in the different computer-based activities and formulate questions about possible confusions. Moreover, the tutors model these processes before coaching and scaffolding the tutee's efforts in becoming full-fledged members of the community of practice.

Part B: Research Framework

Phonological Awareness and Early Reading Development

In revealing the course of reading acquisition, different schemes have been proposed for differentiating the developmental phases through which readers go from developing pre-reading to competent reading skills and abilities (Chall, 1983; Ehri, 1987; 1991; Goswami, 1986; Juel, 1988). Of interest to the present study is Ehri's schema (1991, 1994, 1995) portraying the development of word reading processes and consisting of five overlapping developmental phases. Each phase of development in Ehri's schema is characterized by learners understanding and using the alphabetic system in their own reading. This is especially relevant when trying to understand the optimal conditions under which phonological awareness skills are built and mastered. The five phases are: pre-alphabetic, partial alphabetic, full alphabetic, consolidated-alphabetic, and automatic alphabetic. Each phase can extend beyond the next phase and mastering one phase may or may not be a prerequisite for moving to the next.

During the pre-alphabetic phase alphabetic knowledge is not used to read words. Pre-alphabetic readers have very limited knowledge of letters and do not grasp the concept that letters in written language have corresponding sounds in oral language. They also have no ability what so ever to decode words. During the partial alphabetic phase, readers can read sight words by using partial alphabetic cues. They still have not mastered word decoding since they do not have enough grasp of the alphabetic system. Full alphabetic readers have working knowledge of the major grapheme-phoneme correspondences and they have some degree of phonological awareness. There is some growth in their sight vocabularies and their text reading is rather slow. The consolidated-alphabetic phase begins simultaneously with the full-alphabetic phase and is characterized with furthering of phonological awareness skills and orthographic knowledge. In the automated alphabetic phase readers have proficient word reading because of their highly developed automaticity and fluency in identifying both familiar and unfamiliar words in their sight vocabulary.

According to Ehri's schema for reading acquisition, phonological awareness begins to develop during the consolidated alphabetic phase and continues to be mastered during the automated alphabetic phase. Phonological awareness refers to the ability to reflect upon the speech sounds of a language independent from their meaning (Snow, Burns, & Griffin, 1998) and is placed in the context of metalinguistic awareness entailing thinking about one's language. For example, a word like cat has one syllable, it rhymes with words like hat, mat, sat and it begins with the same sound as crib. The manipulation of speech sounds includes deleting, adding, and substituting syllables or sounds. According to Torgesen (1997) students who are not able to correctly recognize and manipulate speech sounds have difficulty relating the speech sounds to the corresponding printed words and their word decoding problems lead to reading comprehension difficulties.

A great deal of research has evaluated the effectiveness of phonological instruction in facilitating phonological awareness skills and reading acquisition, examined the relations between phonological awareness and reading acquisition, and sought to determine under what circumstances and for which children phonological awareness instruction is most effective.

Effectiveness of Phonological Awareness Instruction in Facilitating Phonological Awareness

Several decades of research have demonstrated a link between phonological awareness and learning to read, whereas recent studies suggest that the effect of PA instruction on helping children acquire PA is large and significant (Ball & Blachman, 1991; Blachman, 2000; Bus & van Ijzendoorn, 1999; Ehri et al., 2001; Share, Jorm, Maclean, & Matthews, 1984). Intervention studies employing either concurrent phonological awareness and reading instruction or including only phonological awareness instruction with pre-readers and early readers demonstrate that when students are trained in phonological awareness skills their phonological skills improve (e.g. McGuiness, McGuiness, & Donohue, 1995; O'Connor, Jenkins, & Slocum, 1995; Torgesen, Morgan, & Davis, 1992; Vadasy, Jenkins, Antil, Wayne, & O'Connor, 1997; Wise & Olson, 1999, 2000). Some studies have focused on trying specifically to treat the underlying phonological deficit in children with phonologically based reading disabilities (PRD) (Torgesen, Wagner, Rashotte, Alexander, & Conway, 1997; Wise & Olson, 1995).

This research has demonstrated that training children with PRD in phonological awareness leads to an improvement in those skills. Ehri and colleagues' (2001) meta-analysis examining phonological awareness instruction showed that the effect size for PA instruction in improving further PA is large (ES = 0.86) and is not statistically different from the effect size at follow-up testing (ES = 0.73). This finding confirms that PA instruction teaches PA skills effectively and students are able to maintain their skills after instruction has ended.

Effectiveness of Phonological Awareness Instruction in Facilitating Reading Acquisition

Generally, studies have shown that PA training makes a statistically significant contribution to reading acquisition and more specifically word recognition (Ehri et. al, 2001; Nation & Hulme, 1997; Snider, 1997). Ehri and colleagues' (2001) meta-analysis examining phonological awareness instruction showed that the effect size for PA instruction in improving further word recognition is moderate (ES = 0.53) and is not statistically detectable from the effect size at follow-up testing (ES = 0.45). The effect of PA instruction on reading comprehension is small (ES = 0.34). This finding confirms that strong gains in PA lead to transfer in word recognition and students are able to maintain their skills after instruction has ended. A considerable body of research indicates that phonological awareness is necessary but not sufficient for reading acquisition (Foorman, Francis, Novy, & Liberman, 1991; Juel, Griffith, & Gough, 1986). Researchers have supported the view that phonological awareness instruction should be combined with instruction in letter-sound correspondence (Ball & Blachman, 1991; O'Connor et al., 1995), instruction that makes clear use of the alphabetic principle that enables readers to translate visual symbols into sounds (Spector, 1995), and instruction in rapid naming and list learning, e.g. memorizing a list such as the alphabet (Cornwall, 1992), in order to produce contribution to reading acquisition beyond word recognition.

Relations between Phonological Awareness and Reading Acquisition

Although research has demonstrated the relationship between phonological awareness and reading an alphabetic script (Ehri & Wilce, 1980; Mann, 1986), there is a range of hypotheses explaining the nature of this relationship. Specifically, PA has been stipulated to (1) have causal relationship to the development of reading acquisition; (2) develop as a consequence of learning to read an alphabetic script; and (3) to have reciprocal relationship to the development of reading acquisition.

Intervention studies with pre-readers and beginning readers provide support for the causal relationship between PA and reading acquisition (Ball & Blachman, 1991; Burgess & Lonigan, 1998; Goswami & Bryant, 1990; Hatcher, Hulme, & Ellis, 1994; O'Connor et al., 1995). By investigating the effect of phonological awareness instruction on consequent phonological awareness development, word recognition, and spelling abilities, intervention studies demonstrated that training in phonological awareness influences reading achievement. Correlational studies (Bradley & Bryant, 1983; Bryne & Fielding-Barnsley, 1993; McGuiness et al., 1995) also demonstrate that phonological awareness skills predict later reading acquisition. Studies comparing good and poor readers (Juel, 1988; Siegel, 1993, Stanovich, 1988; Vellutino & Scanlon, 1987) indicate that for poor readers, the lack of phonological awareness is a core deficit. The causal relationship between phonological awareness and reading acquisition does not exclude other directional relations between the two constructs. Intervention studies with normally achieving and low achieving students (Hatcher et al., 1994; McGuiness et al., 1995) indicate that training integrating reading and phonological awareness is most effective in increasing reading achievement and phonological awareness for readers with different abilities – normally achieving, normal/low intelligence and reading disability.

The two views: that phonological awareness precedes and is causal to the development of reading and spelling abilities, and that reading acquisition is a causal factor in the development of phonological awareness skills, insinuate a reciprocal relationship between phonological awareness and reading acquisition. In a reciprocal relationship, phonological awareness could mediate learning to read an alphabetic script, which can subsequently contribute to the development of phonological awareness, thus leading to a bi-directional causal relationship between phonological awareness and word recognition. Training studies show that phonological skills are necessary for initial reading acquisition, but that the experience of reading assists the further growth of phonological awareness skills (Perfetti, Beck, Bell, & Hughes, 1987; Wagner & Torgesen, 1987; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993).

Components of Effective Phonological Awareness Instruction and Beneficiaries of Phonological Awareness Instruction

PA instruction has been shown to improve reading and to be more effective when taught with letters versus without (Byrne & Fielding-Barnsley, 1995; Foorman et al., 1991; Juel et al., 1986; Mcguinness et al., 1995). For example, Byrne and Fielding-Barnsley (1989) concluded that pre-school children who were taught and have learned phonemic segmentation and phonemic identification skills are able to transfer those skills and apply them to new stimuli words. Similarly, Ball and Blachman (1991) found that when kindergarteners are instructed in phonological awareness and letter-sound correspondence, they significantly outperform kindergarteners instructed only in phonological awareness or not receiving any training on measures of phonological awareness. McGuiness et al. (1995) confirm these findings with a sample of first graders. They found that children who were trained in letter-sound correspondence and phonological awareness skills significantly outperform non-trained controls.

Instruction in PA assists readers with different abilities and from different age groups. Intervention studies in PA training have been conducted with normally achieving students (Ball & Blachman, 1991; Byrne & Fielding-Barnsley, 1995; Mcguinness et al., 1995), students at risk for learning disabilities (Barker & Torgesen, 1995; Torgesen et al., 1992), and learning disabled students (Vallentino & Scanlon, 1987; Wise et al., 1999; 2000). Pre-schoolers, Kindergarteners, and students from grades one to six benefit from phonological awareness instruction (Byrne & Fielding-Barnsley, 1989; Davidson & Jenkins, 1994; Mcguinness et al., 1995; Wise et al., 1999; 2000).

In summary, phonological awareness is essential in reading acquisition. The reviewed studies demonstrate that when normally achieving students, students at risk for learning disability, or learning disabled students from different age groups are trained in phonological awareness skills their phonological awareness and word recognition skills improve. Despite the different views about the nature of this relationship, it is critical to acknowledge and to understand the significance phonological awareness instruction plays during reading acquisition.

Effectiveness of One-to-One Tutoring in Early Reading

The search for the best instructional delivery arrangement for teaching emergent reading skills has yielded a variety of practices. Undifferentiated regular classroom instruction is the norm in education (Baker & Zigmond, 1990), however it has proven to have little sustainability when trying to address the needs of students with diverse abilities (Elbaum et al., 2000). Different options have been sought among researchers and practitioners in order to find effective teaching strategies for improving struggling student's reading skills. Reading intervention programs providing explicit and visible instruction (Swanson, Hoskyn, & Lee, 1999; Wong, 1999), offering ongoing opportunities for interactive dialogue between learner and teacher (Wong, 1999) and capitalizing on time on task and student participation are considered among the strongest and proven to be the most effective (Elbaum, Vaughn, Hughes, & Moody, 1999).

Two forms of one-to-one tutoring are described in the literature: adult-mediated and peer-mediated. Adult-mediated one-to-one tutoring involves teachers, trained adults or community volunteers. Peer-mediated one-to-one tutoring refers either to same-age peer tutoring or cross-age peer tutoring. Same-age peer tutoring occurs when two students at the same age are paired together and the more skilled student in the pair is responsible for delivering instruction. Cross-age peer tutoring occurs when an older student is matched with a younger student to deliver instruction.

One-to-one tutoring is among the instructional practices that are widely acknowledged to be beneficial for struggling readers (Elbaum et al., 1999). In a review of five adult-delivered, one-to-one instructional programs for struggling readers in the primary grades, Wasik and Slavin (1993) conclude that all five programs: Reading Recovery, Success for All, Prevention of Learning Disabilities, Wallach Tutoring Program, and Programmed Tutorial Reading, yield significant positive effect on students' school success and academic achievement. One-to-one tutoring has proven to be an efficient instructional method in improving students' reading skills (Elbaum, Moody, Vaughn, Hughes, Moody, & Schumm, 2000; Juel, 1996; Shanahan, 1998). Juel (1996) studied one-to-one tutoring sessions between college athletes and 30 first graders at risk for reading failure. The study findings suggest that tutoring is an effective instructional method that is dependant on successful tutor-tutee relationships. Tutors whose children demonstrated greater reading gains provided more scaffolded reading and writing opportunities with strong reinforcement of progress and engaged in explicit cognitive modelling. Wasik (1998) and Shanahan (1998) emphasize the importance of tutors' training and need of instructional support as essential components for a successful tutoring program in reading. According to a meta-analysis conducted by Elbaum and colleagues (2000) students benefit from working in a variety of grouping formats that reflect their knowledge, skills, interests, and progress. Tutoring is an instructional format that accommodates enhanced student learning. More specifically, for students with learning disabilities the overall effect size for peer pairing is moderate (ES = 0.37).

Adult Mediated One-to-One Tutoring

Several studies have examined whether instruction provided by trained adults and community volunteers helps students at risk for reading failure to become better readers.

Vadasy, Jenkins and Pool (2000) examined whether a reading program delivered by community volunteers improved the reading achievement of first grade students who were at risk for learning disability (LD). Students at risk for LD (n = 23) were tutored for one school year, two hours a week in phonological skills, letter-sound correspondence, explicit decoding, rime analysis, writing, spelling, and reading phonetically controlled text. At the end of the school year, the tutored students outperformed untutored control students who received classroom instruction and Title I services on measures of phonological skills, word recognition, and reading fluency. One year after treatment, the tutored students performed similarly to the control students on measures of word recognition and reading fluency, whereas they significantly outperformed them on measures of phonological skills and spelling of regular words.

Fitzgerald (2001) found that first and second grade students (n = 64) who were at risk for reading problems benefited from tutoring from adults participating in the America Reads Challenge, an initiative established by the Clinton administration. Tutoring sessions began with training in phonological awareness and also taught student to read words in isolation.

