

Abstract

EFFECTIVENESS OF A COMPUTER LITERACY INTERVENTION FOR YOUNG  
CHILDREN WITH ATTENTION AND READING PROBLEMS

by

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An adverse relationship between inattention and literacy has been documented in the research literature. This relationship appears to be pervasive and detrimental, leading many inattentive children to fall significantly behind their peers in reading achievement. However, research on interventions for children with early attention and early reading problems is sparse. A few studies, though, have highlighted the potential of Computer-Assisted Intervention (CAI) for this population, likely because its format is interactive and engaging. The current study tested the effectiveness of a literacy-based CAI, *Earobics*<sup>®</sup> Step 1 interactive software, with three first grade children who were rated by their teachers as having attention and reading problems. It was hypothesized that the *Earobics*<sup>®</sup> intervention would improve the participants' oral reading fluency, phoneme segmentation fluency, and attention to task. The intervention was implemented in the school setting with each participant for 20 minutes 4 days a week for 4 weeks. A multiple

baseline across participants design was used to determine intervention effectiveness. Reading progress was monitored using Dynamic Indicators of Basic Early Literacy Skills (DIBELS) oral reading fluency and phoneme segmentation fluency probes twice a week, and attention to task was monitored twice a week using systematic direct observation. Results indicate that all participants increased their oral reading fluency, phoneme segmentation fluency, and attention to task after the *Earobics*<sup>®</sup> intervention was implemented compared to baseline functioning. Given the multiple baseline across participants design, it can be conclusively determined that the *Earobics*<sup>®</sup> intervention was effective in improving the participants' oral reading fluency while it cannot be confirmed that the *Earobics*<sup>®</sup> intervention was responsible for the increases in phoneme segmentation fluency and attention to task. A graphical depiction of the results across subjects is presented, and the implications of the findings are discussed.



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## CHAPTER I: INTRODUCTION

Attention is a necessary component for the process of learning to occur. Children must attend to teacher instruction and class assignments in order to be academically successful. Attention is critical for literacy development in particular; young children must attend to and become aware of the different sounds and blends that make up words (phonemic awareness) as a precursor to formal reading instruction. Yet attention problems are relatively common among school-aged children. A survey conducted by Wolraich, Hannah, Baumgaertel, and Feurer (1998) found that over 15 percent of elementary school children display frequent inattention and/or poor concentration. The prevalence of attention problems in children is also apparent in the abundance of children diagnosed with Attention-deficit/Hyperactivity Disorder (ADHD; 3-7% of school age children, American Psychological Association, 2000). The impact that ADHD has on children's achievement is often severe, with estimates of the overlap between ADHD and underachievement in school-aged children as high as eighty percent (Cantwell & Baker, 1991).

### *The Link between Inattention and Reading Problems*

Numerous studies have documented a link between ADHD and reading problems (e.g., Riccio & Jemison, 1998; Willcutt & Pennington, 2000), with inattention being the strongest mediator. For example, Willcutt and Pennington (2000) found that the association between reading disability and ADHD was stronger for symptoms of inattention than for symptoms of hyperactivity/impulsivity. In addition, Carroll,

Maughan, Goodman, and Meltzer (2005) found that the relationship between ADHD and literacy difficulties was mediated by inattention and not hyperactivity.

Not only are children with ADHD at-risk for reading problems but so are children with elevated but subclinical levels of inattention. Longitudinal studies investigating the relationship between inattention and reading achievement in elementary school children show that even subclinical levels of inattention appear to have long lasting effects on children's reading achievement. Merrell and Tymms (2001) found that children whose teachers rated them as inattentive at the beginning of formal schooling had increased academic difficulties over the following year. Likewise, Morgan, Farkas, Tufis, and Sperling (2008) found that children who displayed poor task engagement in first grade were more likely to have reading difficulties in third grade.

Rabiner, Coie, and the Conduct Problems Prevention Research Group (CPPRG) (2000) also provided compelling evidence for the adverse relationship between inattention and reading achievement. They tracked internalizing and externalizing behaviors in 387 students from kindergarten through fifth grade. They found that attention problems in the first grade predicted children's reading achievement, even after controlling for IQ, prior reading achievement, and parental involvement, and that the negative effect of attention problems on reading achievement was often substantial. For example, about one third of the children who were reading in the normal range during kindergarten but who were highly inattentive during first grade had reading outcomes in fifth grade that were more than one standard deviation below those of their peers. Because first grade is a critical time for the attainment of early reading skills (i.e.

phonetic decoding), Rabiner et al. (2000) hypothesized that early attention problems may interfere with the acquisition of early reading skills, leading these inattentive children to fall significantly behind their peers.

Based on the above findings linking inattention and reading problems during the elementary school years, researchers are beginning to investigate whether this relationship exists during the preschool years. Preschool is a critical time in which children are acquiring preliteracy skills, which are then used to develop basic reading and decoding skills when they enter formal schooling. Studies have shown that children who enter school without adequate preliteracy skills tend to have greater reading difficulties and are less likely to catch up to their peers when they fall behind (Spira, Bracken, & Fishel, 2005). Arnold (1997) found that inattention mediated the relationship between low emergent academic skills and disruptive behaviors in preschool children, while Lonigan et al. (1999) found that higher levels of inattention predicted the possibility of preliteracy skill delay in preschool children. Walcott, Scheemaker, and Bielski (2009) extended this research by documenting that higher levels of preschool inattention predicted lower levels of specific preliteracy skills (i.e. phonemic awareness and letter naming) one year later when the children were in kindergarten. In addition, children with attention problems in preschool showed a flatter learning slope for initial sound fluency from preschool to kindergarten than did children without attention problems. Similar to Rabiner et al. (2000), Walcott, Scheemaker, and Bielski (2009) hypothesized that early attention problems may interfere with the acquisition and development of key preliteracy skills, namely phonemic awareness and letter naming fluency.

Based on the above findings, it appears that the adverse relationship between inattention and literacy development exists in the ADHD population, in school-aged children with subclinical levels of inattention, and even among preschoolers with significant attention problems. The effect that early attention problems has on literacy appears to be pervasive and detrimental, leading many inattentive children to fall significantly behind their peers in reading achievement. Because ADHD is often not diagnosed until later elementary school years, children who display early attention problems may “fall through the cracks and fail to receive assistance that could enhance their short- and long-term reading outcomes” (Rabiner et al., 2000, p. 866).

*Research on Literacy Interventions for Children with Inattention*

The above studies highlight the need for screening for early attention problems and for providing subsequent early reading intervention. However, the research on interventions for children with early attention problems is sparse. Rabiner, Malone, and the CPPRG (2004) examined the impact of an intervention package that included traditional tutoring, a classroom-wide social-behavioral intervention, and a weekly parenting program on early reading achievement in first-grade children with and without significant attention problems. The authors hypothesized that if early attention problems interfere with the acquisition of early reading skills, then supplemental instruction in phonetic decoding in a one-on-one context (e.g., the traditional tutoring part of the intervention package) would be effective in preventing these inattentive children from falling significantly behind their peers in early reading, presumably because children with attention problems are more likely to focus during one-on-one instruction. In addition,

they examined whether attention problems moderated the impact of tutoring on early reading development. The approximately 34-week tutoring intervention consisted of three 30-minute sessions per week of individual reading instruction that emphasized phonetic decoding skill acquisition. They found that the intervention package provided modest reading achievement benefits for inattentive children without early reading difficulties and substantial benefits for children with early reading difficulties who were not inattentive. However, children who were both inattentive and poor early readers did not benefit from the tutoring intervention. After determining that children with both significant reading delays and inattention were no less likely to miss an intervention session than the other two groups, the authors posited that the intervention may have been unsuccessful with this group because they did not attend adequately during the intervention sessions. However, they did not directly measure attention to task during the intervention sessions, so this conclusion is an assumption.

#### *The Potential of Computer-Assisted Instruction*

Because inattentive children often have difficulty maintaining focus, computer-assisted instruction (CAI) has the potential to be an effective instructional alternative because it can be game-like and engaging. Many forms of CAI allow students to focus their attention on academic tasks by presenting individualized instructional objectives, using multi-sensory modalities, and providing immediate feedback about accuracy of responses (DuPaul & Eckert, 1998). Despite the potential of CAI, few studies have investigated its effectiveness with inattentive children. Kleiman, Humphrey, and Lindsay (1981) found that a CAI drill and practice mathematics program produced significantly

more work completion behaviors in ADHD children than a paper-and-pencil format. Ota and DuPaul (2002) found that a CAI significantly improved math performance among older elementary students with ADHD.

One prior study has examined the impact of CAI on reading. Using a single-subject design, Clarfield and Stoner (2005) examined the effectiveness of the Headsprout computerized reading program on the oral reading fluency of three boys, ages six to seven years old. This CAI targets both phonemic awareness and phonics skills. All three boys met DSM-IV criteria for ADHD, one with inattentive only concerns, the other two with combined inattention and hyperactivity. The CAI was administered for eight to 10 weeks, depending on the child, three days per week for 20-30 minute sessions. They found the mean level of oral reading fluency to increase from baseline to intervention phases for all three boys. Additionally, they found greater rates of growth during intervention as compared to baseline rates, and the multiple baseline design found that reading improvements immediately followed the introduction of the intervention.

The above studies provide preliminary evidence for the effectiveness of CAI with children with ADHD. However, further research is needed to investigate whether CAI is an effective instructional alternative for children who have subclinical levels of attention problems and early reading problems.

#### *Purpose and Significance of Study*

Because children who are both significantly inattentive and poor early readers are the ones who need early intervention the most, Rabiner et al.'s (2004) finding that their traditional tutoring intervention was ineffective for these children is dismaying. However,



research on CAI approaches suggests this may be a viable option (Clarfield & Stoner, 2005). Using a game-like format, inattentive children may find CAI to be more engaging than an intervention that uses a more traditional drill-and-practice format.

Additionally, instead of employing a phonics-based approach, an intervention that includes both phonemic awareness training and phonics may be more relevant for poor readers with significant attention problems. Research on inattention and preliteracy development in the preschool population suggests that these children may have not acquired the appropriate preliteracy skills that are the building blocks to the development of phonetic decoding. Children who have not adequately acquired phonemic awareness skills may have added difficulty decoding words using phonics. This hypothesis is supported by research by Walcott et al. (2009) who found that children with and without significant attention problems differed in the development of initial sound fluency. Therefore, the present study's intervention tested an empirically-validated CAI in which both phonemic awareness and phonics skills are taught through the use of colorful, motivating, and interactive games.

### *Statement of Problem*

Prior research has documented a significantly adverse relationship between attention problems and children's literacy development. These studies highlight the need to screen for inattention and preliteracy problems so that early interventions can be implemented. However, there is little research investigating the effectiveness of academic interventions for children with both early reading and attention problems. Because the literature highlights the potential of CAI for children with significant attention problems,

this study extended this research by examining the effectiveness of a CAI, which utilizes a game format and specifically targets phonemic awareness and phonics skills, for first grade students who have elevated teacher-rated attention problems and poor early reading skills.

