The Efficacy of a Computer Program to Improve Phonological Awareness In Mid – Primary School Aged Children

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PART A CONTENTS

PART B ABSTRACT

This study explored the efficacy of a computer program in improving the phonological awareness skills of mid-primary school aged children with reading difficulties. In addition, it was also examined whether gains in phonological awareness were transferred to word recognition. The specificity of the computer program was assessed by monitoring the math skills of the participants' throughout the duration of the study.

A total of three participants, 2 males and 1 female, attending a mainstream school were involved in the study. Ages ranged from 9;10 to 11;5 years.

A single-subject experimental design with multiple baseline across participants was used. The study was broken down into three phases; baseline, intervention and follow up, with phonological awareness, math and word recognition assessed periodically. The participants received computer intervention for thirty minutes, three times a week, for either four or five weeks.

Visual analysis revealed that all participants increased their phonological awareness skills following introduction of the intervention. At the 16 week follow up, phonological awareness skills had remained above baseline measures. Math levels did not change in response to the computer training. Statistical analysis showed that two of the participants demonstrated significant gains in word recognition by the end of the study.

The results indicate that the computer program was successful and specific at improving the phonological awareness skills of the participants involved in the study. In conjunction with literature, this study supports the use of the computer program as an adjunct to a traditional, clinician-delivered therapy model.

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PART D STATEMENT OF AUTHORSHIP

I certify that the attached material is my original work. I declare that no other person's work has been used without due acknowledgement. Except where I have clearly stated that I have used some of this material elsewhere, it has not been presented by me for examination in any other course or unit at this or any other institution.

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All research procedures reported in the thesis were approved by the relevant Ethics Committee. In the current study, this was the La Trobe Faculty of Health Sciences Faculty Human Ethics Committee (reference: FHEC06/80) and the Department of Education and Training (reference: SOS003336).

PART E LIST OF FIGURES AND TABLES

CHAPTER 1 RESEARCH LITERATURE EVALUATION

1.1 INTRODUCTION

This literature review critically evaluated the literature pertaining to the relationship between phonological awareness and the acquisition of reading. Much research has demonstrated that phonological awareness is a strong predictor of later success in reading (Adams, 1990; Ball & Blachman, 1991; Bradley & Bryant, 1983; Brady, Fowler, Stone & Winbury, 1994; Bryant, Bradley, Maclean & Crossland, 1989; Hulme, Hatcher, Nation, Brown, Adams & Stuart, 2002; Muter, Hulme, Snowling & Taylor, 1998; Lundberg, Frost & Peterson, 1988; Rivers & Lombardino, 1998; Savage & Carless, 2005). However, there remains some controversy surrounding the exact nature of the relationship between these factors. Phonological awareness has been linked to reading acquisition when early research suggested that the more sensitive children are to the constituent sounds of speech, the better they tend to be at reading (Adams, 1990; Bradley & Bryant, 1983; Goswami & Bryant, 1990). In this review, almost three decades of research has been explored in an attempt to discuss the exact nature and extent of the relationship between phonological awareness and the acquisition of reading, as well as some of the interpretations that have been suggested by theorists. In addition, some of the additional factors, which may have influences the conclusions of previous studies, have been discussed.

1.2 READING ACQUISITION

What do children need to become successful readers? Reading is not a unitary skill. It involves a multitude of skills and it is not an all – or – none phenomenon, but a continuum that develops over time (Adams, 1990). She argues that becoming a proficient reader involves "an automatic capacity to recognize frequent spelling patterns visually and to translate them phonologically" (p. 293). Amongst other things, it involves being aware of the nature of print (that print represents speech), that speech is made up of individual words, that individual words are made up of individual letters and that individual sounds in words are represented by letters (Adams, 1990).

1.3 PHONOLOGICAL AWARENESS

Before reviewing the literature, it was critical to define phonological awareness, as it is a multi – level set of skills that has been defined slightly differently across various authors. To start with, the terms 'phonological awareness' and phonemic awareness' are often used synonymously in the literature. For the purpose of this paper, the term 'phonological awareness' has been used as defined by Gillon (2004). She defines the term 'phonological awareness' as "an individual's awareness of the sound structure, or phonological structure, of a spoken word" (p. 2).

It is widely recognized that phonological awareness is a multi – level skill that develops as children develop. Phonological awareness can be described as consisting of syllable awareness, onset – rime awareness and phoneme awareness.