A recent meta-analysis of 29 intervention research studies conducted by Elbaum et al. (2000) assessing the effectiveness of adult-delivered tutoring for elementary school students at risk for reading failure (n = 1539) confirmed that both community volunteers and trained adults are effective as tutors in teaching decoding-word recognition, reading comprehension, and phonological awareness. Tutors whose students made the greatest gains as a result of one-to-one tutoring were college students (ES = 1.65), followed by teachers (ES = 0.36) and community volunteers (ES = 0.26). Students' grade level was associated with the variation in effect sizes – the mean effects for students in grades 1-3 were moderate (ES = 0.37-0.49) and for students in grades 4-6 was not significantly different from 0. The duration of the one-to-one tutoring interventions was not significantly associated with the intervention outcomes. Students who were tutored in reading comprehension made the greatest gains (ES = 2.41), followed by students who were tutored in decoding, word recognition, and reading comprehension (ES = 0.50), and students who were tutored in phonological awareness (ES = 0.43).

Same-Age Peer Tutoring

Peer mediated tutoring has also been shown to be an effective instructional method in reading (Elbaum et al., 2000; Mathes & Fuchs, 1994). Same-age peer tutoring, a form of peer mediated instruction, is defined as a direct instructional method in which a more skilled student repeatedly presents academic stimuli to a peer.

The most widely researched program for peer-mediated classwide tutoring is Peabody Peer-Assisted Learning Strategies (PALS) (Fuchs et al., 1997) which was developed by researchers at Peabody College of Vanderbilt University. It is built on the foundation of the Classwide Peer Tutoring (CWPT; Greenwood, Delquadri, & Hall, 1989) and is supplementing the regular reading and math instruction of students in the upper elementary grades, 2 to 8. PALS is specifically designed to provide support to the general classroom teacher whilst trying to provide accommodation for each student in the classroom. According to the program's rationale, classroom teachers identify children who require support on specific skills and children who could be the most appropriate to help their peers to work on those skills. Partners are changed over certain periods of time, thus giving an equal opportunity for all students to be "coaches" and "players." PALS Reading involves three activities: partner reading, paragraph shrinking, and prediction relay.

Kindergarten PALS, First Grade PALS, and High School PALS have been developed as extensions of PALS. Kindergarten PALS has phonological awareness and beginning decoding as the program's major components; First Grade PALS centers on word decoding and fluency; and High School PALS includes motivational and helping strategies as an add-on to the original PALS program.

PALS has been shown to be an effective instructional method for supplementing regular reading and math classroom instruction for students at different ages. PALS is beneficial for all of the involved parties – tutor, tutee, and classroom teacher. A recent meta analysis evaluating peer-assisted learning interventions with elementary school students produced positive effect sizes (weighted ES = 0.33, $p < .0001$) indicating improved students achievement (Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003). PAL interventions that include opportunities for interdependent group reward contingencies, e.g. working toward a common goal, rewards are given depending on the efforts of all team members, produced greater achievement outcomes than PAL interventions that used one-way peer interaction or no reward contingencies.

Fuchs, Fuchs, Kazdan and Allen (1997) showed that PALS is effective at improving reading achievement for students with learning disabilities as well as low- and average achievers. Similar results were reported by Mathes, Howard, Allen and Fuchs

(1998) (n = 96). It was demonstrated that children who participate in First Grade PALS experience greater gains in reading achievement than children who receive regular classroom instruction. Low achieving students profit the most from the program, average achievers benefit somewhat from the program, and reading achievement of high achievers does not improve.

New components such as mini lessons and elaborate training in help giving have been added to PALS by researchers in order to find out whether students will benefit more from participating in the enhanced versions of PALS. Mathes (2001) studied whether mini lessons advanced the effects of First Grade PALS. Low and average readers make statistically significant reading growth in reading achievement after participating in PALS with or without mini lessons. Student training in elaborated help giving in addition to PALS produced different results for children, depending upon whether they are in the primary or intermediate grades (Fuchs et al., 1999). Intermediate students benefit from elaborate help giving and primary students perform better without additional help-giving strategies.

Cross-Age Peer Tutoring

Another form of peer mediated tutoring, cross-age peer tutoring, has been shown to be effective. Cross-age mediated peer tutoring is defined as a direct instructional method in which academic stimuli are repeatedly presented to a younger child by an older child and immediate feedback in the form of praise or correction is provided (Maheady et al., 1991).

Peer tutoring in both its forms – same age and cross-age peer tutoring – is viewed as an alternative supplemental instructional approach, and although the literature is conclusive about its effects on the reading development of struggling readers and normally achieving readers, it has rarely been compared to other instructional approaches. Mathes, Torgesen, Clancy-Menchetti, Santi, Nicholas, Robinson and Grek (2003) compared teacher-delivered small group instruction and peer-assisted instruction with parallel materials and routines for first grade students (n = 89) struggling with reading. The study revealed that both practices are effective in improving students' reading performance.

In summary, adult-mediated tutoring, same-age tutoring, and cross-age tutoring are forms of one-to-one tutoring. Adult-mediated tutoring is an instructional method in which trained adults help students learn. Same-age tutoring and cross-age tutoring are methods of instruction in which learners help each other and in turn learn by teaching. There are a number of similarities and differences among these instructional practices. Adult-mediated tutoring, same-age tutoring, and cross-age tutoring all entail individualized instruction, one-to-one attention, immediate support, modelling and feedback delivered from a more skilled individual to a less skilled student. Adult-mediated tutoring may involve professionals, whereas same-age tutoring and cross-age tutoring involve students who at the same or different age. Thus, there are similar social groupings in same age tutoring and cross age tutoring versus adult-mediated tutoring. The power imbalance in adult-mediated tutoring leads to a different social and emotional tone between the adult and the student whereas cross-age and same age peer tutoring offer opportunities for more informal interaction between the tutor and the tutee. Not surprisingly, students with LD prefer to work with a peer (Vaughn, Schumm, Klingner, & Saumell, 1995) and consider one or few of their classmates to be their favorite teachers (Klingner, Vaughn, Schumm, Cohen, & Forgan, 1998). The reviewed studies on one-to-one tutoring and early reading achievement support the idea that adult-mediated tutoring, same-age tutoring, and cross-age tutoring are effective instructional practices to improve phonological awareness of struggling readers in the early grades.

Computer-Assisted Instruction in Phonological Awareness

Computer-assisted instruction has been shown to be effective for both normally developing and at-risk readers. For over 15 years, literacy educators have tried to assess the impact of the use of computers on students at all levels of education (Hawisher & Selfe, 1996). Generally, studies have shown that computer use improves students' letter recognition, spelling and story writing skills (Boone, Higgins, Notari, & Stump, 1996; Moxley, Warash, Coffman, Brinton, & Cancannon, 1997). Talking storybook programs have improved comprehension and decoding skills of children in the primary grades (Jogsma, 2001; Lewin, 1997, 2000; McKenna, 1998, Wise & Olson, 1992). Recent studies have explored the effects on literacy development of incorporating multimedia as a collection of interactive texts and visuals (Kozma, 1994; Jonassen, Cambell, & Davidson, 1994). Students' interests and motivation (Tierney, Keefer, Whalin, Desai, Moss, Harris, & Hopper, 1997), their individual differences and cognitive learning styles (Turkle & Papert, 1990) have been investigated by scholars in light of their relationship with literacy and literacy development.

Based on the degree of interaction between student and computer, three levels of CAI have been identified: drill-and-practice, tutorial and dialogue. A recent synthesis on computer-assisted instruction in reading for students with learning disabilities shows that computer-based instruction is most often in the form of drill-and-practice exercises, when students' responses are monitored (Hall, Hughes, & Filbert, 2000). The CAI drill-and practice exercises offer opportunities for extensive rehearsal and strengthening of skills that the students have. CAI drill-and-practice includes corrective feedback and reinforcement with the main focus on mastering a targeted skill by repetition. It is not surprising that drill-and-practice CAI is the most frequently occurring form of CAI for students with learning disabilities, since most students with learning disabilities because of their unique learning needs require substantial and extensive practice before a skill is acquired and subsequently mastered. Despite some of the criticisms that CAI drill-and-practice exercises target low-order cognitive skills, it is a serious misconception to think that drill-and-practice computer programs are second-class or less original in comparison to other computer programs (Barker & Torgesen, 1995).

Studies of computer-assisted instruction in PA have taken advantage of the ability of computers to provide opportunities for extended practice whilst monitoring for speed and accuracy of students responses (MacArthur, Ferretti, Okolo, & Cavalier, 2001). According to the U.S. National Reading Report on evidence-based assessment of the scientific research literature on reading and its implications for reading instruction (National Institute of Child Health and Human Development, 2000), the yearly proportion of all technology studies ranges from 2% to 5% of all the research on reading and writing. For the purposes of this literature review, the results from a limited number of studies dealing with whether CAI in PA can improve children's performance on measures of phonological awareness, will be described chronologically with respect to the age of the children involved in the studies.

Lonigan, Driscoll, Phillips, Cantor, Anthony and Goldstein (2003) evaluated the effect of computer-assisted instruction in phonological awareness to preschoolers (n = 45) who are at risk for reading problems. The study findings indicate that children in the treatment condition improved their rhyming and elision skills by making statistically detectable gains in comparison to the control group.

Foster et al. (1994) conducted two experiments with preschool and kindergarten children whilst evaluating the instructional effectiveness of DaisyQuest, a computer program designed to increase PA in young children. In Experiment 1 (n = 27) and in Experiment II (n = 69) the children in the treatment conditions showed greater improvements from pre to posttesting on measures of phoneme identification and segmentation skills than the control groups who did not receive training.

Reitsma and Wesseling (1998) specifically demonstrate that CAI and practice could be quite successful in increasing the phonological awareness skills of kindergarteners. They provided converging evidence that the use of a computer program for a 12-week period improves the ability of Kindergarten children to synthesize phoneme-size segments into a single word sound. Three experimental conditions were present: children in the first condition received specific training in blending sounds into words using a researcher-developed program; children in the second condition received training in vocabulary using the same computer program; and children in the third condition did not have access to the computer program. The blending skills of all children improved, but there was a statistically detectable additional effect due to the use of the computer program.

Van Daal and Reitsma (2000) examined if Kindergarten children (n = 21) can independently acquire initial reading and spelling skills by using CAI program. There were two treatment conditions – children in the first were exposed to CAI, and children in the second condition were engaged in usual classroom activities. Children in the experimental condition made significant gains in letter knowledge and outperformed the control group on measures of word recognition and nonword reading. This study confirmed Reitsma and Wesseling's (1998) findings that high-quality interactive program can enhance phonological awareness in young children.

Barker and Torgesen (1995) evaluated the use of computer-assisted instruction to train phonological awareness skills among at-risk first graders. There were three experimental conditions in the study: phonological awareness training; phonological decoding training control, and attentional control. The children who were exposed to the phonological awareness training made statistically detectable improvements in PA and word recognition when compared to the children in the other two groups.

Consistent with the research on PA training without computer technology, Wise et al. (2000) provide evidential data that students who are phonologically trained through CAI gain more in phonological skills and untimed word reading than untrained children. They studied the Reading with Orthographic and Segmented Speech (ROSS) CAI program which offered second to fifth grade students assistance with decoding and

A.D.D by Lindamood-Bell Leaning Processes which provided students with opportunities for PA practice. There were two training conditions: accurate reading in text condition and phonological-analysis condition. Children in the accurate reading in text condition read stories and learned comprehension strategies, while children in the phonological-analysis condition learned phonological strategies, read stories and practiced phonological exercises. In follow-up testing, phonologically trained children scored higher on phonological decoding and children in both conditions scored equivalently on word reading. Although this research results are consistent with the research on PA without CAI, it is difficult to determine from this study what it is the effect of the CAI program in PA, since there is an interference of the other computer program.

Studies that compare computer-assisted instruction with teacher led instruction in phonological awareness found that effective instruction could be accomplished with computer technology. Mitchell and Fox (2001) examined the effectiveness of DaisyQuest and Daisy's Castle, computer programs designed to increase the phonological awareness in young readers. Research results show that kindergarten children (n = 72) who have received computer administered phonological awareness instruction and children who have received teacher-delivered phonological awareness instruction make significant gains in rhyme identification, segmenting, and blending.

In summary, the reviewed studies of computer-assisted instruction in PA demonstrate that CAI in PA promotes the acquisition and mastering of phonological awareness skills, word recognition, and fluency for normally developing, at-risk and reading disabled children from different age groups. CAI in PA is comparable to teacher-led PA training and is similarly effective.

Part C: Research Basis of Earobics

Earobics

Phonological awareness is conceptualized as a step in the language-to-literacy model of reading acquisition by the creators of Earobics (Cognitive Concepts, 2003). According to this model certain skills are an important prerequisite to moving toward and mastering the next skill while at the same time these skills can develop simultaneously and could be reciprocally influenced. Auditory processing and speech perception skills allow for understanding of oral language and are the foundation for phonological awareness development. Having good phonological awareness skills is an attribute of good readers. Fully mastered phonological awareness and letter-sound correspondence are requirements for word decoding and orthographic skills. The final step of the language-to-literacy model is reading comprehension, that could be achieved when word decoding is automatized and accurate.