#### *Definitions of Pertinent Concepts*

For the purposes of this study, significant inattention refers to teacher-rated inattention scores that are more than one standard deviation above the norm-referenced mean score, as measured by the *BASC-2* Attention Problems subscale. Early reading difficulty refers to students who have teacher-reported reading difficulties relative to peers. Computer-assisted intervention (CAI) refers to the *Earobics*<sup>®</sup> Step 1 interactive software designed for children ages four to seven.

#### *Research Questions*

The general study hypothesis is that the *Earobics*<sup>®</sup> CAI intervention will be effective in improving phonemic awareness skills and oral reading fluency for students with pre-intervention reading difficulties and attention problems. Based on the literature review, the following specific hypotheses are presented:

- H1. The CAI will improve participants' oral reading fluency relative to baseline functioning.
- H2. The CAI will improve participants' phoneme segmentation fluency relative to baseline functioning.
- H3. The CAI will improve participants' attention to task relative to baseline functioning.

## CHAPTER II: LITERATURE REVIEW

### *Prevalence of Attention Problems in School-Aged Children*

Attention is a vital component in the process of learning. Children must attend to teacher-directed instruction and assignments in order for them to learn the curriculum and succeed academically. However, attention problems are common among school-aged children. Wolraich et al. (1998) conducted a survey in which they questioned teachers of grades kindergarten through fifth grade about prevalence rates for Attention-deficit/Hyperactivity Disorder (ADHD) based on criteria listed in the Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition (DSM-IV). Teachers reported that over 15 percent of the children displayed frequent inattention and/or poor concentration. The prevalence of attention problems in children is also readily apparent in the fact that three to seven percent of school-aged children are diagnosed with ADHD (American Psychological Association, 2000).

### *ADHD and Achievement Problems*

Many children with ADHD also struggle with academic achievement. Cantwell and Baker (1991) report that as many as 80 percent of students with ADHD experience academic performance problems. In addition, it has been found that children with ADHD often score lower than normal or lower than control group children on standardized achievement tests (Barkley, DuPaul, & McMurray, 1990). A study conducted by Murphy, Barkley, and Bush (2002) also found that a population of young adults with ADHD had significantly less education, were less likely to have graduated from college, and were more likely to have received special educational services relative to their peers.

### *Inattention and Reading Problems*

Numerous studies have documented a link between ADHD and reading problems (e.g. Riccio & Jemison, 1998; Willcutt & Pennington, 2000; McGee, Prior, Williams, Smart, & Sanson, 2002; Carroll et al., 2005). Several studies have suggested that inattention and not hyperactivity/impulsivity is the strongest mediator between ADHD and reading difficulties. For example, Willcutt and Pennington (2000) compared a community sample of twins with and without reading disability to understand the relationship between reading disability and ADHD. They found that the association between reading disability and ADHD was stronger for symptoms of inattention than for symptoms of hyperactivity/impulsivity (i.e. 31% vs. 22% in boys and 22% vs. 8% in girls respectively). Additionally, Carroll et al. (2005) investigated the relation between specific literacy difficulties and psychiatric disorder in a large-scale national sample of children ages 9 to 15 years. They found the association between specific literacy difficulties, defined as reading or spelling scores well below predicted scores based on general intellectual ability, and ADHD were significantly mediated by inattentiveness and not hyperactivity/impulsivity.

### *Subclinical Levels of Inattention and Reading Problems*

In addition to the negative relationship between attention problems and reading problems in children diagnosed with ADHD, this relationship also appears to exist in children with elevated but subclinical levels of inattention who do not have a formal diagnosis of ADHD. Longitudinal studies of school-age children indicate that even

subclinical levels of inattention appear to have long lasting effects on reading achievement.

Merrell and Tymms (2001) examined the academic achievement and progress of a large sample of young children who were identified from teachers' ratings as having several behavioral problems of inattention, hyperactivity, and impulsivity. These children were followed from the start of formal education at age 4 to 5 years old to one year later when the children were 6 to 7 years old. Results of the study indicated that children who obtained high scores on the predominantly inattentive subtype of the behavior rating scale at the beginning of formal schooling had significantly lower reading achievement and showed less reading progress one year later than did children who were not rated as inattentive.

Using data from the *Early Childhood Longitudinal Study-Kindergarten Class* (ECLS-K) which is composed of a nationally-representative sample of elementary school children, Morgan et al. (2008) sought to determine whether children with behavior problems in first grade were more likely to experience reading problems in third grade. When testing whether one of five types of behavior (i.e. task engagement, self-control, interpersonal skills, externalizing problem behaviors, and internalizing problem behaviors) increased the risk for developing reading problems, they found that only poor task engagement in first grade elevated a child's odds of having poor reading skills in third grade and that this odds ratio was high (e.g. 3.07).

Rabiner et al. (2000) also provided especially valuable evidence for the adverse impact that inattention has on reading achievement. They examined whether attention

problems predict the development of reading problems and lead to clinically significant impairment in reading for some children. They also explored whether screening for attention problems would be a useful tool in identifying young children who are at-risk for reading difficulties. The researchers tracked internalizing and externalizing behaviors in 387 students from a longitudinal, multisite investigation of the development and prevention of conduct problems. These children were followed from kindergarten through fifth grade. The longitudinal investigation produced several compelling findings. First, they found that only attention problems, as opposed to other behavioral variables examined (i.e. hyperactivity, internalizing problems, and externalizing problems), predicted children's reading achievement, even after controlling for IQ, prior reading achievement, and parental involvement. Even more importantly, they found that the negative impact of inattention on reading achievement was often considerable. For example, they found that about one third of the children who were reading in the normal range during kindergarten but who were rated as highly inattentive during first grade had standardized fifth-grade achievement scores that were more than one standard deviation below those of their peers. Because first grade is when children are acquiring early reading skills (i.e. phonetic decoding), Rabiner et al. (2000) hypothesized that early attention problems interfere with the acquisition of early reading skills, leading these inattentive children to fall significantly behind their peers in reading achievement. Based on their findings, they highlight the possible practical benefits of screening for early attention problems during kindergarten and/or first grade, so that these children could be identified as at-risk for reading underachievement. Although they note that the false-

positive rate would probably be high, Rabiner et al. point out that fairly minor interventions could be implemented to help these children acquire necessary early reading skills.

*The Relationship between Inattention and Literacy Problems in the Preschool Population*

Because many studies have documented an adverse relationship between inattention and reading problems during the elementary school years, researchers are now beginning to examine whether this relationship occurs during the preschool years. During preschool, young children are acquiring preliteracy skills, defined as the skills that are developmental precursors to conventional forms of reading and writing (Whitehurst & Lonigan, 1998). These preliteracy skills are then used to develop basic decoding and reading skills when children enter formal schooling. Preliteracy skills have been found to be important predictors of later reading achievement (Spira & Fishel, 2005). Studies have indicated that children who enter school without adequate preliteracy skills tend to have greater reading difficulties and are less likely to catch up to their peers when they fall behind in reading (Spira et al., 2005). Thus, young children with attention problems may fail to acquire essential preliteracy skills before formal schooling begins, leading them to continually struggle with reading throughout their school experience (Spira & Fishel, 2005).

A few studies have examined this relationship between inattention and preliteracy development in the preschool population. Arnold (1997) explored the co-occurrence of externalizing behavior problems and emergent academic problems in a sample of 74 low-SES preschool boys. He found that inattention mediated the relationship between low

emergent academic skills and disruptive behaviors in these preschool children. Lonigan et al. (1999) also assessed the relationship between behavior problems and preliteracy skills in preschool children. Results indicated that while all of the problem behaviors were related to emergent literacy, inattention was most strongly and consistently associated with less well developed emergent literacy skills in the preschool population. These results suggest that high levels of inattention may place preschool children at risk for preliteracy skill development. The authors highlight that identification of children at-risk for later reading underachievement should employ assessment of both preliteracy skills and attention problems and that intervention efforts should focus on both areas.

Walcott et al. (2009) extended this research by measuring inattention and specific preliteracy skills across a one-year period. They sought to determine whether greater teacher-rated attention problems during preschool predicted lower preliteracy skill development at one-year follow-up and whether preliteracy skill trajectories differed for those with and without significant attention problems in preschool. Participants were 47 children who attended a public Pre-Kindergarten center. Teachers at the Pre-Kindergarten center rated children's level of attention problems using the Attention Problems scale on the *Behavior Assessment System for Children, Second Edition Teacher Rating Scale-Preschool Form*. Four key aspects of preliteracy skill were also measured: identification of phonemes, rhyme production, rapid naming, and alphabet knowledge. Multiple regression analyses indicated that higher levels of preschool inattention predicted lower levels of specific preliteracy skills (i.e. phonemic awareness and letter naming) one year later when the children were in kindergarten, even after accounting for initial language



ability and preschool preliteracy performance. In addition, when children who were rated as significantly inattentive in preschool were compared to children who were not, they found that children with attention problems showed a flatter learning slope for initial sound fluency (a measure of phonemic awareness) from preschool to kindergarten than did children without attention problems. Similar to Rabiner et al. (2000), Walcott et al. (2009) hypothesized that early attention problems may interfere with the acquisition and development of key preliteracy skills, namely phonemic awareness and letter naming fluency.

*The Need for Early Identification of and Intervention for Children with Attention Problems*

The above studies indicate that the adverse relationship between inattention and literacy development has been documented in the ADHD population, in school-aged children with subclinical levels of inattention, and even among preschoolers with elevated attention problems. This adverse relationship appears to be pervasive and detrimental, leading many inattentive children to fall significantly behind their peers in reading achievement. Children with ADHD are often not diagnosed until the later elementary school years after the critical period for the development of early reading skills (Walcott et al., 2009). Thus, children who display early attention problems may “fall through the cracks and fail to receive assistance that could enhance their short- and long-term reading outcomes” (Rabiner et al., 2000, p. 866).

These studies highlight the need for screening for early attention problems and for providing subsequent early reading intervention. Yet, there is little research on literacy

interventions for children with early attention problems. One study, conducted by Rabiner et al. (2004), has examined the effectiveness of tutoring in improving early reading achievement for children with and without attention problems. Based on the Rabiner et al. (2000) finding that attention problems during first grade predicted the development and persistence of reading difficulties five years later when the children were in fifth grade, the authors hypothesized that inconsistent attention to classroom instruction when early reading skills (i.e. phonetic decoding) are taught was the rationale for why these children had lower reading achievement. Thus, they believed that supplemental instruction in phonetic decoding in a one-on-one context would be effective in preventing these inattentive children from falling significantly behind their peers in reading achievement, presumably because inattentive children are more likely to maintain focus consistently during one-on-one instruction. The authors also examined whether attention problems moderated the impact of tutoring on early reading achievement.