Awareness that words can be divided into syllables is the most basic level of phonological awareness and comprises syllable awareness (Gillon, 2004). Adams (1990) argued that children develop syllable awareness first because the syllable is the natural phonological unit. Tasks that allow children to demonstrate syllable awareness include the segmentation of words into syllables. For example, being able to clap out the syllables in *kitten,* as in *ki – tten*, demonstrates awareness at the level of the syllable.

Onset – rime awareness reflects awareness at the intra – syllabic level and requires and understanding that syllables and words can be divided at the onset – rime level (Goswami & Bryant, 1990). The onset is otherwise known as the 'beginning' sound and the rime is otherwise known as the 'remaining unit of sound'. For example, in the word *cat*, the *c* is the onset and the *at* is the rime unit of the syllable.

Phoneme awareness reflects an awareness that words can be broken down into their smallest parts, the individual phoneme (Gillon, 2004). Phoneme awareness is reportedly the most complex level of phonological awareness and perhaps the level to cause the most controversy. Gillon (2004) described phonemes as an "abstract concept" (p. 7) as they are not necessarily audible as individual units in spoken speech. Instead, the individual phonemes are blended together and coarticulated to form syllables and words.

All children who learn to talk possess implicit awareness of phonemes. Castles and Coltheart (2004) stress the importance of the 'awareness' constituent of the term 'phonological awareness', arguing that phonological awareness at the level of the phoneme is more than the unconscious discrimination of speech sounds and involves "explicitly and deliberately processing and acting upon them" (p. 78).

1.3.2 Development of Phonological Awareness

Although researchers agree that phonological awareness typically develops from awareness of larger units (syllables) to intermediate units (onsets and rimes) to smaller units (phonemes), it remains unexplored whether each level is facilitated by the one before. If awareness of smaller units is, indeed, facilitated by awareness of larger units, one would expect that phonological awareness at any level would predict later reading ability. As explained below, this does not appear to be the case.

Liberman, Shankweiler, Fischer and Carter (1974) were among the first to discuss the development of phonological awareness. They found that young children capable of segmenting words into syllables found it significantly more difficult to segment words into phonemes. An increase in phoneme segmentation was noted in the first year of school, suggesting that both an increased level of intellectual maturity and possibly formal reading instruction were required for children to gain awareness at the level of the phoneme.

Burt, Holme and Dodd (1999) examined the development of phonological awareness and found that older children had greater levels of phonological sensitivity than younger children. Their results were also consistent with suggestions that phonological awareness may be influenced by socio – cultural factors (Justice & Pullen, 2003; Lonigan, Burgess, Anthony & Barker, 1998). Lonigan et al. (1998) made this claim based on their findings that children in middle income families had greater rates of growth in phonological awareness than did children in lower – income families. Children of higher socio – economic class had better syllable and onset – rime awareness and this was explained by the authors to be the result of a richer language learning environment and greater play activities.

While research suggests that there is a hierarchy among the three levels of phonological awareness, the order of development between the skills does not appear to be linear and each level does not appear to be facilitated by the one before.

1.4 THE ALPHABETIC PRINCIPLE

The Alphabetic Principle is defined as the relationship between letters (graphemes) and sounds (phonemes), and children must understand that individual phonemes can be represented by letters and that those letters and sounds can be analysed during the reading process (Nicholson, 1997).

1.5 PUTTING IT ALL TOGETHER

Fundamental to acquiring success in reading an alphabetic language is understanding that the individual phonemes of speech are represented by graphemes

(Dodd & Gillon, 2001). This is the core of the Alphabetic Principle. However, it is established that in order to understand that the sounds of speech are represented by letters, one must understand that speech itself is compromised of individual sounds (Adams, 1990). This forms the basis for the argument that phoneme awareness is causal in reading acquisition. Lonigan et al. (1998) said “sensitivity to phonemes is often assumed to have a special status in the relation between phonological sensitivity and reading both because it is at this level that graphemes correspond to speech sounds in reading” (p. 295). While this idea is as Adams (1990) described it “elegantly simple” (p. 255) in theory, in practice becomes much more complicated. Adams (1990) discussed that while English is fundamentally an alphabetic language, it is not perfect. If it were, each letter would correspond to exactly one phoneme and one phoneme would correspond to exactly one letter and the number of grapheme – phoneme correspondences would be twenty – six. However, in the case of English, letters and phonemes do not directly correspond with each other. Treiman (1992) went on to hypothesise that the beginning reader uses higher levels of phonological awareness, in particular onset – rime awareness to avoid the confusion caused by learning to read at the level of the phoneme. In this theory, children can reduce the number of exceptions and use knowledge of rhyme to read unfamiliar words.