Earobics is premised on two perspectives: phonological awareness perspective and auditory processing perspective. The games in Earobics Step 1 and Step 2 provide comprehensive training in rhyming, phoneme identification, blending, segmentation, and phonological manipulation, thus applying findings from phonological awareness research. Rhyming has been viewed as an intermediate step towards development of phonological awareness (Goswami & Bryant, 1990); awareness of phonemes has been seen as a key to understanding of an alphabetic language (Burgess & Lonigan, 1998);

mastering of phoneme blending, segmenting, phonological manipulation is necessary for the realization of early reading skills (Hurford & Johnston, Napote, Hampton, Moore, & Neal, 1994; Murray, 1998; Torgesen, Wagner, Lindamood, Rose, Conway, & Garvan, 1999). The games in Earobics Step 1 and Step 2 also incorporate training in auditory discrimination, auditory performance with competing signals, auditory short-term memory, and auditory sequential memory, thus applying findings from auditory processing research. According to Tallal, Miller, Jenkins and Merzenich (1997) children who have language impairments and children who are poor readers experience difficulties processing rapidly changing auditory stimuli. On this basis, Earobics offers opportunities for extended practice in discriminating, screening, and remembering auditory speech.

Comparison between DaisyQuest and Earobics

Several intervention studies have utilized DaisyQuest developed by Great Wave Software and have concluded that using the program has a positive impact on phonological awareness skills, word analysis, and word identification skills (Barker & Torgesen, 1995; Foster et al., 1994). DaisyQuest is the first CAI program that provides training in phonological awareness. DaisyQuest contains instructional activities that are designed to build analytic and synthetic phonological awareness skills. It teaches the following skills: recognizing words that rhyme; recognizing words that have the same beginning, middle, and ending sounds; recognizing words that could be formed from separately presented phonemes; counting number of sound in words (Foster et al., 1994). There are tutorials for each skill that include explanation of the concept that is being taught and correct and incorrect instances of the concept. After completing a particular tutorial, children are asked yes/no and multiple choice questions in order to see if they have mastered the skill they were taught. Demonstration of mastery is reinforced with a treasure and a clue for Daisy, the friendly dragon. There are three skill levels for each skill with no or with time limits.

In contrast to DaisyQuest, Earobics is a much more interactive program. Earobics teaches a greater range of phonological awareness skills. It also provides training in auditory processing skills and has more skill levels (between 11 and 114) than DaisyQuest. As opposed to DaisyQuest, Earobics does not include a tutorial. It directly introduces the game that is to be played and presents what is required by the player. Also in Earobics there are no yes/no and multiple choice questions that have to be answered by the player. It contains six games and there is no link between them. The reinforcement in Earobics is after each player's input versus DaisyQuest that awards a clue about the whereabouts of the dragon after all the test material is completed. This way, Earobics integrates much better than DaisyQuest the instruction explaining each skill, opportunities for extended practice for each skill, and reinforcement after each skill. In contrast to DaisyQuest, Earobics is a very visual program with a lot of nicely done and not overwhelming animations that children really enjoy. It is adaptive, meaning that the program automatically adjusts according to the performance of the player.

Having considered the similarities and differences between DaisyQuest and Earobics, I think that Earobics is a much more sophisticated program because of its specific design characteristics. Despite the fact that both computer programs are based on research findings in the area of phonological awareness, since Earobics includes training in more skills, has more levels for each skill, and includes training in auditory processing, it makes sense to predict that an instruction using Earobics will lead to an increase in phonological awareness skills.

Summary

In summary, the present study uses the framework of socio-cultural theory, mental actions theory, situated learning theory, and cognitive apprenticeship theory and builds upon the early reading development, effectiveness of one-to-one tutoring, and effectiveness of computer-assisted instruction literature whilst investigating the efficacy of cross-age mediated peer tutoring in combination with computer-assisted instruction in phonological awareness for primary grades students.

Phonological awareness is essential in reading acquisition. Intervention studies demonstrate that when normally achieving students, students at risk for learning disability, or learning disabled students from different age groups are trained in phonological awareness skills their phonological awareness and word recognition skills improve. Despite the different views about the nature of this relationship, it is critical to acknowledge and to understand the significance phonological awareness instruction plays during reading acquisition. The preceding literature review on one-to-one tutoring and early reading achievement supports the idea that adult-mediated tutoring, same age tutoring, and cross-age tutoring are effective instructional practices to improve phonological awareness of struggling readers in the early grades. CAI in phonological awareness promotes the acquisition and mastering of phonological awareness skills, word recognition, and fluency for normally developing, at-risk and reading disabled children from different age groups. Earobics, the computer program that is used in this study, is built on the principles of phonological awareness and auditory processing research, thus it makes sense to predict that using the software will be beneficial for students. The findings from the review of the literature provide a rationale for using cross-age peer tutors in combination with computer-assisted instruction in phonological awareness for providing instruction to primary grades students. The instructional approach developed for use in this study adds to the intervention research literature, first, by adding the component of tutoring to computer-assisted instruction in phonological awareness; secondly, by evaluating if practicing with Earobics has positive impact on phonological awareness development; and thirdly, by demonstrating what constitutes a successful and effective instruction for developing phonological awareness for students at risk for reading disabilities.

Chapter 3
Methodology

Research Design

The study employed a four-group posttest quasi-experimental design. This experimental design was chosen because it allows for the examination of treatment effects on intact groups of participants. Children were assigned using a stratified random procedure to one of the two conditions: (1) cross-age peer tutoring in combination with computer-assisted phonological awareness instruction (CAIPT); and (2) phonological awareness instruction (PAI). Tutees and tutors in the CAIPT group were age matched to pairs of children in the PAI control groups. The independent variable was the training method and the dependent variable was the level of phonological awareness skill.

Participants

Eighty-seven children selected to participate in the study were drawn from a Summer Reading Program to tutor children at risk for reading disabilities. Flyers advertising this program were sent to elementary schools throughout the Lower Mainland of British Columbia. Participants were assigned to one of the four groups: CAIPT-tutors (n = 23), CAIPT-tutees (n = 23), PAI-tutors (n = 18), and PAI-tutees (n = 23). Since there were errors in the administration of the phonological processing pre-test, results from the pre-test had to be disregarded. Subjects were assigned to treatment and control conditions based on their results from the Letter-Word Identification subtest on the Woodcock Johnson Achievement Battery - Third Edition. Children in the two CAIPT groups were poor readers (i.e., standard scores ≤ 80 on the Letter-Word Identification subtest on the Woodcock Johnson Achievement Battery – Third Edition). However, CAIPT-tutors were 8-9 years old and CAIPT-tutees were 6-7 years of age. Children assigned to the two PAI control groups were good readers (i.e., standard scores >80 on the Letter-Word Identification subtest on the Woodcock Johnson Achievement Battery – Third Edition) matched on age to the CAIPT-tutors and CAIPT-tutees.

Apparatus

All computer-assisted instruction used Apple Macintosh desktop and laptop computers with operating system OS X. All the machines were situated in a large computer lab and equipped with CD-Rom drives and internal speakers. The laptop computers were additionally equipped with external mice in order to avoid difficulties commonly experienced by young students when a tap pad has to be operated.

Measures

As shown in Table 1, participating students were administered measures of cognitive ability and word recognition prior to intervention and measures of phonological processing were administered after intervention. All administered measures were selected according to the following criteria: (1) the measure has established psychometric properties; (2) the measure has established reliability and validity based on previous research; (3) the measure is age appropriate for the participants.

Table 1
Test battery

Measures	*Subtests*
Cognitive ability	
• Stanford-Binet Intelligence Scale	Vocabulary, Absuridities, Pattern Analysis, Copying, Quantitative, Bead Memory, Memory for Sentences, Memory for Digits
Word Recognition	
• Woodcock-Johnson Psycho-Educational Battery	Letter-Word Identification
Phonological Processing Ability	
• Comprehensive Test of Phonological Processing	Elision, Blending, Sound Matching, Nonword Repetition, Rapid Object Naming, Rapid Digit Naming, Rapid Letter Naming, Rapid Color Naming

A) Cognitive Ability

Cognitive ability was assessed with the *Stanford-Binet Intelligence Scale – Fourth Edition* (Thorndike, Hagen, & Sattler, 1986). The following subtests were administered: Vocabulary, Absurdities, Pattern Analysis, Copying, Quantitative, Bead Memory, Memory for Sentences, Memory for Digits. These tests were selected from the complete test battery because they represent a balance between verbal and abstract reasoning. The tests were suggested by the test creators as suitable for assessment of children who are having difficulty learning in school. Median subtest reliabilities for Vocabulary, Absurdities, Pattern Analysis, Copying, Quantitative, Bead Memory, Memory for Sentences, Memory for Digits subtests of the Stanford-Binet test battery ranged from .73

to .94 (Thorndike et al, 1986). On the Vocabulary subtest, the examinee is asked to provide a definition or synonym of the stimulus word in order to pass each item. On the Absurdities test, the examinee is required to determine what is silly in a picture that is presented. Pattern analysis requires student to either insert colored pieces into a form board or to arrange colored cubes according to a specific pattern that is shown on a card. Copying requires the examinee to copy a specific design onto a paper, using a pencil. Quantitative test requires the examinee to solve mathematical story problems. Bead Memory, Memory for Sentences and Memory for Digits are measures of short term memory of either visual or verbal information.

B) Word Recognition

Word recognition was measured with the Letter-Word Identification subtest from *Woodcock-Johnson Psycho-Educational Battery – Third Edition* (Woodcock, McGrew, & Mather, 2001). The test progresses from matching a picture of an object with a rebus to identifying isolated letters and words. More difficult items on this subtest require the examinee to identify less frequent words with irregular spelling. The reliability of the Letter-Word Identification subtest is calculated using split-half procedure and it ranges from .88 to .99 for the different age groups (Woodcock et al., 2001). The median reliability for all age groups is .94.

C) Phonological Processing

Phonological awareness, phonological memory and rapid naming are three kinds of phonological processing tasks that are associated with reading acquisition. Phonological processing was assessed using the *Comprehensive Test of Phonological*

Processing (CTOPP) (Wagner, Torgesen, & Rashotte, 1999). All of these constructs are consistent with the nature of the phonological awareness core deficit model (Torgesen & Wagner, 1998). CTOPP for individuals ages 5 to 6 contains seven core subtests: elision, rapid color naming, blending words, sound matching, rapid object naming, and nonword repetition. CTOPP for individuals ages 7 to 24 contains six core subtests: elision, blending, memory for digits, rapid digit naming, nonword repetition, and rapid letter naming. The elision subtest measures the extent to which the examinee can pronounce and manipulate the sounds of a word. For example, the examinee is instructed, "Say cat." After repeating "cat," the examinee is told: "Now say cat without saying /c/." The blending words subtest measures examinee's ability to blend sounds. For example, the examinee is asked, "What do these sounds make: c-at?" The sound matching subtest measures the sound matching abilities of the examinee. For example, the examinee could be asked which of these three items – can, pig, or dog – begin with the same sound as cat. The nonword repetition subtest assesses examinee's ability to repeat nonwords ranging in length from 3 to 15 sounds. This test was tape-recorded and asked students to repeat 18 nonsense words which varied in terms of number of syllables and consonant clusters within syllables. This test was used as a measure of phonological short-term memory and articulation accuracy.

Rapid color naming, rapid object naming, rapid digit naming, and rapid letter naming measure the speed with which the examinee can name colors, objects, digits, and letters. Cronbach's α for the CTOPP subtests ranged from .72 to .93. The reliability on the rapid naming subtests is calculated using alternate-form reliability and it ranges from .72 to .96. Test-retest reliability ranges from .68 to .97 (Torgesen & Wagner, 1998).

Children's performance on the phonological awareness tasks was charted daily using the Earobics software. It allows viewing of data across tasks for the same date of training and viewing data across multiple days of training. Daily records were kept for each tutor-tutee training session describing the frequency of observed behaviours, such as addressing by name, focusing attention, initiating dialogue, etc. (See Appendix B). Field notes were collected that documented the interaction of the tutor-tutee pairs.

Data Collection

All pre- and post-testing was administered individually by the researcher herself and research assistants – one graduate student with background in psychometric testing and nine undergraduate students. Testing took place during May and June, 2003 with the exception of CTOPP testing, which was administered in July, 2003. Data were collected before the beginning, during and at the end of the Summer Reading Program.

Procedures

The study was conducted from July 3 until July 28, 2003. Forty-eight fourth year undergraduate students implemented the intervention. All students had taken previous coursework in psychology of education and in theories of learning disabilities. Two undergraduate students were assigned to administer instruction to two children in the CAIPT group (1 tutor and 1 tutee) and two children in the PAI control group (1 tutor and 1 tutee). To control for the effect of different teachers on instructional outcomes, the undergraduate students alternated delivery of CAIPT and PAI control procedures.

CAIPT

All children in the CAIPT group started with games in Earobics Step 1. The researcher monitored the progress of each tutor-tutee pair after each training session. When both children in a pair had a success rate of 90-95% items correct in one of the six games, they were advanced to a more difficult game. When both children in the CAIPT group mastered the advanced tasks for Earobics Step 1, they were moved to Earobics Step 2. There was only one pair of children that initially had a very high success rate with Earobics Step 2 and the researcher manually changed the levels for each game by selecting the most advanced ones. All the other children who used Earobics Step 2 were progressing through the regular course of the games depending on their correct and incorrect responses.

Tutoring took place five times per week over a 3-week period. Each tutoring session lasted 25 minutes. During the first 5 minutes of each session the CAIPT group tutor was provided with prompts and procedures to use during the tutoring session. After the CAIPT tutor's training, the tutee in the CAIPT group joined the CAIPT tutor. During the next 15 minutes children in the CAIPT group played 3 games. Games were selected by the tutee and each game was played for 5 minutes. During the last 5 minutes of the intervention, the tutor and the tutee in the CAIPT group filled out social validity questionnaires. Children in the control group participated in 20 minutes of phonological awareness and literacy activities taught by the second undergraduate student.