Participants of the Rabiner et al. (2004) study were first-grade students who were part of the Fast Track project, which is a longitudinal investigation of the development and prevention of conduct disorder. The tutoring intervention, which consisted of three 30-minute sessions per week of individual reading instruction that emphasized phonetic decoding skill acquisition, was part of a comprehensive intervention package that also included a class-wide social-behavioral intervention and a weekly parenting program. Standardized reading achievement measures (i.e. the Letter-Word Identification subtest from the Woodcock-Johnson Psychoeducational Battery and the word-attack subtest from the Diagnostic Reading Scales) were administered at the end of kindergarten and first

grade to assess early reading ability. During the spring of kindergarten and first grade, participants' inattentive behavior was assessed by teacher ratings using the AD/HD Rating Scale.

The study had several important findings. First, similar to findings by Rabiner et al. (2000), Rabiner et al. (2004) found that attention problems in kindergarten predicted lower reading achievement scores at the end of first grade, even after controlling for IQ and earlier reading ability. Additionally, they found that attention problems did, in fact, moderate the impact of the tutoring intervention. As children's level of attention problems increased, the benefits associated with tutoring decreased substantially. They found that the intervention package produced modest reading achievement benefits for inattentive children without early reading difficulties and substantial benefits for children with early reading difficulties who were not inattentive. However, children who were both inattentive and poor early readers did not benefit from the tutoring intervention. After determining that children with both significant early reading delays and inattention were no less likely to miss an intervention session than the other two groups, the authors posited that these students may have been more difficult to consistently engage during tutoring than children with either problem alone, and thus did not benefit from the tutoring intervention. However, the authors did not measure children's level of engagement during the tutoring sessions, so they could not confirm that hypothesis.

#### *The Potential of Computer-Assisted Instruction*

Computer-assisted instruction (CAI) has the potential to be an effective instructional alternative for inattentive children, purportedly because it can be more

engaging and game-like than traditional instructional methods. Many CAIs offer specific features that help students with attention problems maintain their focus on academic tasks. Such features include presenting specific instructional objectives, highlighting essential material, using multi-sensory modalities, dividing content material into smaller units of information, and providing immediate feedback about accuracy of responses (DuPaul & Eckert, 1998).

Despite the potential of CAI, few studies have examined its effectiveness with children with attention problems. Kleiman et al. (1981) explored whether a CAI drill-and-practice mathematics program improved the attending behaviors of 18 children diagnosed as hyperactive or ADHD. They found that students completed almost twice as many problems in the CAI condition as compared to a paper-and-pencil condition. In addition, students in the CAI condition spent significantly more time working on problems than those in the paper-and-pencil condition. Although the study provides evidence that the CAI condition improved academic productivity, it is unclear whether the CAI condition improved the students' academic performance, as the study focused exclusively on productivity and not accuracy.

Ford, Poe, and Cox (1993) examined the effectiveness of several CAI programs on the attending behavior of 21 elementary-aged children diagnosed with ADHD. Using a within-subjects group design, participants participated in four CAI programs across a 4-week period: math drill and practice, math instructional game, reading drill and practice, and reading tutorial. Each program had a game and non-game format for comparison. They found that participants were significantly more attentive when the CAI included a

game format with animation. When the CAI included only drill-and-practice or tutorial instruction, significantly more nonattending behaviors were observed. Like the Kleiman et al. (1981) study however; Ford et al. (1993) did not examine the effects of the CAI programs on academic performance.

Ota and DuPaul (2002) extended Ford et al.'s (1993) findings by examining the effects of software with a game format on the math performance of children with ADHD. Using a single-subject, multiple baseline design, they compared the math software to a written seatwork condition to determine whether the math software would improve the attending behaviors of 3 fourth-to sixth-grade students with ADHD. In addition, they examined whether the math software would improve the students' math performance relative to typical math instruction. During the baseline phase, attending behavior was analyzed for all participants using the Behavioral Observation of Students in Schools twice a week during teacher-directed math sessions. In addition, Curriculum-Based Measurement (CBM) math probes were administered to each participant prior to the implementation of the intervention. During the experimental phase, the participants used the math software, Math Blaster, in their classroom three to four times a week for 20 minutes. The CAI took the place of independent seatwork during the experimental sessions. Results of the study indicate that there was an increase in active engaged time and a decrease in passive engaged time during the intervention phase for all participants. In addition, all participants showed an increase in correct digits per minute on the CBM probes during the intervention phase. Thus, these results suggest that use of CAI software

with a game format may be beneficial as a supplement to typical math instruction for children with ADHD.

Although the effects of CAI on math performance have been examined, only one prior study has examined the impact of CAI on reading performance. Clarfield and Stoner (2005) investigated a CAI, Headsprout, as an intervention for beginning reading instruction with 3 students, ages six to seven, who were identified with ADHD. They examined whether the CAI would improve the students' oral reading fluency and task engagement. The Headsprout CAI was selected because it focuses on explicit instruction in phonemic awareness and phonics and has animated lessons which are individualized and adapt to each child's pace. The researchers used a single-subject, multiple baseline design to examine the CAI's effects on oral reading fluency and task engagement. During the baseline condition, Dynamic Indicators of Basic Early Literacy Skills (DIBELS) Oral Reading Fluency first grade probes were administered once a week to each participant to obtain a measure of the participants' reading fluency prior to implementation of the CAI. In addition, direct observations of the participants' attending behaviors were conducted during the students' typical reading instruction to obtain a measure of the students' task engagement prior to intervention. During the experimental condition, the CAI was administered for eight to 10 weeks, depending on the child, three days per week for 20-30 minute sessions. Participants' task engagement was also measured while they used the CAI. Results of the study indicate that the mean level of oral reading fluency increased from baseline to intervention for all three participants. Additionally, they found greater rates of growth in words read correctly as compared to baseline rates. Providing more

evidence for the CAI's effect on oral reading fluency was that reading improvements immediately followed the introduction of the intervention. Also, they found that the introduction of the CAI produced immediate decreases in the rate of off-task behavior for all participants. This finding suggests that the participants were observed to be highly engaged during the CAI, as compared to teacher-directed instruction.

The above studies provide preliminary evidence for the effectiveness of CAI with children with ADHD. However, further research is needed to investigate whether CAI is an effective instructional alternative for children who have subclinical levels of attention problems and early reading problems. The present study extended the research on CAI by investigating the effectiveness of a CAI, *Earobics*<sup>®</sup> Step 1, for first-grade students who have elevated teacher-rated attention problems and poor early reading skills. Based on Rabiner et al.'s (2004) finding that their traditional tutoring intervention was ineffective for children with both early attention problems and reading problems, likely because the children did not adequately attend to the tutoring intervention, *Earobics*<sup>®</sup> Step 1 was chosen for the present study because it employs colorful, motivating, and interactive games. Using a game-like format, inattentive children may find the CAI to be more engaging than an intervention that utilizes a more traditional drill-and-practice format. The present study determined whether the participants found the *Earobics*<sup>®</sup> Step 1 CAI to be engaging by measuring participants' attention to task during the intervention sessions. The *Earobics*<sup>®</sup> Step 1 CAI was also chosen because it targets both phonemic awareness and phonics skill acquisition. Rabiner et al.'s (2004) tutoring intervention focused primarily on the acquisition of phonics skills. However, an intervention that includes both

phonemic awareness and phonics training may be more relevant for children who have significant early reading difficulties and attention problems. Research on inattention and preliteracy development in the preschool population suggests that these children may not have acquired essential preliteracy skills (i.e. phonemic awareness skills) that are needed for the development of phonetic decoding. Therefore, children who have not adequately acquired phonemic awareness skills may have added difficulty decoding words using phonics. Unlike the Clarfield and Stoner (2005) study which only measured whether the CAI improved participants' oral reading fluency, the present study specifically measured whether the *Earobics*<sup>®</sup> Step 1 CAI improved participants' phonemic awareness skills in addition to their oral reading fluency skills.



## CHAPTER III: METHOD

### *Participants*

All participants in this study were first grade children who attended Snow Hill Primary School in Greene County, North Carolina. All children received instruction in the regular education setting, and none had any medical diagnoses, including ADHD. The participants, one male and two females, (all African American) ranged in age from 6 years, 6 months to 7 years, 2 months. These children were selected to participate in the study based on teacher reports that indicated both attention and reading problems. Participant 1 and 2 received instruction in the same classroom while Participant 3 received instruction in another classroom.

Participant 1 is a 6 year, 6 month old male. His teacher completed the Attention Problems subscale from the *Behavior Assessment System for Children, Second Edition Teacher Rating Scale* (BASC-2 TRS). He received an Attention Problems T-score of 69, which falls at the 99<sup>th</sup> percentile. His teacher reported that he does not display hyperactive symptoms but does display significant inattention. She noted that he often daydreams and has trouble maintaining attention to class work. His teacher also reported that he was at a level 5-6 in reading based on the Diagnostic Reading Assessment (DRA), which falls three levels below expected grade level.

Participant 2 is a 6 year, 6 month old female. Her teacher also completed the Attention Problems subscale from the BASC-2 TRS. She received an Attention Problems T-score of 68, which falls at the 95<sup>th</sup> percentile. Her teacher noted that Participant 2 is

often fidgety, talkative, and has trouble maintaining attention to class work. In addition, her teacher reported that she was reading at a level 5-6 based on the DRA.

Participant 3 is a 7 year, 2 month old female. Based on the Attention Problems subscale from the BASC-2 TRS completed by her teacher, Participant 3 received an Attention Problems T-score of 70, which falls at the 97<sup>th</sup> percentile. Her teacher noted that she often daydreams and has trouble maintaining attention to class work. In addition, she indicated that Participant 3 was reading at a level 7-8 based on the DRA, which falls two levels below grade level.

### *Setting*

The study was conducted in the school setting. The intervention was implemented by the experimenter for two days of the week, Monday and Wednesday. During participant/experimenter sessions, a laptop computer was placed in an enclosed room and the participants used headphones in order to minimize distraction. The room was used mainly for storage and had several stacked boxes lining the wall. There was a small table in the center of the room, and the room was devoid of any wall hangings. Each participant followed the CAI for 20 minutes while the examiner systematically recorded his/her on-task behavior. The examiner sat beside the participant to help set up the computer program but otherwise did not interact with the participant.

The intervention was implemented by the participants' teacher for two days of the week, Tuesday and Thursday. During participant/teacher sessions, the participants used a computer available within the classroom and used headphones to minimize distraction

and classroom noise. The participants followed the CAI for 20 minutes with little or no teacher input.