After participating in CAIPT and PAI, children were engaged in 15 minutes of reading activities designed by the undergraduate students and tailored to improve children's ability to read connected text meaningfully. Table 2 shows the Summer Reading Program activity's timeline for the CAIPT and PAI groups.

Table 2
Summer Reading Program timeline

Time Allocated	CAIPT Group	PAI Group
5 min	Tutor's training	
15 min	Earobics with tutor/tutee	PA instruction
5 min	Daily evaluation of intervention with tutees and tutors	
5 min	Break	
15 min	Reading for meaning activities	

Earobics Software

Students in the CAIPT group had daily access to the *Earobics* software program developed by Cognitive Concepts. It focuses on improving phonological encoding and phonological awareness and consists of perceptually and linguistically based activities. The perceptually based activities target auditory processing abilities, whereas the more linguistically based activities target phonological awareness skills (Diehl, 1999). Earobics is described as learning software that acknowledges phonological awareness as a step in the language-to-literacy model of learning to read (Cognitive Concepts). The intended population for using the program include children identified with speech and language problems, cognitive, attention, or processing deficits, language-based learning disabilities, hearing malfunctions, ESL learners or at large any child who requires phonological supplemental instruction.

Earobics Step 1 is used for children aged 4 to 7 years and Earobics Step 2 is used for children aged 7 to 10 years. There are six games in Earobics Step 1: Karloon's balloons, C.C. Coal Car, Rap-a-Tap-Tap, Caterpillar Connection, and Basket Full of Eggs. Each of the games gives 10 sec of response time to a stimulus, with the exception of Rap-a-Tap-Tap at 5 sec. After three correct responses the level of difficulty is increasing and after two incorrect responses the level of difficulty is decreasing. Table 3 identifies the primary target skills for each one of the six games.

Table 3
Primary skills targeted by Earobics Step 1

Game	Skills	Game	Skills
Karloon's Balloons	Auditory attention Auditory sequential memory Auditory short term memory Auditory performance with competing signals	Caterpillar Connection	Phonological blending Auditory attention Auditory short term memory Auditory sequential memory
C.C. Coal Car	Sound-symbol correspondence Phoneme discrimination & identification Phonological sequencing	Rhyme Time	Rhyming Auditory attention Auditory short term memory Auditory sequential memory Auditory performance with competing signals
Rap-a-Tap-Tap	Phonological segmentation Auditory short term memory	Basket Full of Eggs	Auditory and phoneme discrimination Auditory attention Auditory short term memory Auditory sequential memory Auditory pattern recognition

In Karloon's Balloons, Karloon the Clown presents a sound effect, one syllable word, digit, or speech sounds. There are nine boxes on the screen and the player is required to click on the box that contains the corresponding stimulus to the one pronounced by the Clown. If the response is correct, the player gets a balloon; if it is incorrect, one of Karloon's balloons pops.

In C.C. Coal Car, a train introduces a target sound. On the computer screen there are two boxes with letters – one is the target sound, the other one is crossed over with a line and it is not the target sound. The player is prompted to click on the corresponding sound to the one pronounced by the C.C. Coal Car Train. After sound recognition is mastered, the level of difficulty of the game is increased and the player is asked to identify the position of the sound in a word by clicking on the corresponding for beginning position – engine, middle position – coal car, or end position – caboose. If the response is correct, the player gets coal in one of the cars of the train and the train advances in its destination.

In a Rap-a-Tap-Tap, a music band with a drummer presents a series of 1 to 4 drum beats. The player is required to count the beats and to click with the mouse for each drum beat. If the response is correct, the band plays a catchy melody, if it is incorrect – the band plays a short melody out of sync. After the player becomes proficient in counting drum beats, speech sounds, syllables in word, and segmenting speech sounds in a word is presented.

In Caterpillar Connection, Katy-Pillar presents two words that make a compound word and the player is asked to click on the corresponding picture of the targeted compound word. When the player gains proficiency, blending two and three syllables in a word, blending two, three, and four speech sounds is presented. By giving correct responses, the player turns Katy-Pillar into a beautiful butterfly.

In Rhyme Time, the player is interacting with Bog Frog and his frog crew. This game uses both rhyming and non-rhyming activities. In the first part of the game, the child is asked to figure out which of the presented words does not rhyme with the target word. In the second part, the child is asked to successfully identify which of the presented words rhyme with the target word.

In Basket Full of Eggs, Farmer Fardell collects eggs from two white hens in a nest on the left hand side of the screen and one white and one brown hen in a nest on the right hand side of the screen. He presents two sounds, if they are the same, the player is asked to click on the two white hens, and if they are different, the player is asked to click on the one white and one brown hen. If the response is correct, the farmer can collect the eggs from the nesting hens, and if it is incorrect – the eggs get broken. The game advances by presenting increasingly similar sounds and consonant-vowel syllables.

Earobics Step 2 consists of five games: Calling All Engines, Paint by Penguin, Pesky Parrots, Hippo Hoops, and Duck Luck. Table 4 identifies the primary target skills for each one of the games.

Table 4
Primary skills targeted by Earobics Step 2

Game	Skills	Game	Skills
Calling All Engines	Auditory attention Auditory short-term memory Auditory sequential memory Auditory performance with competing signals Following oral directions Comprehension of linguistic concepts	Hippo Hoops	Auditory & phoneme discrimination Phoneme identification Phonological sequencing
Paint by Penguin	Auditory short term memory Auditory sequential memory Auditory pattern recognition Phonological sequencing Phonological segmentation Phonological manipulation	Duck Luck	Auditory short term memory Phoneme identification Rhyming Auditory & phoneme discrimination Phonological blending Phonological segmentation Phonological manipulation Word closure Sound-symbol correspondence Recognizing word endings
Pesky Parrots	Auditory short term memory Phonological blending Auditory & phoneme discrimination Word closure Auditory performance with degraded signals		

In Calling All Engines, the player helps Firefighter Fly to put out fires by recalling and sequencing sounds. There is a burning building on the screen with nine windows. The player is required to listen to the instructions and to click on the window that contains the corresponding stimulus to the one pronounced by the Firefighter. The game advances and the player learns how to recall words, sequence of long vowels, and consonant sounds.

In Paint by Penguin, the player is painting masterpieces with Mr.Pierre Penguin. The player selects a sponge of his/her choice by clicking on it. This is followed by presentation of speech sounds from Mr. Penguin. The child is required to count the number of speech sounds and to click on the canvas for each sound heard. If the response is correct, Mr. Penguin starts doing a painting. The game advances and the player learns how to sequence speech sounds in a word, and learns how to create new words by deleting, adding, substituting, and moving sounds within the word.

In Pesky Parrots, the player helps Pirate Patch to get back his stolen jewels. On the computer screen a treasure chest is shown. The pesky parrots present two syllables that make a word. Three pictures appear on the sails of the pirate ship. The player is required to click on the corresponding picture of the word spoken by the parrots. If a response is correct, the parrot get one of their jewels back, if it is incorrect unfortunately they end up with a coconut. The game advances and the player learns how to complete words by filling in missing syllables or speech sounds.

In Hippo Hoops, Hakeem Hippo is playing one-on-one basketball with the Rhino. The player is asked to help the Hippo score banana points whilst learning to recognize and discriminate speech sounds. When the whistle blows, the player is invited to click on the ball and hold down the mouse button and listen to Hakeem Hippo repeat one word or nonword. The player is prompted to let go of the mouse when a different word is heard. The game advances and the player learns how to discriminate similar sound contrasts and how to identify the position of sounds within words.

In Duck Luck, the player enjoys the Duck Luck Arcade while having some carnival fun. Lyle Kyle Crocodile presents a sound pattern that corresponds to the letters displayed on the screen, the player is asked to click on one of three little ducks that each speaks a different word. The player should select a duck whose word ends with the sound pattern presented by Lyle Kyle Crocodile. The game advances and Lyle Kyle Crocodile presents one syllable words divided into onset-rimes and words with a sound removed.

Training Overview

Undergraduate Students Training

All undergraduate students underwent nine hours of training before the beginning of the CAIPT intervention. In the first three hour session all students were introduced by the researcher to the concepts of phonological awareness and early reading development. Objectives and purposes of the study were not discussed. During this session the researcher demonstrated how each game in the Earobics software package is played and explained the different skills each game is teaching. The students were given 40 minutes to explore the different games in the software. They were given a copy of the software so they could practice the games on their own time. In the second three-hour session the researcher responded to questions from students about intervention procedures, e.g. time on task, undergraduate students' involvement and provision of feedback. Students were given additional time to explore the six different games. The researcher demonstrated data collection procedures and provided a timeline for the different activities. During the final session, the researcher engaged in a role-play with each pair of students. The researcher pretended to be a tutee, one student was the tutor, the second student trained the tutor and role played observing the interaction between the tutor and the tutee. Students completed the role play several times until they showed that they understood and were able to carry out the intervention. The researcher also monitored the implementation of intervention procedures throughout the course of the intervention program.

CAIPT-Tutor Training

The undergraduate students trained the child tutors on a daily basis. Research has shown that when the tutoring sessions are well structured and the content and delivery of instruction are carefully scripted, consistent positive achievement for tutees is generated (Cohen et al., 1982; Wasik & Slavin, 1993). Therefore, the tutoring sessions were structured and included each of the following elements: students' interaction; involvement of the tutor; involvement of the tutee; use of different computer games; providing scaffolding and feedback on tutee's performance. Careful monitoring and reinforcement of progress was included as part of the tutoring sessions because they have proven to lead to a successful tutor-tutee relationship and tutees were able to move from total support to complete independence (Juel, 1996).

In the first session, child-tutors were familiarized with the goals and objective of the study. They were taught computer troubleshooting skills such as how to unfreeze a frozen computer, how to start a particular program, etc. They were instructed in basic computer skills for using Earobics, tutoring tips, and basic instructional delivery strategies and prompting procedures. For each of the six games in Earobics, two prompts were used for each game. Prompts varied according to which game was played (see Appendix C).

The undergraduate students rehearsed the prompts with the tutors and their sequence. Checklists of procedures to be followed during each tutoring session were provided to the tutors and the undergraduate students (see Appendix D and Appendix E). During the tutors' training, the undergraduate students discussed the goals and purpose of the activity and the steps that need to be followed. The tutees were instructed to try to incorporate the same type of behaviours when teaching their tutees. Tutors were reminded to use the prompts and to give specific feedback and praise to their tutees.

Treatment Integrity

The investigator assessed the accuracy with which the tutors led their sessions through direct observation methods. Students interaction; involvement of the tutor; involvement of the tutee; use of different computer games; providing scaffolding and feedback on tutee's performance was noted. Fidelity observations were conducted continuously throughout the intervention based on the behaviours included in the undergraduate students records.

The undergraduate students, the CAIPT-tutors and the CAIPT-tutees were required after each training session to fill out treatment integrity checklists. The undergraduate students were encouraged to read and to scribe for the children who needed help. The checklist for the undergraduate students included the following: gaining attention of the student, picking up a game, introducing the activity, setting a purpose for the activity, introducing/reinforcing the rules of the game, explaining the different concepts involved, recalling prior knowledge, modelling the activity, directing the behaviour of the students, provision of continuous feedback, giving praise, monitoring tutor-tutee interaction and assessing performance with the tutor and the tutee. The checklist for the tutors was a simplified version of the checklist for the undergraduate students. The tutors were also required to keep a dairy with daily reflections on how their tutee is learning. The diary entries were kept brief to two sentences per session. The tutees were asked to indicate their likes and dislikes for the games played during each session by rating them with the corresponding happy or sad faces. They were asked if they liked the game a lot and in such cases they had to circle a smiling face. If they sort of liked the game, they were to select the second face whose mouth was depicted as a straight line, or if they did not like the game at all, the tutees were to select the frowning face (see Appendix F).

PAI Control Group

Children in the PAI control group participated in a variety of phonological awareness and early literacy activities, such as phonemic puzzles, crosswords, Scrabble, word bingo, Collect a sentence, etc. They also used computers during PA activities, however not in pairs. Examples of websites used during the PAI literacy activities were:

Yahooligans (http://www.yahooligans.com) and PBS Kids (http://pbskids.org/). In all conditions, the undergraduate students monitored the children to stay on task. The monitored time was kept as equivalent as possible among children and among conditions. All undergraduate students instructed all children with equal enthusiasm, energy, and passion and were trying their best to be as objective as possible when delivering and monitoring instruction.

Chapter 4
Results

In this chapter, the results of the CAIPT program are presented. There are four sets of data analysis around which this chapter is organized. First, a sample description of both the CAIPT and the PAI groups is provided. Second, reliability estimates and correlations between measures of phonological processing are reported. Third, CAIPT and PAI group performances on outcome measures of phonological processing are compared. Finally, a profile analysis of CAIPT and PAI group performance on the phonological processing tasks administered at post-test is conducted. Data is analyzed using SPSS version 11. Missing data is randomly dispersed throughout the dataset and overall accounted for less than 5% of the total data. According to Tabachnick and Fidell (2001) when missing values are randomly distributed among 5% or less of a large data set, no serious violations of assumptions are expected to occur in the data analysis.