### *Study Variables*

*Independent variable.* The independent variable is the *Earobics*<sup>®</sup> Step 1 computer-assisted intervention. *Earobics*<sup>®</sup> Step 1 is interactive software designed for children ages four to seven that provides individualized, explicit instruction in early literacy skills, including recognizing and blending sounds, rhyming, and discriminating phonemes within words. The program utilizes colorful and friendly cartoon characters that instruct students in how to complete the interactive exercises. The program contains a beginner, intermediate, and advanced level. As the students answer each question, the exercises automatically adjust to each student's individual level of ability, and this adaptive technology helps to minimize the child's frustration. *Earobics*<sup>®</sup> Step 1 contains five interactive games, C.C. Coal Car, Rap-A-Tap Tap, Caterpillar Connection, Rhyme Time, and Basket Full of Eggs (Cognitive Concepts, Inc., 1997).

In C.C. Coal Car, the child learns how to recognize long vowels, short vowels, and consonant sounds, and to identify the position of sounds within words. C.C. Coal Car introduces a target sound, such as the long vowel a. Then, sounds are presented and the child must determine whether the sounds they hear are the same as the presented target sound. With success, each train car is filled with coal. As the child progresses, more challenging sounds are presented, and he must determine the position of a sound in a word (i.e. beginning, middle, or end) (Cognitive Concepts, Inc., 1997).

Rap-A-Tap-Tap involves listening to a series of drum beats and clicking the mouse the correct number of times to reproduce the same sequence. The difficulty level increases in this game when the drum beats are presented closer together, and when drum beats are replaced with speech sounds and syllables. The child is rewarded for each success with a short musical interlude (Cognitive Concepts, Inc., 1997).

In Caterpillar Connection, the child learns to blend words into compound words, and blend syllables and sounds into words. Katy-Pillar's body is disconnected and a small word or sound is attached to each part of her caterpillar body. When the parts are put together, they combine to make a compound word. The child must click on the picture that corresponds to the compound word. The game becomes more difficult by increasing the time between words and by introducing more similar sounding response choices (Cognitive Concepts, Inc., 1997).

Rhyme Time uses animated frogs to teach rhyming skills. A number of frogs (starting at 3 and gradually increasing to 5) each say a word and the child must identify the one that does not rhyme. Then, the child is asked which frog said a word that rhymes with the given word (Cognitive Concepts, Inc., 1997).

In Basket Full of Eggs, the child learns to hear the differences between vowels and consonant-vowel combinations. The child must click on the pair of same-colored hens when they hear a pair of sounds that are the same and click on the white and brown hen couple when the sounds they hear are different. The vowel sounds and consonant-vowel combinations presented become increasingly similar as the child progresses (Cognitive Concepts, Inc., 1997).

The *Earobics*<sup>®</sup> software program is listed as an effective intervention for improving alphabets in the U.S. Department of Education's *What Works Clearinghouse* (Constantine, 2007). A randomized field trial of *Earobics*<sup>®</sup> software was conducted in the Los Angeles Unified School District in 2002. In this study, students in kindergarten through third grade who were identified with reading difficulties were randomly assigned to an experimental and a control group. The researchers administered the *ORAL-J: Early Literacy Achievement Test* and the *Test of Memory and Learning (TOMAL)* as a pretest and posttest assessment measure. In the experimental group, students received in-class instruction with the *Open Court Reading*<sup>®</sup> curriculum and additional instruction with *Earobics*<sup>®</sup> software for 30 minutes, 5 days per week. The control group only received in-class instruction with *Open Court Reading*<sup>®</sup>. Based on comparison of change in group means from pretest to posttest, the study found that students in the *Earobics*<sup>®</sup> group achieved significantly greater improvements in phonological awareness and memory than did those who received instruction with *Open Court Reading*<sup>®</sup> alone (Cognitive Concepts, 2003). Another study by Pokorni, Worthington, and Jamison (2004) compared the effectiveness of three computer-assisted interventions, Fast ForWord, Earobics, and LiPS, in improving phonological awareness skills. They found that Earobics was associated with significant gains on phonological awareness measures 6 weeks after intervention.

#### *Dependent Variables*

The dependent variables included phonemic awareness, oral reading fluency, and attention to task. The DIBELS measures are standardized and individually administered.

Attention to task was assessed using systematic direct observation procedures. Specific details about each measure are presented below.

*Phonemic awareness.* As a measure of phonemic awareness, DIBELS Phoneme Segmentation Fluency (PSF) probes were administered. For PSF, the examiner orally presents words of three to four phonemes. The child is then asked to segment and verbally produce the individual phonemes for each word. The final score is the number of sound segments produced correctly per minute. For the PSF measure, the two-week, alternate-form reliability is 0.88 and the one-month, alternate-form reliability is 0.79 in May of kindergarten. The concurrent, criterion-related validity of PSF with the Woodcock-Johnson Psycho-Educational Battery Readiness Cluster score is 0.54 in spring of kindergarten. The predictive validity of spring-of-kindergarten PSF with winter-of-first-grade Nonsense Word Fluency is 0.62, 0.68 with the spring-of-first-grade Woodcock-Johnson Psycho-Educational Battery Total Reading Cluster score, and 0.62 with spring-of-first-grade CBM ORF (Good & Kaminski, 2002).

*Oral Reading Fluency.* DIBELS Oral Reading Fluency (ORF) probes were administered. For ORF, the student is asked to read a grade-appropriate passage aloud for one minute. Word omissions, substitutions, and hesitations of more than three seconds are scored as errors, while words that are self-corrected within three seconds are scored as correct. The oral reading fluency rate is the number of correct words per minute. For the ORF measure, the test-retest reliabilities for elementary students range from 0.92 to 0.97, while the alternate-form reliability of different passages taken from

the same level ranges from 0.89 to 0.94. The criterion-related validity coefficient ranges from 0.52 to 0.91 (Good & Kaminski, 2002).

*Attention to Task.* To monitor attention to task during the CAI, on-task behavior was measured by systematic direct observation during two of the four intervention sessions per week. On-task behavior was defined as the student attending to and engaging with the computer game (e.g. looking at the computer, pressing or moving the mouse, talking to the observer about the task). The observer conducted 15 minutes of interval coding (every 15 seconds) to determine whether the student was displaying on-task or off-task behavior at the moment of observation (these were mutually exclusive categories). Percent on-task behavior was determined by dividing the number of intervals coded as on-task by the total number of observation intervals.

#### *Procedure*

A letter explaining the study and requesting participation was sent out to all first grade teachers at the primary school. Teachers interested in participating in the study were interviewed to discuss potential participants. A letter requesting participation in the study, along with a consent form, was sent out to eligible students. After participants were recruited, the participants' teachers completed the Attention Problems subscale from the BASC-2-TRS to rate the participants' level of inattention. The experimenter was trained in the administration of the DIBELS PSF and ORF measures using the Assessment Integrity Checklist, which is included in the DIBELS manual. The experimenter was also trained in the administration of systematic direct observation.

*Baseline condition.* ORF measures were administered to each student until a stable baseline was reached. PSF measures were also administered during this period, although these measures were not used to drive the multiple baseline design. During this period, the students' percentage of time on-task was monitored during small-group reading instruction for 15 minutes using systematic direct observation.

*Experimental condition.* Once a stable baseline was reached in ORF, the *Earobics*<sup>®</sup> Step 1 CAI was implemented with each participant for 20 minutes, four days a week, for 4 weeks. The order of presentation of the *Earobics*<sup>®</sup> Step 1 games was counterbalanced. During each session, the students played each game for 4 minutes. Students' percentage of time on-task during the intervention was monitored two of the four days a week using systematic direct observation. To monitor the student's fluency progress and to monitor the effectiveness of the intervention, the students were administered DIBELS PSF and ORF first grade probes twice a week for 4 weeks.

#### *Research Design*

The study utilized a single-subject, multiple baseline across participants design. In this design, a baseline is established for all participants. Once a stable baseline is established for the first participant, the independent variable is implemented for that participant only. During this time, baseline is maintained for the other participants for a predetermined amount of time. After this time period, the independent variable is then implemented with the second participant. This procedure is repeated with all other participants.



The multiple baseline across participants design controls for threats to internal validity by varying the length of the baseline for each participant. In this way, changes in the dependent variable can be attributed to the intervention and only the intervention if the changes in the dependent variable occur concurrently with implementation of the intervention. If a third variable was causing the changes in the dependent variable, then changes would occur across all participants at once, regardless of when the intervention is implemented (Riley-Tillman & Walcott, 2007).

In this study, a baseline was established for Participant 1. Then, the *Earobics*<sup>®</sup> Step 1 CAI was implemented for 4 weeks. For Participant 2, a stable baseline was established and maintained for 1 week longer than Participant 1. The *Earobics*<sup>®</sup> intervention was then implemented with Participant 2 for 4 weeks. A stable baseline was maintained for Participant 3 for one more week, and then the *Earobics*<sup>®</sup> intervention was implemented with Participant 3 for 4 weeks. If PSF and ORF increase only after *Earobics*<sup>®</sup> is implemented, it provides evidence that the intervention is improving the students' fluency and not an extraneous variable. The multiple baseline across participants design was also chosen because it is unethical to withdraw the intervention once the target academic behaviors (PSF and ORF) have improved and because one would not expect the students to lose the skills they learned after the intervention is withdrawn.

#### *Data Analysis*

Data for this study were examined by graphing each participant's progress in phoneme segmentation fluency and oral reading fluency over time as well as by graphing

their attention to task over time. Visual analysis of the graphs was used to determine whether a stable baseline had been reached (using ORF to drive the design) and whether the intervention phase corresponded with improved DIBELS fluency scores and increased on-task behavior for each participant. Mean level changes across phases, variability within and across phases, proportion of overlapping data across phases, immediacy/latency of effects, magnitude of changes in the dependent variable, and consistency of intervention findings across participants were considered. These data were used to determine whether the intervention improved participants' reading performance and attention to task relative to baseline functioning.

## CHAPTER IV: RESULTS

The participants' progress was monitored using DIBELS Oral Reading Fluency (ORF) and Phoneme Segmentation Fluency (PSF) probes administered bi-weekly for a period of four weeks. Attention to task during the intervention was also measured bi-weekly. The ORF data drove the initial timing for phase changes from baseline to intervention for this multiple baseline across participants design; when the ORF data were stable for each participant, the intervention was implemented for four weeks. As such, although PSF and attention to task data were obtained, only the ORF data can be directly tied to intervention effectiveness. Figure 1 displays a multiple baseline graph indicating each participant's progress in ORF after implementation of the intervention compared to baseline functioning. Figure 2 displays each participant's number of errors in ORF after implementation of the intervention compared to baseline functioning. Figure 3 displays a multiple baseline graph indicating each participant's progress in PSF after implementation of the intervention compared to baseline functioning. Figure 4 displays a multiple AB graph indicating each participant's progress in attention to task after implementation of the invention compared to baseline functioning (i.e. small-group reading instruction). A description of each participant's results follows.

### *Participant 1*

*Oral reading fluency.* Oral Reading Fluency is denoted by the solid lines with triangle markers in Figure 1. The mean number of words read correct (WRC) per minute for Participant 1 increased from baseline to intervention from 10 to 11.9. This represents a mean level increase in ORF of 1.9 WRC per minute from baseline to intervention. The

trendline for the baseline phase shows a slope of 0 WRC per day and 0 WRC per week, while the trendline for the intervention phase shows an increasing slope of 0.4 WRC per day and 2.8 WRC per week. Research by Deno, Fuchs, Marston, and Shin (2001) indicate that students in Grade 1 should gain approximately 1.80 Words Read Correctly (WRC) per week. Participant 1 exceeded this growth rate by gaining 2.8 WRC per week when after the CAI was implemented. The percentage of non-overlapping data points in the intervention phase compared to the baseline phase was 50 percent.

Each participant's number of errors/minute in ORF is denoted by the double lines with diamond markers in Figure 2. Participant 1's average number of errors/minute in the baseline phase was 6.5 errors/minute and 7.4 errors/minute in the intervention phase. This represents a mean level increase of 0.9 errors/minute in ORF from baseline to intervention.

*Phoneme segmentation fluency.* Phoneme Segmentation Fluency (PSF) is denoted by the dashed lines with square markers in Figure 3. The average number of correct phonemes per minute for Participant 1 increased from baseline to intervention from 6 to 7.9. This represents a mean level increase in PSF of 1.9 correct phonemes per minute from baseline to intervention. The trendline for the baseline phase shows an increasing slope of 0.79 correct phonemes per day and 5.53 correct phonemes per week while the trendline for the intervention phase shows an increasing slope of 0.09 correct phonemes per day and 0.63 correct phonemes per week. The percentage of non-overlapping data points in the intervention phase compared to the baseline phase was 25 percent.

*Attention to task.* Figure 4 displays each participant's attention to task. Attention to task during small-group reading instruction served as the baseline phase and attention to task during the *Earobics*<sup>®</sup> intervention served as the intervention phase. There was a mean increase from the baseline phase to the intervention phase in task attention from 81.1 percent on-task to 95.4 percent on-task. This represents a mean increase in task attention of 14.3 percent from baseline to intervention. The trendline for the baseline phase shows a decreasing slope of 0.33 percent per day and 2.31 percent per week while the trendline for the intervention phase shows a decreasing slope of 0.15 percent per day and 1.05 percent per week. The percentage of non-overlapping data points in the intervention phase compared to the baseline phase was 100 percent.

#### *Participant 2*

*Oral reading fluency.* The average number of words read correct (WRC) per minute for Participant 2 increased from baseline to intervention from 10 to 17.5. This represents a mean level increase in ORF of 7.5 WRC per minute from baseline to intervention. The trendline for the baseline phase shows an increasing slope of 0.03 WRC per day and 0.21 WRC per week while the trendline for the intervention phase shows an increasing slope of 0.02 WRC per day and 0.14 WRC per week. Participant 2 did not meet the average growth rate of 1.80 WRC per week (Deno et al., 2001) and only improved 0.14 WRC per week after the CAI was implemented. The percentage of non-overlapping data points in the intervention phase compared to the baseline phase was 75 percent.

Participant 2's average number of errors/minute in ORF in the baseline phase was 7.9 errors/minute and 8.0 errors/minute in the intervention phase. This represents a mean level increase of 0.1 errors/minute in ORF from baseline to intervention.

*Phoneme segmentation fluency.* The average number of correct phonemes per minute for Participant 2 increased from baseline to intervention from 13.7 to 42.1. This represents a mean level increase in PSF of 28.4 correct phonemes per minute from baseline to intervention. The trendline for the baseline phase shows an increasing slope of 1.22 correct phonemes per day and 8.54 correct phonemes per week while the trendline for the intervention phase shows an increasing slope of 1.29 correct phonemes per day and 9.03 correct phonemes per week. The percentage of non-overlapping data points in the intervention phase compared to the baseline phase was 100 percent.

*Attention to task.* There was a mean increase from the baseline phase to the intervention phase in task attention from 74.2 percent on-task to 87 percent on-task. This represents a mean increase in task attention of 12.8 percent from baseline to intervention. The trendline for the baseline phase shows an increasing slope of 1.64 percent per day and 11.48 percent per week while the trendline for the intervention phase shows an increasing slope of 0.37 percent per day and 2.59 percent per week. The percentage of non-overlapping data points in the intervention phase compared to the baseline phase was 88.9 percent.

### *Participant 3*

*Oral reading fluency.* The average number of words read correct (WRC) per minute for Participant 3 increased from baseline to intervention from 14.9 to 27.9. This

represents a mean level increase in ORF of 13 WRC per minute from baseline to intervention. The trendline for the baseline phase shows a decreasing slope of 0.6 WRC per day and 4.2 WRC per week while the trendline for the intervention phase shows an increasing slope of 0.87 WRC per day and 6.09 WRC per week. Participant 3 greatly exceeded the average growth rate of 1.80 WRC per week (Deno et al., 2001) and gained 6.09 WRC per week after the CAI was implemented. The percentage of non-overlapping data points in the intervention phase compared to the baseline phase was 42.9 percent.

Participant 3's average number of errors/minute in ORF in the baseline phase was 9.6 errors/minute and 8.1 errors/minute in the intervention phase. This represents a mean level decrease of 1.5 errors/minute in ORF from baseline to intervention.

The 7<sup>th</sup> data point in the intervention phase was deemed an outlier and was not used to compute the mean increase, trendline, or percentage of non-overlapping data points. The decision to exclude this data point was due to a long break from school between the 6<sup>th</sup> and 7<sup>th</sup> data point. The 7<sup>th</sup> data point was inconsistent with Participant 3's earlier performance while the 8<sup>th</sup> data point was more consistent with her previous performance. It appears that Participant 3 needed to re-orient to the tasks after the long break from school and was able to perform more consistently once she was able to reorient to the purposes of the intervention.

*Phoneme segmentation fluency.* The average number of correct phonemes per minute for Participant 3 increased from baseline to intervention from 28.1 to 54.8. This represents a mean level increase in PSF of 26.7 correct phonemes per minute from baseline to intervention. The trendline for the baseline phase shows an increasing slope of

1.59 correct phonemes per day and 11.13 correct phonemes per week while the trendline for the intervention phase shows an increasing slope of 0.47 correct phonemes per day and 3.29 correct phonemes per week. The percentage of non-overlapping data points in the intervention phase compared to the baseline phase was 100 percent.

*Attention to task.* There was a mean increase from the baseline phase to the intervention phase in task attention from 65.9 percent on-task to 97.5 percent on-task. This represents a mean increase in task attention of 31.6 percent from baseline to intervention. The trendline for the baseline phase shows an increasing slope of 1.12 percent per day and 7.84 percent per week while the trendline for the intervention phase shows a decreasing slope of 0.14 percent per day and 0.98 percent per week. The percentage of non-overlapping data points in the intervention phase compared to the baseline phase was 100 percent.