Posttest Analyses

Sample Description

As shown in Table 5, an analysis of variance (ANOVA) found no statistically detectable between CAIPT-tutee and PAI-tutee group differences on age, $F(1, 44) = .01$, $p = .93$ and IQ, $F(1, 44) = .83$, $p = .37$. No statistically detectable difference between CAIPT-tutee and PAI-tutee group difference is found on sex, Mann-Whitney χ^2 (1, N = 46) = 218.50, $p = .24$. Thus CAIPT-tutee and PAI-tutee groups are comparable on age, sex, and IQ. The PAI-tutee group outperforms CAIPT-tutee group on word recognition, $F(1, 42) = 10.16$, $p = .003$.

As shown in Table 6, an ANOVA shows no statistically detectable between CAIPT-tutor and PAI-tutor group differences on age, $F(1, 39) = .05$, $p = .82$ and IQ, $F(1, 39) = .02$, $p = .09$. No statistically detectable between CAIPT-tutor and PAI-tutor group difference is found on sex, Mann-Whitney χ^2 $(1, N = 41) = 157.50$, $p = .12$. Thus the two groups are comparable on age, sex, and IQ. PAI-tutor group outperforms CAIPT-tutor group on word recognition, $F(1, 39) = 10.55$, $p = .002$.

Table 5
Sample characteristics of CAIPT-tutee group and PAI-tutee control group (n = 46)

	CAIPT-tutee n = 23			PAI-tutee n = 23					
Variable	M	SD	n	M	SD	n	*F*	*(df)*	χ^2
Age in months	83.00	9.19		82.74	9.49		.01 ^{ns}	(1, 44)	
Sex									
Male/Female			11/12			15/8			218.50 ^{ns}
IQ	89.78	10.50		92.57	10.23		.83 ^{ns}	(1, 44)	
Letter-Word Identification	89.5	12.12		100.18	10.01		10.16*	(1, 42)	

Note. ^{ns}p > .05

**p < .05*

Table 6
Sample characteristics of CAIPT-tutor group and PAI-tutor control group (n = 41)

	CAIPT-tutor n = 23			PAI-tutor n = 18					
Variable	M	SD	n	M	SD	n	*F*	*(df)*	χ^2
Age in months	97.13	7.13		96.44	12.30		.05 ^{ns}	(1, 39)	
Sex									
Male/Female			17/6			9/9			157.50 ^{ns}
IQ	92.22	8.55		91.83	10.43		.02 ^{ns}	(1, 39)	
Letter-Word Identification	84.35	11.60		97.56	14.46		10.55*	(1, 39)	

Note. ^{ns}p > .05

*p < .05

Reliability

Reliability estimates for measures of phonological awareness are calculated using Cronbach's alpha. Reliability estimates for elision (.89), blending (.85), sound matching (.89), nonword repetition (.82), rapid object naming (.88), rapid letter naming (.89), and rapid digit naming (.82) with the exception of rapid color naming (.66), are high.

Intervention Outcomes

Table 7 presents the posttest means and standard deviations on measures of phonological processing for the CAIPT treatment and PAI control groups.

Table 7

Posttest mean scores and standard deviations on phonological processing measures

	CAIPT-tutor n = 23		PAI-tutor n = 18			CAIPT-tutee n = 23		PAI-tutee n = 23		
Measure	M	SD	M	SD	F^a	M	SD	M	SD	F^b
Elision	8.70	4.09	10.44	3.93	1.66^{ns}	5.10	2.45	6.64	4.19	2.14^{ns}
Blending	10.80	3.49	12.44	3.01	2.21^{ns}	8.52	4.00	8.23	2.74	$.08^{ns}$
Sound Matching	-	-	18.00	-	-	8.89	5.09	11.70	4.62	1.60^{ns}
Nonword Repetition	10.25	3.27	10.81	3.45	$.25^{ns}$	9.00	3.56	8.77	3.10	$.50^{ns}$
Rapid Object Naming	-	-	146.00	-	-	117.44	37.98	103.20	29.14	$.85^{ns}$
Rapid Color Naming	-	-	110.00	-	-	98.11	28.37	103.60	37.27	$.13^{ns}$
Rapid Digit Naming	46.50	15.34	47.27	12.61	$.03^{ns}$	70.33	18.77	56.42	27.63	2.08^{ns}
Rapid Letter Naming	50.50	19.09	48.87	10.81	$.09^{ns}$	62.33	30.62	56.00	25.24	$.31^{ns}$

Note. There was only one subject aged 67 months in the PAI-tutor group. Sound Matching, Rapid Object Naming, and Rapid Color Naming are subtests from CTOPP for children aged 5-6 years. Means and standard deviations for these subtests for the PAI-tutor group are based on the results from only one subject.

$^a F$ -test with 1 and 34 *df* comparing mean scores between groups.

$^b F$ -test with 1 and 45 *df* comparing mean scores between groups.

$^{ns} p > .05$.

Correlations between phonological processing, IQ, and Letter-Word Identification measures for the subjects aged 5-6 and 7-9 years old are presented in Table 8 and Table 9. Similar correlations are obtained for measures for study participants 5-6 and 7-9 years of age. The following statistically detectable correlations are obtained for subjects aged 5-6 years: (1) blending and elision (r = .70); (2) rapid object naming and rapid letter naming (r = .75); (3) elision and rapid color naming (r = -.46); (4) letter-word identification and elision (r = .69), blending (r = .60), nonword repetition (r = .63), rapid object (r = -.56) and rapid color naming (r = -.59). The following statistically detectable correlations are obtained for subjects aged 7-9 years: (1) blending and elision (r = .46); (2) nonword repetition and elision (r = .37) and nonword repetition and blending (r = .56); (3) rapid digit and rapid letter naming (r = .51); (4) letter-word identification and elision (r = .43) and letter-word identification and blending (r = .36). The correlations obtained between measures of phonological awareness, nonword repetition, and rapid naming for samples of children aged 5-6 years are smaller than when measures are constructed for use with children aged 6-7 years. According to Wagner et al. (1993) as children mature as readers, the relations between phonological awareness and word recognition strengthens. Although the exact nature of relationship between phonological awareness and reading acquisition is a matter of debate, researchers generally agree that phonological awareness facilitates the understanding of the alphabetic principle.

Table 8

Intercorrelations between phonological processing, IQ, and letter-word identification variables for children ages 5-6 (n = 25)

Subtest	1	2	3	4	5	6	7	8
1. Elision	-	.70**	.39	.24	-.17	-.46*	.34	.69**
2. Blending		-	.44	.15	-.11	-.39	.24	.60**
3. Sound matching			-	.06	-.13	-.30	-.56	.63**
4. Nonword repetition				-	-.42	-.34	.19	.37
5. Rapid object naming					-	.75**	-.38	-.56*
6. Rapid color naming						-	-.28	-.59*
7. IQ							-	.26
8. Letter-Word Identification								-

Note. ** $p < .01$, two-tailed

* $p < .05$, two-tailed

Table 9

Intercorrelations between phonological processing, IQ, and letter-word identification variables for children ages 7-9 (n = 67)

	1	2	3	4	5	6	7
1. Elision	-	.46**	.37**	-.20	-.05	.22	.43**
2. Blending		-	.56**	-.01	.08	.07	.36**
3. Nonword repetition			-	.01	.09	.16	.21
4. Rapid digit naming				-	.51**	-.10	-.18
5. Rapid letter naming					-	.05	.04
6. IQ						-	-.08
7. Letter-Word Identification							-

Note. ** $p < .01$, two-tailed

Effect sizes

Average performance on measures of phonological processing of the CAIPT group is compared with the mean of the PAI group using effect size estimates expressed in standard deviation units. The primary index for effect size (ES) calculation is Cohen's *d*. Cohen defines effect size as "the degree to which the phenomenon is present in the population, or the degree to which the null hypothesis is false" (Cohen, 1988, pp. 9-10).

Effect sizes estimates are computed for each posttest by calculating the difference between the posttest means for the (1) CAIPT- tutee group and PAI-tutee control group divided by the pooled standard deviation for both groups, and for the (2) CAIPT-tutor group and PAI-tutor control group. Calculation of *d* involves dividing the difference between the mean of the treatment and control group by the average standard deviation of the treatment and control group:

$$d = \frac{\overline{X}_t - \overline{X}_c}{\frac{1}{2}(S_t + S_c)}$$

where $\overline{X}_t$ is the mean of the treatment group; $\overline{X}_c$ is the mean of the control group; S_t is the standard deviation of the treatment group and S_c is the standard deviation of the control group.

Table 10 shows moderate and positive ES estimates that suggest that the CAIPT tutees aged 5-6 years are on average, outperforming PAI matched controls on rapid object naming (ES = . 42), however, these differences in group performance are not statistically detectable. Effects of the CAIPT intervention on measures of blending (ES = -.46), and sound matching (ES = -.56) are moderate and negative which suggests that although the differences are not statistically detectable, 5-6 year old children in PAI tutee control group are on average, outperforming age-matched children in the CAIPT tutee group on these measures.

Table 10
Effect size estimates comparing CAIPT-tutee group and PAI-tutee group aged 5-6 years on measures of phonological processing (n = 22)

Measure	CAIPT-tutee		PAI-tutee		*F*	ES
	M	SD	M	SD		
Elision	3.67	2.06	4.70	3.92	$.50^{ns}$	-.34
Blending	6.22	2.99	7.70	3.50	$.97^{ns}$	-.46
Sound Matching	8.89	5.09	11.70	4.62	1.60^{ns}	-.56
Nonword repetition	7.67	3.24	8.20	4.29	$.09^{ns}$	-.14
Rapid Object Naming	117.4	37.98	103.20	29.14	$.85^{ns}$	.42
Rapid Color Naming	98.11	28.37	103.60	37.27	$.13^{ns}$	-.16

Note. $^{ns}p > .05$

Table 11 shows moderate and positive ES estimates that suggest that the CAIPT tutees aged 7-9 years are on average, outperforming PAI matched controls on measures of rapid digit naming (ES = .60) and blending (ES = .54), however, these differences in group performance are not statistically detectable. Whereas the direction of treatment effects favors children in the CAIPT tutee group on rapid digit naming and blending, a negative ES suggests that the mean performance of PAI tutees aged 7-9 years on a measure of elision (ES = -.69) is greater than that of the CAIPT tutee intervention group.

Table 11
Effect size estimates comparing CAIPT-tutee group and PAI-tutee group aged 7-9 years on measures of phonological processing (n = 24)

Measure	CAIPT-tutee		PAI-tutee		*F*	ES
	M	SD	M	SD		
Elision	6.17	2.21	8.25	3.84	2.65 ^{ns}	-.69
Blending	10.25	3.86	8.67	1.97	1.60 ^{ns}	.54
Nonword repetition	10.00	3.59	9.25	1.66	.43 ^{ns}	.29
Rapid Digit Naming	70.33	18.77	56.42	27.63	2.08 ^{ns}	.60
Rapid Letter Naming	62.33	30.62	56.00	25.24	.31 ^{ns}	.23

Note. ^{ns}p > .05

Similarly, as shown in Table 12, the ES obtained when comparing CAIPT tutors aged 7-9 years with age matched PAI controls on a measure of elision is moderate and negative (ES = -.59), suggesting that the phonological skill of elision may be the most resistant to treatment.

Table 12
Effect size estimates comparing CAIPT-tutor group and PAI-tutor group aged 7-9 on measures of phonological processing (n = 40)

Measure	CAIPT-tutor		PAI-tutor		*F*	ES
	M	SD	M	SD		
Elision	8.70	4.09	10.93	3.51	2.87 ^{ns}	-.59
Blending	10.80	3.49	12.53	3.09	2.33 ^{ns}	-.53
Nonword repetition	10.25	3.27	11.07	3.41	.51 ^{ns}	-.25
Rapid Digit Naming	46.50	15.34	47.27	12.61	.03 ^{ns}	-.06
Rapid Letter Naming	50.50	19.09	48.87	10.81	.09 ^{ns}	.20

Note. ^{ns}p > .05

It is important to note, however, that no statistically detectable differences are found in average group performance across all phonological processing tasks. This is an important finding because it suggests that after participating in CAIPT intervention, both tutees and tutors at-risk for reading disabilities are performing similarly to age-matched controls who are typically developing readers.

Profile Analyses

Profile analysis is conducted to examine whether the performance of 5-6 years old CAIPT-tutees differ in performance on phonological awareness compared to their age-matched PAI-tutees controls. Similarly, profile analysis is conducted for the CAIPT-tutees aged 7-9 years and their PAI-tutees age-matched controls. Since only one subject aged 67 months is in the PAI-tutor group, this subject is deleted from the analysis along with the other subject from the pair. Profile analysis is done for the CAIPT-tutors aged 7-9 years and their age-matched PAI-tutor controls. Overall, three profile analyses are conducted.

Three questions guide the profile analysis. The test of parallelism assesses whether the profile of scores on a set of measures differs between groups. The levels test determines whether on average the performance of one group on a collected set of measures is higher than the performance of the other group. The flatness tests assesses whether the group profiles show highs and lows across the measurements within the profile or are flat.

Profile analysis for CAIPT- tutee group aged 5-6 years and age- matched PAI-tutee control group

Group sample sizes in this data set are similar: 9 cases for the treatment group and 10 cases for the control group. There is missing data for three cases on each of the six dependent measures. Skewness and kurtosis values for elision, blending, sound matching, nonword repetition, rapid object and rapid color naming show values less than 1.07 and higher than –1.35. This suggests the distributions are approximately normal, indicating that the assumption of normality is met.