Figure 1. Participants' Progress in ORF

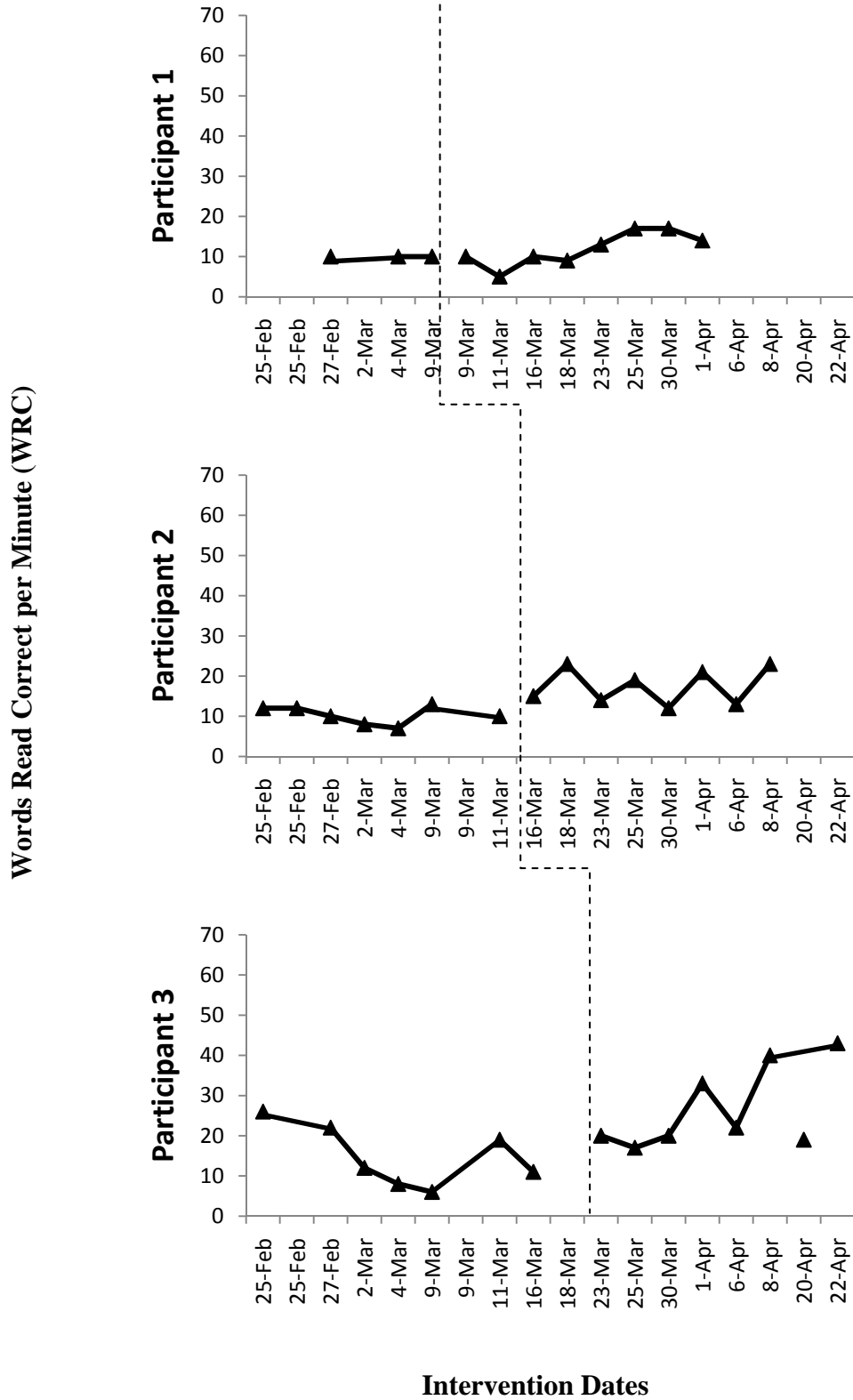


Figure 2. Participants' Number of Errors in ORF

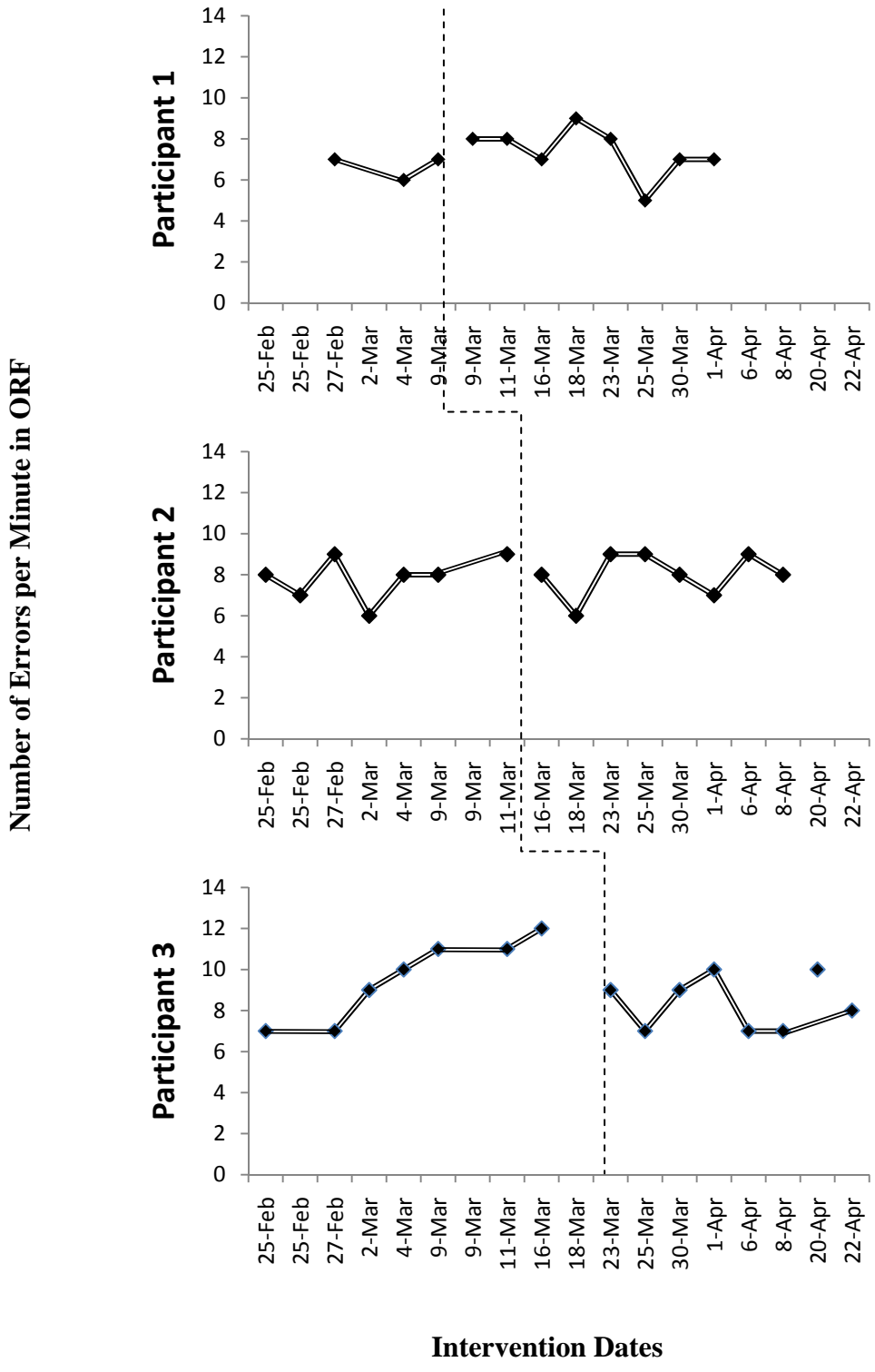


Figure 3. Participants' Progress in PSF.

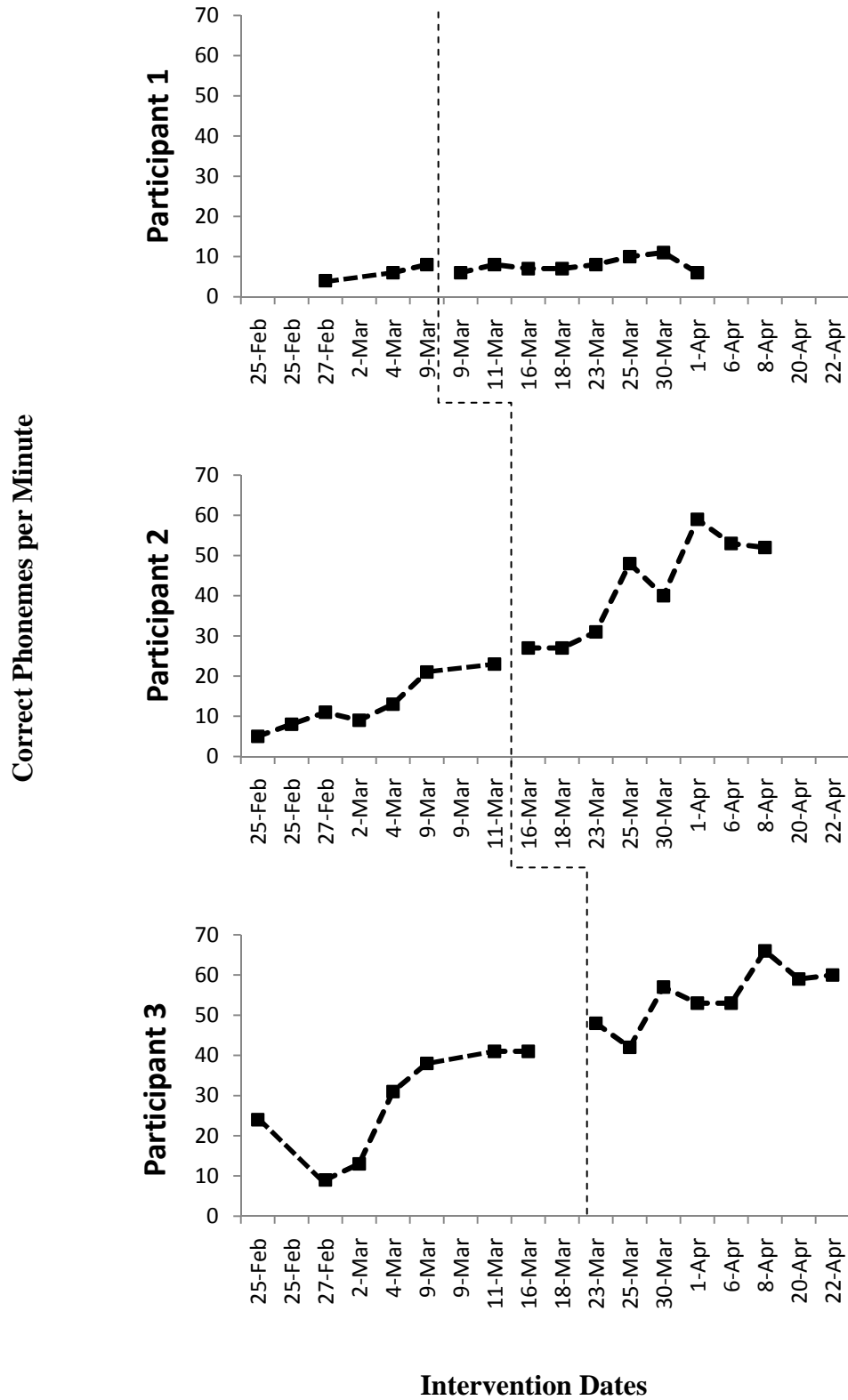
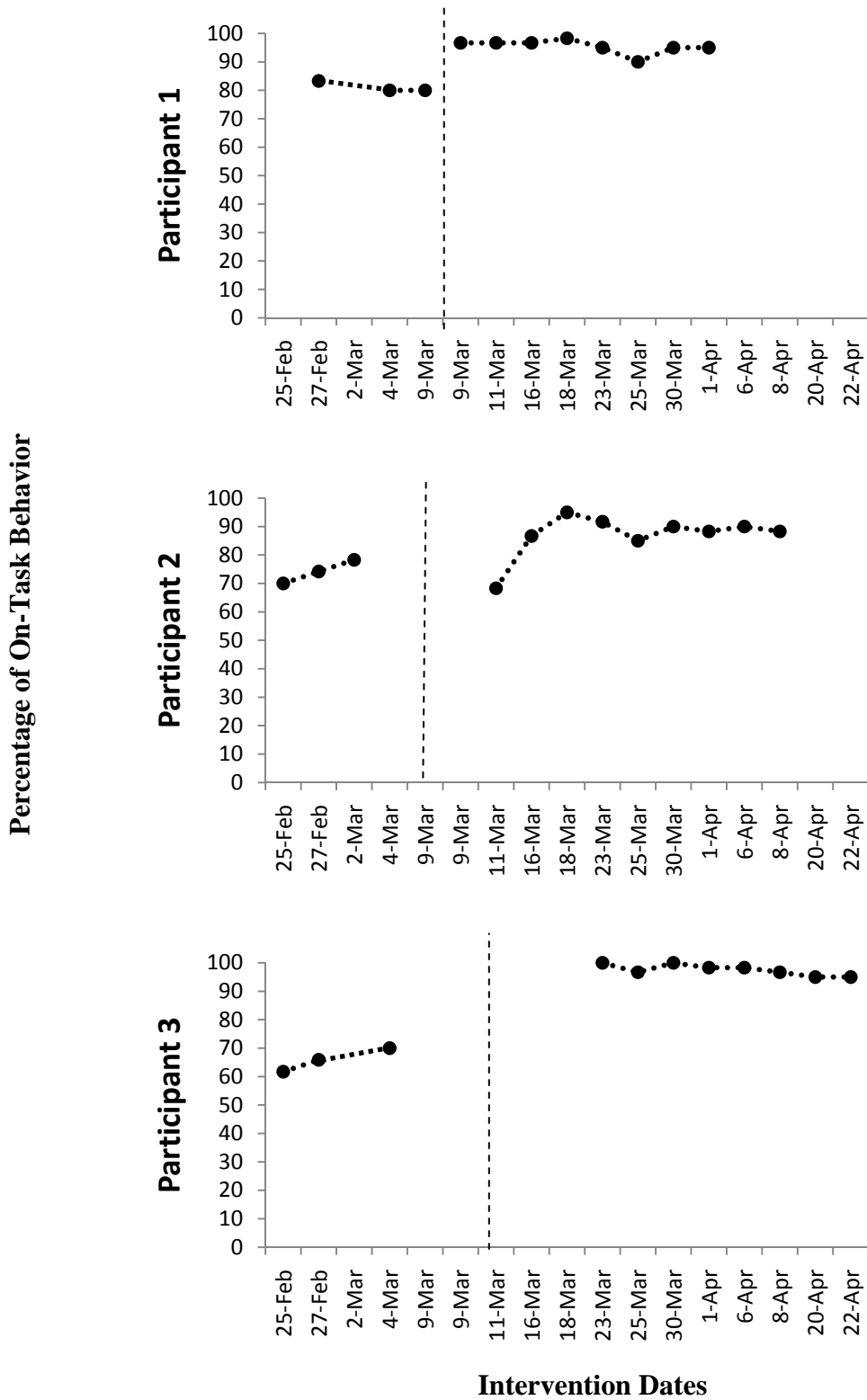


Figure 4. Participants' Progress in Attention to Task.