To test for multivariate outliers Mahalanobis distance is used. With a critical $\chi^2 = 22.46$, p<.001 indicates that there are no multivariate outliers in the solution with the highest distance being 11.58. Since this is a relatively small data set, z-scores are calculated to determine if there are any univariate outliers. Outliers are z-scores in excess of 3.29 (Tabachnick & Fidell, 2001); scores this far from the population mean have a p value of p >.001. Since there were no standardized scores in excess of 3.29 (p>.001), there are no univariate outliers within the solution.

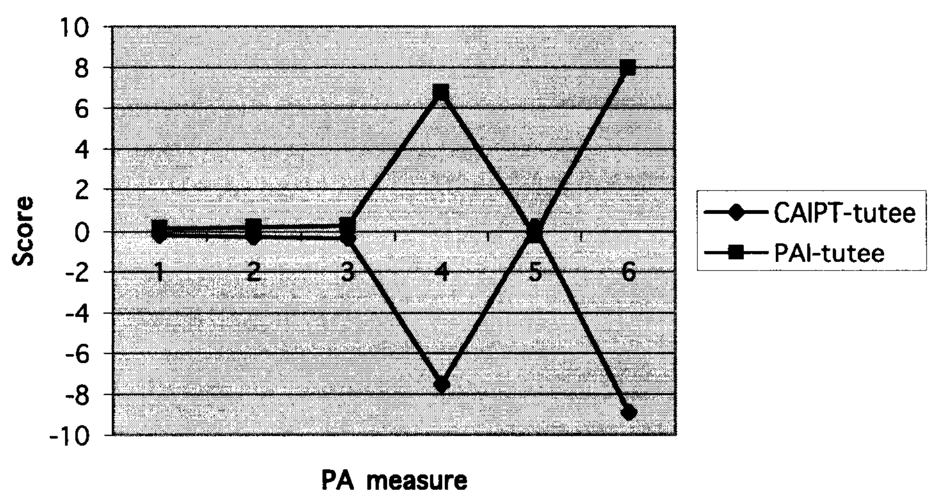
To test for the homogeneity of the variance-covariance matrices the Box's M= 57.7, F = 1.66, p =.03 indicates that the assumption of homogeneity of variance-covariance matrices may have been violated; however, I decided to proceed with caution because Box's test is known to be overly sensitive.

To test the assumption of linearity, scatterplots between all pairs of dependent variables are evaluated. The patterns within the scatterplots show that the dependent measures are normally distributed. Correlations among the dependent variables are low (<.35). Tabachnick and Fidell (2001) report that SPSS GLM also prevents correlated variables from entering the analysis. The Mauchly Sphericity is a test to determine if the error covariance matrix of the dependent variables is proportional to an identity matrix. The test revealed that there is a correlation, Mauchly's W = .072, p = .00, therefore the Huynh-Feldt Epsilon is used to adjust values on the variables.

In sum, the assumptions of normality of sampling distribution, outliers, linearity, homogeneity of variance-covariance matrices, multicollinearity and singularity are not grossly violated. For this analysis, the group assignment variable is the grouping variable, and blending, elision, sound matching, nonword repetition, rapid object naming, and rapid color naming are the dependent variables. Raw scores on all measures are converted to z scores for this analysis.

The test of parallelism tests adjacent segments of the profiles to see whether a pattern exists in terms of the high and low scores on the phonological awareness measures. The profiles seen in Figure 1 do not deviate significantly from parallelism, $F(3.3, 56.1) = .58$, $p = .65$, $\eta^2 = .03$.

Figure 1
<u>Profiles of phonological awareness scores for 5-6 years old CAIPT-tutee group and age-matched PAI-tutee control group</u>



1- elision; 2- blending; 3- sound matching; 4- nonword repetition; 5-rapid object naming; 6- rapid letter naming

The levels test assesses whether the group means for the measures of phonological awareness are significantly different from one another. No statistically detectable differences are found among groups when the scores are averaged over all subtests, $F(1, 17) = 1.11$, $p = .31$, $\eta^2 = .06$. Therefore no differential effect for group assignment appears to exist on phonological awareness measures.

The degree of flatness of the group profiles tests whether all dependent measures have the same average response across groups. When averaged across groups, however, the profile on measures of phonological awareness are found not to deviate significantly from flat, $F(3.3, 56.1) = .002$, $p = 1$, $\eta^2 = .0$.

Profile analysis for CAIPT- tutee group aged 7-9 years and age-matched PAI-tutee control group

Sample sizes in this data set are equal: 12 cases per group and there are no missing data on each of the five dependent measures. Groups are small but equal in size and there are more cases than dependent measures in each group. Since all the kurtosis and skewness values are less than 1.1, this would also suggest that the distributions are approximately normal. Therefore, there was no concern about deviation from multivariate normality and the central limit theorem assured acceptably normal sampling distributions of means for use in the profile analysis.

Multivariate outliers were sought through Mahalanobis distance. With a critical $\chi^2 = 20.52$, $p<.001$ indicates that by this criterion, none there are no multivariate outliers, the largest Mahalanobis distance in either group is 13.58. Therefore, all cases are retained for the analysis. An examination of the distribution of the z-scores indicated that there were no extreme univariate outliers within the solution.

To test for homogeneity of the variances-covariances matrices, Box's M = 33.94, F = 1.7, p = .05 indicates that the assumption is not violated. Examination of the scattreplots between all pairs of dependent variables reveals that the dependent measures are normally distributed. The Mauchly Sphericity test showed that the assumption of sphericity is not violated, Mauchly's W = .54, p = .19. An examination of the correlations between all dependent measures demonstrated that the assumptions of multicollinearity and singularity are satisfactory.

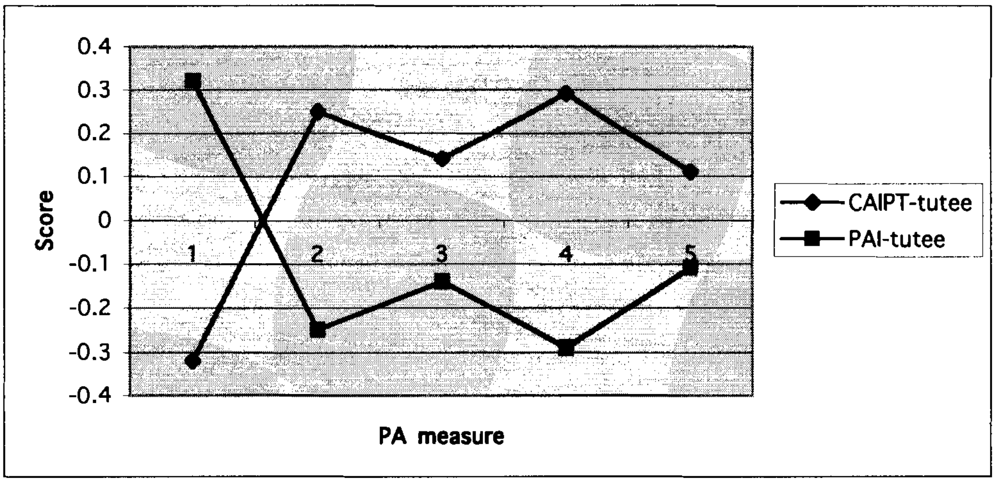
In sum, the assumptions of normality of sampling distribution, outliers, linearity, homogeneity of variance-covariance matrices, multicollinearity and singularity are met.

For this analysis, the group assignment variable was chosen as the grouping variable, and blending, elision, nonword repetition, rapid letter naming and rapid digit naming are the dependent variables.

Using Wilks' criterion, the profiles seen in Figure 2, do not deviate significantly from parallelism, F(4, 19) = 1.56, p = .23, $\eta^2 = .25$. No statistically detectable differences are found among groups when the scores are averaged across all subtests, F(1, 22) = .65, p = .43, $\eta^2 = .03$. When averaged over groups, Hotelling's T results show subtests do not deviate from flat, F(4,19) = .0, p = 1, $\eta^2 = .0$.

Figure 2

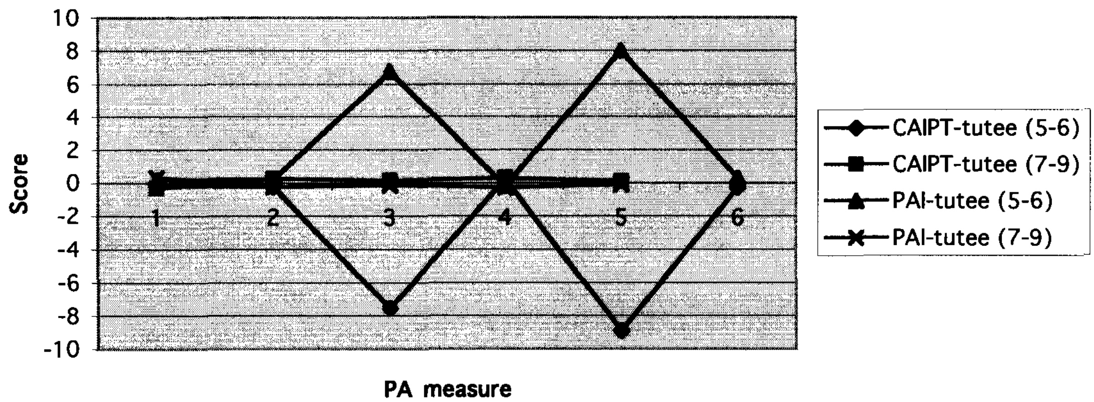
<u>Profiles of phonological awareness scores for 7-9 years old CAIPT-tutee group and age-matched PAI-tutee control group</u>



1 - elision; 2 - blending; 3 – nonword repetition; 4 – rapid digit naming; 5 – rapid letter naming

Figure 3 displays the profiles of 5-6 and 7-9 years old CAIPT-tutee groups and their age matched PAI-tutee groups.

Figure 3
Profiles of phonological awareness scores for CAIPT-tutee groups and age-matched PAI-tutee control groups



1 - elision; 2 - blending; 3 – nonword repetition; 4 – rapid object naming/rapid digit naming; 5 – rapid color naming/rapid letter naming; 6 – sound matching

Profile analysis for CAIPT-tutor group aged 7-9 years and age- matched PAI-tutor control group

Sample sizes in this data set are unequal: 20 cases for the treatment group and 15 cases for the control group. There is missing data for six cases on each of the five dependent measures. According to Tabachnick and Fidell (2001) unequal sample sizes present no specific difficulties in profile analysis because the hypotheses are tested as if in a one-way design. There are more cases than dependent measures in each group.

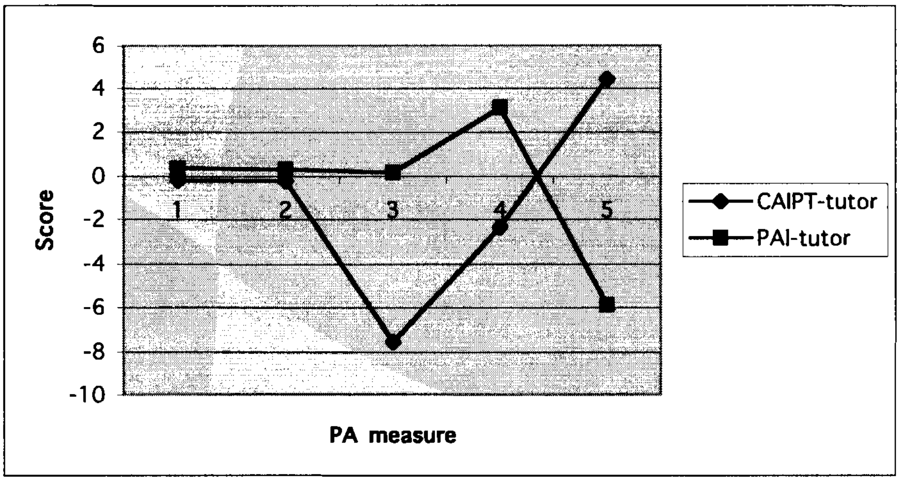
Multivariate outliers are investigated through Mahalanobis distance. A critical $\chi^2 = 20.52$, p<.001 indicates that by this criterion, there are no multivariate outliers. The largest distance in either group is 15.1. The z-scores are normally distributed as well, thus suggesting that no univariate outliers are in the solution.

To test for homogeneity of variances-covariances matrices, Box's M = 25.7, F = 1.42, p = .13 indicates that the assumption is met. The Mauchly Sphericity test shows that the assumption of sphericity may be violated, Mauchly's W = .28, p = .0001, therefore the Huynh-Feldt Epsilon is used to adjust the values on the variables.

The assumptions of linearity, multicollinearity and singularity are not significantly violated. For this analysis, the group assignment variable is the grouping variable, and blending, elision, nonword repetition, rapid letter naming and rapid digit naming are the dependent variables.

The profiles seen in Figure 4, did not deviate significantly from parallelism, F(2.95, 97.25) = .99, p = .4, $\eta^2 = .03$. There are no statistically detectable differences between the means of the groups combined over the five phonological awareness measures, $F(1, 33) = 1.27$, $p = .27$, $\eta^2 = .04$. There are no statistically detectable differences among the groups with respect to flatness, $F(2.95, 97.25) = .07$, $p = 98$, $\eta^2 = .002$.

Figure 4
<u>Profiles of phonological awareness scores for 7-9 years old CAIPT-tutor group and age-matched PAI-tutor control group</u>



1- elision; 2 - blending; 3 – nonword repetition; 4 – rapid digit naming; 5 – rapid letter naming

Overall the profile analysis shows that mean phonological awareness scores for the treatment and control groups result in similar profiles that are parallel and flat. This indicates that the analysis was successful in establishing that the means across phonological awareness scores for the CAIPT-tutee groups, and CAIPT-tutor groups and their age-matched PAI controls do not differ from one another in outcomes.