### *Hypothesis Testing*

A single-subject, multiple baseline, across participants design was used to test the study hypotheses. This experimental design was chosen because it utilizes the four steps of baseline logic: prediction, affirmation of the consequent, verification, and replication. The data collected during the baseline phase for Participant 1 served as the prediction step to confirm that had no independent variable been implemented, the dependent variable (i.e. ORF) would be expected to continue as observed. The intervention phase for Participant 1, when the Earobics<sup>®</sup> intervention was implemented, served as the affirmation of the consequent step. This step serves to provide evidence that a predicted change in the outcome data was due to implementation of the intervention. However, this step cannot yet be confirmed because another variable other than the intervention could be responsible for the change in the dependent variable. Thus, stable data were collected in the baseline phase for Participant 2 in the verification step. In this step, the baseline data for Participant 2 were collected and maintained for one week longer than Participant 1. By varying the length of the baseline for each participant, changes in the dependent variable can be attributed to the intervention and only the intervention if the changes in the dependent variable occur concurrently with implementation of the intervention. If a third variable was causing the changes in the dependent variable, then changes would occur across all participants at once, regardless of when the intervention is implemented. By implementing the intervention with Participant 2 and observing a similar change in the dependent variable, the replication step served to increase the likelihood that the intervention is controlling the changes in the dependent variable. Baseline data were

collected for Participant 3 to provide another verification step and the intervention was implemented to provide another replication step. These data served to provide further evidence that the intervention was responsible for the change in the dependent variable (Riley-Tillman & Walcott, 2007).

Hypothesis 1 predicted the following: The CAI will improve participants' oral reading fluency relative to baseline functioning. Results of the study indicate that all three participants increased their oral reading fluency relative to baseline functioning.

However, the increase in oral reading fluency was much more substantial for Participant 3 than for Participant 1 or Participant 2. Because the oral reading fluency data were used to drive the multiple baseline across participants design, baseline logic provides evidence for the effectiveness of the Earobics<sup>®</sup> CAI. Because the ORF data remained stable during the baseline phase for all participants and increased only when the Earobics<sup>®</sup> CAI was implemented with each participant, this provides evidence that the Earobics<sup>®</sup> CAI was responsible for the change in oral reading fluency.

Hypothesis 2 predicted the following: The CAI will improve participants' phoneme segmentation fluency relative to baseline functioning. Results of the study indicate that all three participants increased their phoneme segmentation fluency relative to baseline functioning. However, this finding was more substantial for Participant 2 and Participant 3 than for Participant 1. Because phoneme segmentation fluency data were not stable in the baseline phase for each participant but rather showed an increasing trend, it cannot be conclusively determined that the increase in phoneme segmentation fluency in the intervention phase was due to the Earobics<sup>®</sup> CAI or to an extraneous variable.

Hypothesis 3 predicted the following: The CAI will improve participants' attention to task relative to baseline functioning. Results of the study indicate that all three participants increased their attention to task during the Earobics<sup>®</sup> CAI compared to baseline functioning (i.e. small-group reading instruction). For task attention specifically, a multiple baseline across participants design was not used because data were only collected at the beginning of the baseline phase for each participant. However, the data could be interpreted instead as a multiple AB design, where A represents the baseline phase and B represents the intervention phase. Unfortunately, it cannot be conclusively determined that the Earobics<sup>®</sup> CAI caused the changes in attention to task. This is because an AB design cannot rule out if another variable was responsible for the changes in attention to task. However, despite this design limitation, it appears promising that the Earobics<sup>®</sup> CAI was more engaging than small-group reading instruction.

#### *Treatment Integrity*

Two teachers implemented the Earobics<sup>®</sup> CAI, one with Participant 1 and Participant 2 and another with Participant 3. These teachers were asked to implement the intervention with the participants two of the four days a week for a period of four weeks, which amounts to eight intervention sessions total. According to the intervention fidelity checklists provided to each teacher, Teacher 1 completed only two out of eight intervention sessions with Participant 1 and Participant 2 while Teacher 2 completed seven out of eight intervention sessions with Participant 3. However, the experimenter did implement the intervention with fidelity for all participants the other two days of the

week. Thus, Participant 1 and 2 did consistently receive the intervention but not at the same level of intensity that Participant 3 received the intervention.



## CHAPTER V: DISCUSSION

Research has documented a significantly adverse relationship between attention problems and children's literacy development. This relationship has been found in the ADHD population, in school-aged children with subclinical levels of inattention, and even among preschoolers with significant attention problems. This adverse relationship between early attention problems and literacy appears to be pervasive and detrimental, leading many inattentive children to fall significantly behind their peers in reading achievement. These studies highlight the need for early screening for inattention and preliteracy problems so that early interventions can be implemented. However, there is currently little research on interventions for children with both significant early attention problems and early reading problems. Rabiner et al. (2004) tested the effectiveness of a phonics-based tutoring intervention with first grade children with and without attention problems. They found that the phonics-based tutoring intervention was ineffective for students who were both inattentive and poor early readers, and posited that such dual-deficit readers may not have attended adequately during the intervention sessions. The authors did not, however, measure attention to task during the intervention sessions, so they could not test this hypothesis.

Because children who are both significantly inattentive and poor early readers are the ones who need early intervention the most, Rabiner et al.'s (2004) finding that their traditional tutoring intervention was ineffective for these children is dismaying. However, research on computer-assisted intervention (CAI) approaches suggests that CAI may be a viable option, likely because it can be game-like and engaging. Clarfield and Stoner

(2005) examined the effectiveness of the Headsprout computerized reading program on the oral reading fluency of three boys with ADHD and found that the CAI was effective in improving the oral reading fluency of all their participants. Clarfield and Stoner (2005) also measured participants' task engagement and found that the participants were more engaged during the CAI as compared to teacher-directed instruction.

The purpose of the present study was to examine the effectiveness of the *Earobics*<sup>®</sup> Step 1 CAI on the oral reading fluency skills, phonemic awareness skills, and attention to task of three first-grade students who have elevated teacher-rated attention problems and poor early reading skills. This study extended the research of Rabiner et al. (2004) by examining a CAI that targets not only phonics skills but also phonemic awareness skills. It was posited that an intervention that includes both phonemic awareness skills and phonics may be more relevant for poor readers with significant attention problems because these children may have not acquired the appropriate preliteracy skills that are the building blocks to the development of phonetic decoding. Unlike the Rabiner et al. study, this study also specifically measured the participants' attention to task during the *Earobics*<sup>®</sup> Step 1 intervention and compared it to participants' task attention during small-group reading instruction.

Because Clarfield and Stoner (2005) found that the Headsprout CAI was effective in improving the oral reading fluency of three boys with ADHD, the present study extended this research by testing the effectiveness of another empirically-validated reading CAI, *Earobics*<sup>®</sup> Step 1 interactive software. This CAI was chosen because it teaches phonemic awareness skills and phonics skills through the use of fun and engaging

games. It was posited that the *Earobics*<sup>®</sup> Step 1 CAI would be more engaging than traditional reading instruction, and therefore participants would better maintain their attention to the intervention. Unlike the Clarfield and Stoner study which used participants with ADHD, the present study utilized three first-grade participants who had elevated teacher-rated attention problems and early reading problems in order to investigate whether CAI may also be an effective instructional alternative for children who have subclinical levels of attention problems and early reading problems.

Results of the study indicate that all three participants had improvements in oral reading fluency and phoneme segmentation fluency relative to their baseline functioning. In addition, all participants increased their attention to task, when comparing attention to task during small-group reading instruction (baseline) versus attention to task during the *Earobics*<sup>®</sup> Step 1 intervention.

Participant 3 had the most dramatic improvements in oral reading fluency, phoneme segmentation fluency, and attention to task. This finding may be due to the fact that Participant 3 received the intervention more consistently and intensively than did Participants 1 and 2. This was due to problems with treatment fidelity on the part of one teacher, who inconsistently administered the intervention on the two days per week for which she was responsible. However, it is encouraging that all participants improved their oral reading fluency and phoneme segmentation fluency after the intervention was implemented, even when the intervention was only administered consistently by the experimenter two days per week.

The more dramatic improvements in Participant 3 may also be due to the fact that she was reading at a higher level prior to the intervention than the other participants, based on teacher report. However, Participant 3 was still reading two levels below the expected grade level while Participant 2 and 3 were reading three levels below the expected grade level pre-intervention. In addition, due to their differing instructional levels, Participant 3 was administered the advanced level of the *Earobics*<sup>®</sup> Step 1 intervention while Participant 1 and 2 were administered the beginner level. It may be that Participant 3's higher proficiency in reading pre-intervention allowed her to benefit more greatly from the intervention or that the skills taught in the advanced level of the intervention are more appropriate for improving oral reading fluency and phoneme segmentation fluency than the skills taught in the beginner level.

Yet another reason for Participant 3's greater improvements is that the DIBELS ORF probes (which were used to monitor intervention effectiveness) may have been more appropriate for measuring progress with Participant 3 than for Participants 1 and 2. Participant 3 was the only participant who reduced the number of ORF errors after the CAI was implemented compared to baseline functioning. According to the instructional hierarchy, a student must first acquire the skills of reading and become accurate in these skills (i.e. make few errors) before he can read fluently (i.e. rapidly and proficiently) (Daly, Lentz, & Boyer, 1996). The reduction in ORF errors observed by Participant 3 indicates that Participant 3 had acquired the appropriate reading skills and become accurate in these skills at an appropriate level to then develop fluency skills. Because Participant 1 and 2 did not reduce the number of errors when reading the ORF probes,

these data indicate that they had not yet developed an appropriate level of accuracy. Thus, because they were not yet accurate in their reading ability, the DIBELS ORF probes were likely frustrating to them and were a poor instructional match to measure their fluency skills. Oral Reading Fluency (ORF) was chosen as the dependent variable to determine intervention effectiveness because it is one of the best predictors of future reading performance (Hosp, Hosp, & Howell, 2007). DIBELS first grade ORF probes were used because these are the lowest level of DIBELS progress monitoring tools available for measuring oral reading fluency. However, this level of ORF probes was not appropriate for measuring the progress of Participants 1 and 2. The implication of this finding is that because DIBELS is often readily available to many schools, these schools will likely gravitate toward using DIBELS to monitor intervention progress, and DIBELS instructs teachers to use ORF probes to measure reading skills in first grade. However, even the lowest level of ORF probes may not be appropriate for every first grade child, as was found in the current study with Participants 1 and 2. Therefore, schools will need to use other measures to monitor progress in basic reading skills when the child's reading skills are so low that DIBELS ORF is not an appropriate measure of reading ability.

Given the multiple baseline across participants design, it can be concluded that although phoneme segmentation fluency increased for all participants, the increase cannot be decisively attributed to the *Earobics*<sup>®</sup> Step 1 intervention. This is because phoneme segmentation fluency data were not stable in the baseline phase for each participant but rather showed an increasing trend.

The increases found in oral reading fluency for all participants, however, are consistent with the introduction of the *Earobics*<sup>®</sup> Step 1 intervention. This finding is consistent with that of Clarfield and Stoner (2005) who found that the Headsprout CAI was effective in improving participants' oral reading fluency. Because oral reading fluency is the best predictor of future reading performance, this preliminary evidence suggests that the *Earobics*<sup>®</sup> Step 1 intervention may be a useful tool for helping children with early attention problems and reading problems catch up to their peers in reading achievement.

As for improving attention to task, it cannot be conclusively determined that the *Earobics*<sup>®</sup> Step 1 intervention caused the increases in attention to task relative to small group reading instruction. However, it seems likely that the *Earobics*<sup>®</sup> CAI was more engaging than small-group reading instruction for these participants. This finding is consistent with the finding of Clarfield and Stoner (2005) that their participants were more engaged in the CAI than teacher-directed instruction. Taken together, these findings suggest that CAI may be a useful instructional alternative for inattentive children because it is more engaging than traditional reading instruction.

A limitation of the study is that the participants' teacher was instructed to deliver the CAI for two of the four sessions per week, and the experimenter was unable to monitor whether the teacher was implementing the intervention with fidelity. However, this limitation was minimized by requiring the teachers to complete an intervention fidelity checklist at the end of each session. Despite providing a checklist, one of the teachers did not implement the intervention with integrity for Participants 1 and 2 while

the other teacher implemented the intervention more consistently with Participant 3. However, the experimenter did implement the intervention with fidelity for all participants two days of the week. Thus, Participant 1 and 2 did receive the intervention but not to the extent that Participant 3 received the intervention.

In addition, data concerning intervention acceptability were not conducted to determine whether the teachers found the intervention to be easy to implement and useful for their students. However, informal data obtained from periodic teacher interviews indicate that the participants' teachers found the intervention to be easy to administer to the participants and useful for improving the participants' reading skills.

Last, there were no controls in place to monitor what additional reading interventions may or may not have been occurring outside of the school setting. Thus, there is no way to know whether an additional intervention affected the results of the CAI intervention.

Directions for future research include examining the effectiveness of the *Earobics*<sup>®</sup> Step 1 CAI with a larger sample of young children with both attention problems and reading problems. Evidence for the effectiveness of the intervention with a large sample would increase the generalizability of the findings.

Results of the current study suggest that CAIs may be effective early interventions for young children with attention problems and reading problems. CAIs have the benefit of being highly engaging, as compared to traditional reading instruction, while also improving important literacy skills, such as phonemic awareness, phonics, and oral reading fluency. In addition, CAIs have strong utility for teachers because they are easy

to implement and could be easily incorporated into classroom reading instruction. The use of CAIs with children who are both significantly inattentive and poor early readers may be an effective solution for the pervasive problem of these children falling significantly behind their peers in reading achievement.



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## APPENDIX A- PARENT CONSENT FORM

### **Effectiveness of a Computer Literacy Intervention for Young Children**

Your child is invited to take part in a research study on reading development supervised by Dr. Walcott, an ECU Professor, and conducted by two students in the Department of Psychology at ECU.

#### WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of this study is to examine the relationship between specific types of reading skills and levels of inattention among children.

#### WHY WERE YOU SELECTED?

Your child is being invited to participate in this research study because his or her teacher thought your child would benefit from extra literacy instruction.

#### WHAT WILL BE DONE IN THIS STUDY?

If you consent for your child to participate, we will first ask his/her teacher to complete a behavior rating scale to measure attention skills, and we will observe him/her during regular small-group reading instruction (for school age children) or during reading time (for preschool age children) for about one week to measure his/her level of attention during reading activities. Next, we will ask your child to do a computer-based reading intervention called *Earobics*<sup>®</sup> with a graduate or undergraduate student in Psychology. Your child will do the reading intervention four times a week: two days per week with the student, and two days per week with your child's teacher. Your child will do the computer-based reading program for 20 minutes each day for a period of about 4 weeks. Each time your child uses the computer reading program with the student, his or her level of attention will be measured by simply marking whether he or she appears or does not appear to be engaged in the program. In addition, your child will be given the short, two-minute literacy measures. These measures will help us to monitor your child's reading progress.

#### **Description of Reading Intervention:**

*Earobics*<sup>®</sup> Step 1 is interactive software for children ages four to seven that provides individualized, explicit instruction in early literacy skills, including recognizing and blending sounds, rhyming, and discriminating phonemes within words. The program uses colorful and friendly cartoon characters that instruct students in how to complete the interactive exercises. The program contains a beginner, intermediate, and advanced level. As your child answers each question, the exercises automatically adjust to his/her individual level of ability, and this adaptive technology helps to minimize your child's frustration. Your child will likely find this type of reading instruction fun and engaging because it has a game-like format. We will ensure that your child receives this reading program during his/her regular reading instruction so that he/she does not miss instructional time in other important subjects.

### **Description of Literacy Measures:**

Get It Got It Go! Alliteration (for preschool age students only): For this measure of phonemic awareness, the child is shown one image at the top of each card (e.g., rain) and a set of three images in a row at the bottom of each card (e.g., house, rake, pig). The examiner asks the child to point to one of the three pictures at the bottom of the card with the same initial sound as the target picture.

DIBELS Phoneme Segmentation Fluency (for school age students only): This is a measure of your child's phonemic awareness (the ability to hear and manipulate sounds in words). In this measure, the examiner orally presents words of three to four phonemes. The child is then asked to segment and verbally produce the individual phonemes for each word. (Ex. The examiner says "Sam" and the child says /s/ /a/ /m/.)

DIBELS Oral Reading Fluency (for school age students only): This is a measure of your child's accuracy and fluency in reading. It is a strong predictor of future reading performance. In this measure, the child is asked to read a grade-appropriate passage for one-minute and the number of words read correctly in one minute is determined.

### **ARE THERE ANY BENEFITS FOR PARTICIPATING IN THIS STUDY?**

Participating in this reading intervention may help your child gain essential reading skills. Even if you do not think your child has significant reading problems, extra intervention can help to build reading fluency. Collecting this data will help us to better understand the relationship between inattention and development of reading skills in school-age children. Also, after collecting the data, we can share the reading results with your child's teacher.

### **WHAT ARE THE POSSIBLE RISKS OR DISCOMFORTS OF THE STUDY?**

The tasks are academic in nature, so we do not anticipate any serious risks for the children who participate. The only possible minor risk is that the child may become frustrated if he/she finds the task to be difficult. However, the computer-based reading program is designed to automatically adjust to your child's reading ability in order to minimize frustration. In addition, the computer program is designed to teach reading skills with a fun and engaging game-like format.

### **WHO HAS ACCESS TO RECORDS?**

The only people that will have access to the records are the researchers in the study, except for the reading results, which we will share with the children's teachers.

### **WHAT IF I WISH TO WITHDRAW OR NOT PARTICIPATE IN THE STUDY?**

Participation in this study is voluntary, and you or your child can refuse to participate or withdraw at any time without penalty.

WHAT IF I HAVE QUESTIONS ABOUT THIS STUDY OR MY RIGHTS AS A PARTICIPANT?

If you have any particular questions about this study, please contact the investigator, Christy M. Walcott, Ph.D. by phone: (252) 328-1378, e-mail: [walcottc@ecu.edu](mailto:walcottc@ecu.edu), or regular mail: 104 Rawl Bldg., ECU-Department of Psychology, Greenville, NC 27858.

If you have questions or concerns regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact – anonymously if you wish – the ECU University and Medical Center Institutional Review Board at (252) 744-2914, e-mail: [umcirb@ecu.edu](mailto:umcirb@ecu.edu), or regular mail: University and Medical Center Institutional Review Board, Life Sciences Building, Room 104, The Brody School of Medicine at East Carolina University, Greenville, NC 27834.

AUTHORIZATION

By signing below, you are agreeing to let your child \_\_\_\_\_ participate in the project called “**Effectiveness of a Computer Literacy Intervention for Young Children**” as described above.

Parent’s Signature \_\_\_\_\_ Date \_\_\_\_\_

Parent’s Name (please print) \_\_\_\_\_

Thank you and please return this part of the form to your child’s teacher using the enclosed envelope addressed to Christy Walcott or Katie McDuffy.



## APPENDIX B: UMCIRB APPROVAL



**University and Medical Center Institutional Review Board**  
East Carolina University  
Ed Warren Life Sciences Building • 600 Moyer Boulevard • LSB 104 • Greenville, NC 27834  
Office 252-744-2914 • Fax 252-744-2284 • [www.ecu.edu/irb](http://www.ecu.edu/irb)  
Chair and Director of Biomedical IRB: L. Wiley Nifong, MD  
Chair and Director of Behavioral and Social Science IRB: Susan L. McCammon, PhD

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TO: Christy Walcott, PhD, Department of Psychology, ECU, 104 Rawl Bldg.  
FROM: UMCIRB  
DATE: February 12, 2009  
RE: Expedited Category Research Study  
TITLE: "Effectiveness of a Computer Literacy Intervention for Young Children"

### UMCIRB #08-0771

This research study has undergone review and approval using expedited review on 2/6/09. This research study is eligible for review under an expedited category because it is research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies. (NOTE: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b)(2) and (b)(3). This listing refers only to research that is not exempt.). The Chairperson (or designee) deemed this **unfunded** study **no more than minimal risk** requiring a continuing review in **12 months**. Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The investigator must adhere to all reporting requirements for this study.

The above referenced research study has been given approval for the period of 2/6/09 to 2/5/10. The approval includes the following items:

- Internal Processing Form (dated 12/4/08)
- Informed Consent: Parent (dated 1/28/09)
- Letter of Support: Principal

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

**The UMCIRB applies 45 CFR 46, Subparts A-D, to all research reviewed by the UMCIRB regardless of the funding source. 21 CFR 50 and 21 CFR 56 are applied to all research studies under the Food and Drug Administration regulation. The UMCIRB follows applicable International Conference on Harmonisation Good Clinical Practice guidelines.**