Qualitative Analyses

Results from data collected from student questionnaires, computer logs of student performance for each tutor-tutee pair (i.e., game selection, completed tasks, number of errors), experimenter generated field notes and observations suggest that CAIPT facilitates collaboration and communication between learners in an environment that is of high interest to the students. Moreover, there is some evidence to suggest that the tutors used specific features of the Earobics software to enhance communication and learning. To a great extent these themes are interactive and overlapping.

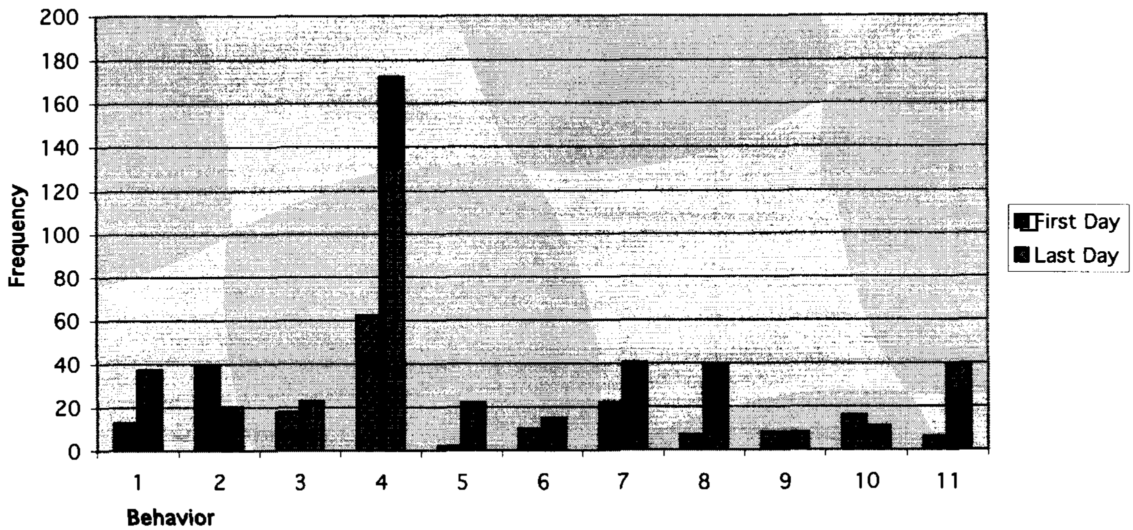
Collaboration between Learners

Collaboration styles of children in computer environments are typically determined by constraints presented by computer technology. In this study, the presence of one keyboard and one mouse requires that children in the tutor-tutee pairs must negotiate use of the keyboard and mouse. Although the Earobics software is not designed specifically to generate simultaneous multiuser interaction, the children in the current study collaborated in the following ways: (1) the tutor operates the mouse based on the tutee's responses, (2) the tutee operates the mouse in response to the tutor's comments, and (3) the tutor and tutee share the use of mouse equal amounts of time.

Communicative Behaviours

As shown in Figure 5, children in the CAIPT group children become more vocal and communicate more with their partners over time. Initially, the tutors dominated the conversation as they demonstrated game procedures through modelling, directing attention and providing corrective feedback. As children become more familiar with each other's role and with the games that are played, the frequency of tutee and tutor initiated conversation increased, including the amount of off-task behaviour. Off task behaviour in this case includes any behaviour that is not directly related to learning and phoneme awareness. Thus, although the children may still be playing the game, they are not engaged in activities that are directly related to learning specific skills such as letter-sound knowledge and/or discrimination of phonemes. Gestures such as: pointing to the computer screen, head nodding and smiling or grimacing increased. Clearly, although the amount of instructional dialogue decreased over time, on average, children's frequency of engagement with the computer and the software remains intact. Information gathered from field notes suggests, however, that children's interest in the software waxed and waned over time, either as a result of children's role in the intervention or their proficiency in the game. For instance, on several occasions, tutors appeared disappointed when they had to stop playing a game to assume their tutor role. As some children became more proficient with the skills required in the game, they found repeated practice less interesting.

Figure 5
Frequency of communicative behaviours



1- addressing by name; 2 – modelling an activity; 3 – talk-through; 4 – praise; 5- specific praise; 6 – use of negative language; 7 – carrying out a dialogue initiated by the tutor; 8 - carrying out a dialogue initiated by the tutee; 9 – providing corrective feedback; 10 – focusing attention; 11 – off task behaviour

Software Features

Data from field observations show that tutors in the CAIPT intervention use features of the Earobics software to tailor instruction to meet individual needs of their students. For example, one feature available to tutors is the option to pause the game and to hear a stimulus multiple times. After training, tutors chose these options to instruct their tutees on a daily basis.

Individual Case Analysis

Interactions between two tutor-tutee pairs in the CAIPT intervention are further examined using data from computer logs and running records of behaviour. These pairs of children were chosen for further study because they exemplify two separate and distinct responses to CAIPT instruction. They were selected based on the number of sessions attended by the children and the completeness of the behaviour running records.

Case 1: Bryce (tutor) and Sean (tutee). During the first three sessions, Sean, the tutee rates the interest level of all six games of Earobics Step 1 as exceptionally high. Bryce, the tutor, reports in his reflective journal that he helps Sean learn by teaching him how to play the games, by providing him with instructions, demonstrations, and by listening to his questions. Observations of tutee-tutor interactions shows, however, that although Bryce embraces and understands his role as a tutor (i.e., he models and provides initial prompts to Sean), he initially disengages (i.e., sits quietly without responding) when Sean plays the games. Bryce appears to have a very shy and quiet temperament. Bryce is reminded each day during his tutor training that talking with Sean is important, however, Bryce is reluctant to provide praise to his student. He frankly acknowledges this reluctance in his daily evaluations of his tutoring session. However, as the difficulty of the games increased, Bryce seems more interested and participates more actively in the games. Bryce communicates more when new games are played, compared times when games are familiar. Clearly, over time, Bryce gains confidence as a tutor and becomes more specific in his directions and instructions. He provides more praise and when he forgets to do so, he documents this in his diary entries. Bryce uses different strategies to focus Sean's attention such as addressing him by name, repeating and rewording questions, reinforcing Sean's successes by smiling. Sean responds well to this tutoring behaviour – he plays the games very attentively and alertly.

Moreover, as time progresses, the boys begin to work well together as a team. During one session, Sean moves Bryce's chair to encourage Bryce to continue with the game. The boys respect each other's choice of games to be played at a particular session. Although they do not actively engage in conversation all the time, the boys communicate well with each other and coordinate their roles to maintain the intervention. For example, on one occasion, Bryce completely stops tutoring Sean. When Sean notices that the activity is not being played in the same way as the previous games, he asks Bryce why this is happening. This question had the effect of reminding Bryce about his role and responsibilities because he began prompting Sean once again. Towards the end of the intervention, the boys are clearly relaxed and at ease with each other – they play games while rocking in their chairs and making jokes about the game characters.

Case 2: Darren (tutor) and Mathew (tutee). Darren is a highly effective tutor when the games are at his level of phonological skill. He addresses Mathew by name, focuses his attention, praises him and engages him in conversation. Darren quickly develops alternative teaching strategies. For example, instead of reviewing each game with Mathew, Darren simply asks: "Do you remember this game?" If the answer is positive, both boys start playing the games right away. When the answer is negative, Darren goes over the rules and purposes of the particular game until he is certain that Mathew knows what is required in the activity. Darren listens attentively to Darren's questions and responses. The computer logs from the first three sessions show a high success rate in all trials. Review of Darren's journal suggests that he enjoys his role as a tutor and he is proud that Mathew has learned from his tutoring. Darren records that he has taught Mathew how to play some games, how to rhyme and how to listen to sounds. Darren recognizes that some of the games are hard for Mathew and that he had helped Mathew learn. Darren writes: "I helped my student. I am happy. Mathew was the best at Rap-a-Tap-Tap. He was the best at C.C. Coal Car."

As the games become more difficult, however, Darren is less able to explain the purpose of the game and he has difficulty correcting the errors made by Mathew. This results in diminished modelling and reinforcement during the sessions, and restless behaviour for Darren and growing frustration for Mathew. As time progresses, it becomes clear that Mathew finds the games easier to play than does Darren. This results in role switching for Darren as tutor and Mathew as tutee. Mathew begins to instruct Darren and he takes charge of operating the computer volume control. Although Darren is clearly less able than Mathew to play games, and he is less able to fill the responsibilities of a tutor (i.e., provide corrective feedback), he seems to feel he remains in the tutor role. In his diary, he writes: "I helped out Mathew with the games. I helped my student." By the end of the CAIPT intervention, Darren and Mathew are both fluent in the games instructions and interact continuously with each other. They sustain their excitement when challenged with a difficult game.

Summary

Profile analyses that compare the performance of the CAIPT treatment and PAI control groups on phonological processing demonstrates that the phonological processing performance for the CAIPT treatment and PAI control groups has identical parallel and flat profiles. There are no age-related and role-related differences with respect to these findings. Five to six and 7-9 year old tutors and tutees from the CAIPT treatment groups have the same parallel and flat profiles with their age-matched controls. Qualitative analyses of the data reveal that CAIPT fosters collaboration and communication among students by providing students with an environment that generates social interaction in a context that is of high interest for learners.

Chapter 5
Discussion

Discussion of Findings

The purpose of this research was to examine the efficacy of computer-assisted instruction in phonological awareness in combination with cross age peer mediated tutors for primary grade students at-risk for reading disabilities. In this chapter, the key findings are summarized and discussed within the context of the literature on phoneme awareness training, computer-assisted instruction and peer tutoring. Next, the limitations of the study are considered. Finally, the theoretical and educational implications will be explored, along with future directions for research.

Findings of the study are discussed here as they relate to the purposes of the research:

(1) Does participation in CAIPT improve the phonological processing of primary grade children at-risk for reading disabilities?

(2) After intervention, is the performance of children in the CAIPT group on measures of phonological processing within age-level expectations?

(3) Is CAIPT a socially valid method of providing instruction?

Previous research has clearly shown that children who are poor readers benefit more from CAI in reading (Wise et al., 2000) and peer mediated reading interventions

(Mathes et al. 1998) than their age matched counterparts who are good readers. Prior to intervention, scores on a measure of letter-word identification were on average statistically lower for children in the CAIPT group than for children in the PAI group. Thus, the response of the CAIPT group is expected to be greater for the CAIPT group than for the PAI group. What is remarkable, however is that after intervention no statistically detectable differences are found between the CAIPT and PAI groups on measures of phoneme awareness. Profile analyses of CAIPT and PAI group responses for children aged 5-6 years and 7-9 years of age on phonological processing reveal identical profiles that are parallel and flat. Together, the findings corroborate previous research that suggests (1) training in phonological awareness improves phonological awareness and word recognition skills of beginning readers (Ball & Blachman, 1991; Blachman, 2000; Byrne & Fielding-Barnsley, 1995; Ehri et al., 2001; Mcguinness et al., 1995; Vadasy et al., 1997) as well as those children at-risk for reading failure (Barker & Torgesen, 1995; Bus & van Ijzendoorn, 1999; Ehri et al., 2001; Torgesen et al., 1992; Wise & Olson, 1999, 2000); (2) computer assisted instruction in phoneme awareness improves phonological skills of poor readers (Barker & Torgesen, 1995; Foster et al., 1994; Lonigan et al., 2003; Mitchell & Fox, 2001; Wise et al., 1999) and (3) peer mediated instruction is an effective technique for improving academic achievement of children across subject areas (Elbaum et al., 2000; Fuchs et al., 1997; Mathes et al., 1998; Mathes & Fuchs, 1994; Vadasy et al., 2000).

To tease out whether CAIPT was successful at enhancing the effects of basic phoneme awareness instruction, the control group was provided instruction in phoneme awareness (without the use of computers or cross-age peer tutors). Findings show that the phoneme awareness of children at-risk for reading disabilities improves to the same level of the control group and provide support for the position that CAIPT enhances phoneme awareness instruction. The efficacy of CAIPT may be attributable in part, to the social interaction that occurs when two children interact together with the computer. Cognition, in this case, is constructed as an intersubjective social event in which thinking is shared across the participants in the learning process (Packer & Winne, 1994). According to McCaslin & Hickey (2001) "cognitive activity is so context bound that one can never distinguish between the individual's cognitive ability, the individual's affective state, the context in which the activity takes place, and the activity itself" (p. 241). Moreover, the social interaction that took place around the computer was guided by principles of instruction that facilitate learning. Tutors apprenticed their tutees by engaging them in a focused dialogue that was strategic and included modelling, scaffolding, prompts and reinforcement.

Tutors in the CAIPT group were trained to use modelling during their interactions with the tutees. One modelling strategy that was frequently used by tutors was thinking aloud, which made their thinking visible to their tutees. This activity is important because it provided tutees with access to the prerequisite knowledge that is necessary to perform on phonological awareness tasks. According to Vaughn, Gersten and Chard (2000) teacher modelling and thinking aloud along with engaging students in apprenticeships and collaborations with more advanced individuals are the key components of effective instruction for students with learning disabilities.

Tutors also provided scaffolds, such as prompts, questions, and feedback as they encouraged their younger counterparts through their individual zones of proximal development. When tutees were faced with cognitively challenging tasks, they frequently engaged in egocentric speech, at which point, the tutor intervened with scaffolding support. Once that task was automatized (i.e., the tutee could perform the task easily alone), task-orientated dialogue between the tutee and tutor lessened. This finding implies that tutees first addressed the phonological skill on an interpsychological plane and after automatizating the skill, they have appropriated it on an intrapsychological plane. Englert and Mariage (2003) assert that "once [actions are] mastered, there remains the quality of hidden dialogicality, insofar as the traces of the talk and actions performed by the others surface to influence the inner talk and behavioural repertoire of the learner" (p. 451).

There were also instances where a specific phonological skill was not fully mastered by the tutor and, therefore, the tutor was unable to provide an accurate model of the activity. When this occurred, there were several possible outcomes: (1) the tutee (if more able) assumed the role of the tutor; (2) the tutor engaged in off-task behaviour, presumably because the tutor's role was compromised; (3) the tutor and the tutee became more focused on the game at hand to determine whether there was support available within the context of the game format; and (4) the tutor and the tutee intentionally provided incorrect responses so the level of the game was adjusted to a level that matched their abilities. Children's learning was an outcome of dialogue with their partners as well as of the flexibility of the software to adjust to individual differences in phonological skill. As the intervention program progressed, the amount of dialogue between the tutee-tutor increased. Moreover, the quality of the dialogue changed as children became more proficient with the tasks. At the beginning of the intervention, dialogue was centred on the game procedures and rules, however, as the intervention progressed, the dialogue became more social as children discussed their likes and dislikes for the games, and made jokes about the different characters in the game.

Taken together, these findings support previous research that shows interventions with tutors who are taught to use training procedures and who are proficient in the skills to be taught are more effective than interventions with tutors who are less skilled in tutoring techniques or who have less knowledge about the content of the task at hand (Elbaum et al., 2000). Thus, the peer tutoring component effectively contributed to the CAIPT intervention in this study because social interaction took place within a framework of sound instructional principles.

The success of CAIPT intervention in this study is noteworthy also because the intervention is relatively brief – 6 hours and 15 minutes. According to Ehri et al. (2001) phonological awareness instruction is most effective when it lasts between 5 and 18 hours rather than longer. However, the CAIPT intervention is intensive because it is daily and monitored. Although adult observers did not engage with the students in the study during the intervention, simply having an adult positioned on a chair a meter away from the activity may have encouraged the children to remain focused on the task at hand. Previous research has shown that when children at risk for learning disabilities receive phonological training that is daily, explicit, and administered in a one-to-one setting, a number of reading difficulties are overcome, especially if the intervention begins early (Stanovich, 1986; Torgesen et al, 2001; Vadasy et al., 2000). The daily training of the tutors and the structured delivery of instruction likely contributed to the positive outcomes in achievement for the children in the CAIPT group.

Results of this study show clear benefits for older and younger students participating in CAIPT, regardless of their role. Most reviews of the literature, however, suggest that in situations of cross-age peer tutoring, the magnitude of achievement gains for tutors is greater than for tutees. In a meta-analysis of 20 studies of reading interventions conducted from 1975 to 1995, Elbaum and colleagues (2000) found that the average effect size obtained on measures of reading for tutors in studies that incorporated cross-age tutoring is high (ES = .86) however, the magnitude of treatment effects for tutees was not statistically detectable (ES = -.07). The positive results for tutees in the current study are explained in part by: (1) the requirement that tutees retrieve prior knowledge and to put it to use; (2) tutees having to learn games that incorporated more advanced phonological skills than currently in their repertoire; and (3) opportunities for extended practice and reinforcement of prior and new knowledge - as the Romans commented – repetitio mater studiorum est (repetition is the mother of learning). Tutees in the CAIPT group received feedback (oral and visual) by the software and by the tutors. Verbal rewards and positive feedback increase intrinsic motivation (Deci, Koestner, & Ryan, 1999) and (4) CAIPT is viewed as pleasurable by the tutors, which in turn, contributes to their motivation to learn new concepts (Okolo, 1992). Evidence from the case study analyses suggests that tutees may have benefited from CAIPT intervention because they enjoyed the interaction with the software and their tutors.

In summary, findings from the present study show that computer-assisted phonological awareness instruction mediated by cross-age tutors (CAIPT) improves phonological processing for children who have been identified at-risk for reading problems, suggesting that CAIPT is a promising intervention program. The positive results of the study support the literature that suggests social interaction enhances instruction, however, results also indicate that intervention outcomes are positive when (1) the social interaction is guided by sound principles of instruction; (2) one member of the tutee-tutor pair (whether it be the tutor or tutee) is more proficient in the skill to be learned; and (3) children are enjoying the instructional activities.

Limitations

Several limitations of the study warrant discussion. First, participants in the study were not pre-tested on measures of phonological processing. The absence of a pre-test measure of phonological processing constrains interpretation of study results because it is unclear whether the gains in achievement of the CAIPT group were greater than for the PAI group. Although prior to intervention, a statistically detectable difference in the word identification abilities of children in the CAIPT and PAI groups is reported, it is possible that group differences in average performance on measures on phonological processing prior to intervention are not statistically detectable.

Second, the study does not include measures to determine whether study results are maintained over time or generalized to different settings or skills. Previous studies that examine the long-term effect of teacher-led instructional programs in phonological awareness demonstrate that children who receive training in phonological awareness tend to outperform their peers on subsequent measures of reading and spelling (Bryne & Fileding-Barnsley, 1995). The current study would be strengthened if measures of word recognition, reading fluency and spelling were included at the conclusion of the study.

Third, the study did not control for differences in treatment outcomes that may have resulted from variation in the amount of time student's have previously spent participating in phoneme awareness training or using computer software that teaches phoneme awareness. It is also possible that some children were receiving additional tutoring during the course of the intervention. Although parents were asked not to enrol their children in additional tutoring, no attempt was made to determine whether parents had adhered to the request.

Educational Implications

Results from this study add to the body of intervention literature on phoneme awareness training by examining an intervention that could easily be translated for use within a cross-grade primary classroom (i.e., grade K-1, 1-2 or grade 2-3). CAIPT is an instructional model for teaching phonological skills to children at-risk for reading failure that likely lessens the burden on the classroom teacher. CAIPT promotes the use of differentiated instruction in the classroom because the software monitors the phonological abilities of each child and instruction is tailored towards the student's specific needs.

CAIPT of children only a few years apart in school may have an impact on the participant's social development and self-esteem. Students with learning disabilities are more vulnerable to academic failure, which in turn can result in lowered self-esteem, a poor self-concept and social challenges (Elbaum & Vaughn, 2003). Participation in peer-tutoring may be helpful because children from the same school work together on valued tasks. Fuchs et al. (2002) assert that children with learning disabilities who participate in peer tutoring are more accepted than their counterparts in classrooms that do not participate in peer tutoring.

Future Directions

While results of this study contribute to the growing body of literature about what constitutes effective instruction in phonological awareness for children at-risk for reading disabilities, several questions requiring further exploration become apparent. First, future research is needed to investigate whether CAIPT can be embedded and successfully delivered within the regular classroom curriculum. Second, while short-term benefits of CAIPT are reported, more information is required about the maintenance and generalization of treatment effects. Replication of the study is necessary to determine the extent to which the study results are robust over time and to different settings. Third, more research is required to investigate individual differences in response to CAIPT. It is important to determine whether specific components of instruction explain treatment effects – characteristics of the tutees/tutors, the software, or an interaction between characteristics of the children in the treatment program and the instructional procedures.

Finally, a limited number of studies exist that investigate the efficacy of CAIPT interventions in cross-cultural contexts and in languages other than English. Whether CAIPT is an appropriate instructional method for children who attend schools in cultures outside of the North American context has rarely been investigated. Moreover, it is not clear whether CAIPT is effective at improving the phonological abilities of children who speak an alphabetic language with a shallow orthography. For example, compared to English, the Bulgarian language has a shallow orthography. Whether CAIPT is equally effective for children who speak Bulgarian as for children who speak English requires further study.

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Appendix A
Ethics Approval

SIMON FRASER UNIVERSITY

OFFICE OF RESEARCH ETHICS

BURNABY, BRITISH COLUMBIA
CANADA V5A 1S6
Telephone: 604-291-3447
FAX: 604-268-6785

December 24, 2002

Ms. Irina Tzoneva
Graduate Student
Faculty of Education
Simon Fraser University

Dear Ms. Tzoneva:

Re: Cross-Age Peer Tutoring: The Effects of Computer-Assisted Instruction in Developing Phonological Awareness

I am pleased to inform you that the above referenced Request for Ethical Approval of Research has been approved on behalf of the Research Ethics Board. This approval is in effect for twenty-four months from the above date. Any changes in the procedures affecting interaction with human subjects should be reported to the Research Ethics Board. Significant changes will require the submission of a revised Request for Ethical Approval of Research. This approval is in effect only while you are a registered SFU student.

Your application has been categorized as 'minimal risk" and approved by the Director, Office of Research Ethics, on behalf of the Research Ethics Board in accordance with University policy R20.0, http://www.sfu.ca/policies/research/r20-01.htm. The Board reviews and may amend decisions made independently by the Director, Chair or Deputy Chair at its regular monthly meetings.

"Minimal risk" occurs when potential subjects can reasonably be expected to regard the probability and magnitude of possible harms incurred by participating in the research to be no greater than those encountered by the subject in those aspects of his or her everyday life that relate to the research.

Best wishes for success in this research.

Sincerely,

Dr. Hal Weinberg, Director
Office of Research Ethics

Appendix B
Behaviour Assessment Record of Tutor-Tutee Session – Running Record

Addressing by name - e.g. *Nikki, This game will teach you how to make long words.*	
Modelling an activity – e.g. *This is how we play this game.*	
Talk-through an activity – e.g. *First I am listening to see if these 2 sounds are the same. I am repeating them silently in my head and if I think that they are the same, I click here.*	
Praise – e.g. *Good job; Super-duper, etc.*	
Specific praise – e.g. *Good job at findings "t" in "cat*	
Use of negative language – e.g. *No, don't do that!*	
Carrying out a dialogue (more than 2 exchanges in total) initiated by the tutor	
Carrying out a dialogue (more than 2 exchanges in total) initiated by the tutee	
Providing corrective feedback – e.g. *This is not quite right because…*	
Focusing attention – e.g. *Listen carefully.*	
Off-task behaviour	

Appendix C
Prompts

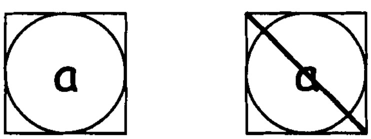
1. Karloon's Balloons

Pause the game every 3-3-4 times and ask the tutee to tell you the names of the objects/digits/sounds.

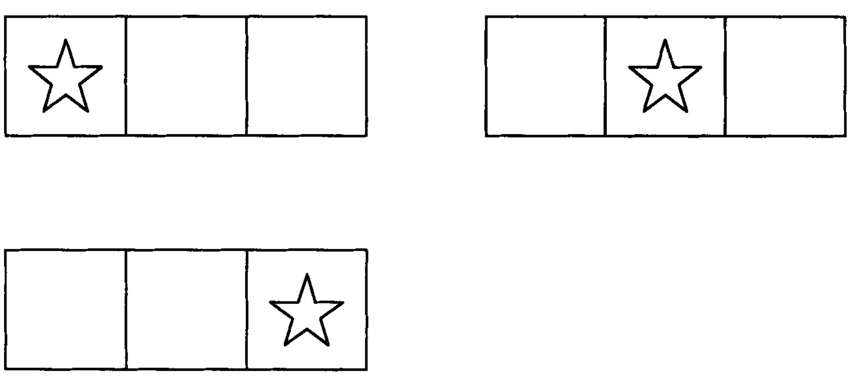
2. C.C. Coal Car

The prompts for this game are presented when the game is introduced.

Show me the no sign.



Which star is at the beginning/ in the middle/ at the end?



3. Rap-a-Tap-Tap

Wait until the drummer stops playing.

Click one time for every beat.

4. Caterpillar Connection

Say the words that Katie P is saying for yourself. Now say them quickly together.

5. Rhyme Time

Say the words that Bog Frog is saying for yourself. Do they sound the same?

6. Basket Full of Eggs

Listen carefully!

Do the sounds sound the same?

Appendix D
Undergraduate Student's Checklist

	YES	NO
1. Gain attention.	☐	☐
2. Pick first game.	☐	☐
3. Introduce activity.	☐	☐
4. Set a purpose for the activity.	☐	☐
5. Introduce/reinforce the rules of the game.	☐	☐
6. Explain the different concepts involved with a particular game – rhyming, blending, counting, no sign, etc.	☐	☐
7. Recall prior knowledge.	☐	☐
8. Model the activity.	☐	☐
9. Direct the behaviour of the student - Avoid giving answers.	☐	☐
10. Repeat procedure, step 2-9 with the second and third game.	☐	☐
11. Provide continuous feedback.	☐	☐
12. Praise, praise, praise.	☐	☐
13. Assess performance with the tutor and tutee.	☐	☐
14. Print out progress chart and make sure all the checklists for the day are completed.	☐	☐

Appendix E
Tutor's Checklist

	YES	NO
1. We played 3 different games today.	☐	☐
2. I explained the game to my student.	☐	☐
3. I listened to my student.	☐	☐
4. I told my student "good job".	☐	☐
5. I wrote 2 sentences in my diary.	☐	☐
6. I think the session was good.	☐	☐

Appendix F
Checklist for Tutees

WHICH COMPUTER GAME DID I LIKE THE MOST TODAY?

Games