Below, some details of how phonological awareness relates to successful reading acquisition have been discussed. There are obviously multiple other factors which need to be considered in the acquisition of reading success, but are simply beyond the scope of this review.

1.6 THE RELATIONSHIP BETWEEN PHONOLOGICAL AWARENESS AND READING

1.6.2 The Role of Syllable Awareness in the Acquisition of Reading

Adams (1990) argued that the syllable is the natural phonological unit and that it is even more salient that the word. Thus, she suggested that it would seem likely that the ability to perceive and segment words into syllables might play an important role in the early stages of learning to read. However, Castles and Coltheart (2004) went on to review a number of studies and concluded that there is little evidence that syllable awareness plays an important role in the acquisition of reading. Their review found that syllable awareness was not correlated to reading acquisition. In one review, they investigated Badian's (1998) study, in which the syllable segmentation skills of 238 pre – school children were assessed using a syllable tapping task, where children were required to tap out the number of syllables in words. Badian (1998) found that syllable segmenting ability did not account for any differences in reading ability in the first or second years of schooling once verbal IQ, socio – economic status, pre – existing reading ability and age had been controlled for.

1.6.3 The Role of Onset – Rime Awareness in the Acquisition of Reading

In a landmark study, Bradley and Bryant (1983) found that children who were insensitive to rhyme and alliteration (defined by being unable to recognize them elements) had difficulties with reading acquisition, even after pre – existing reading ability and IQ had been controlled. The study consisted of two methods. The first was a longitudinal study that measured the sound categorization skills of 368 four and five year old children before they had started to read and correlated these to their reading attainment over the next four years. The second consisted of a training program in which 65 children from the first method received instruction in sound categorization over two years. The authors argued that the two methods were complementary and that together could establish a causal relationship between rhyme and alliteration (onset – rime awareness) and later success in reading acquisition. The longitudinal study revealed a significant positive correlation between children's initial ability to categorise sounds and reading attainment. This provided support for the theory that experience with rhyme (through nursery rhymes) in the preschool years had a lasting effect on reading ability. The 65 children in the training groups were further divided into four groups:

- Group 1 – trained in sound categorization only
- Group 2 – trained in sound categorization and the alphabetic principle
- Group 3 – trained in conceptual categorization only
- Group 4 – control group (received no training)

At the end of the two years, group 1 (sound categorization only) outperformed group 3 (conceptual categorization only) by 3 – 4 months on standardized tests of reading, which the authors claimed suggested a causal relationship between sound categorization and reading acquisition. Group 2 (sound categorization and the alphabetic principle) performed even better than group 1 on standardized tests of reading.

In a later study, Bryant et al. (1989) reported consistency with Bradley and Bryant's (1983) study by exploring the role of nursery rhymes in reading acquisition. They found that children's knowledge of nursery rhymes at 3;3 had a strong correlation to their reading attainment over the next three years; even after differences in the children's IQ, social background and pre – existing phonological awareness skills at the beginning of the beginning of the study had been taken into consideration. This effect is modulated through the children's increased sensitivity to the constituent sounds of words. Bryant et al. (1989) hypothesized that the importance of rhyme may be that it allows children to learn about sequences of letters of words that rhyme. For example, 'ight' as in 'fight' and 'light'. Similarly, Goswami and Bryant (1990) also showed that rhyme awareness is evident prior to learning to read, further evidence that it facilitates reading acquisition. They found that children were able to read unfamiliar words who the two words shared a printed rime. They argued that children make analogies based on rime segments.

As a result of their work, Goswami and Bryant (1990) developed hypothetical models to explain the potential casual link between onset – rime awareness and learning to read. Firstly, they suggested that onset – rime awareness possibly facilitates the development of phoneme awareness, which facilitates the development of reading through the acquisition of phoneme – grapheme correspondences (alphabetic principle).

Alternatively, onset – rime awareness and phoneme awareness may make independent contributions to the acquisition of reading; onset – rime awareness in the beginning stages of reading by allowing children to make analogies between commonly occurring letters and sequences and rimes and phoneme awareness by assisting the acquisition of phoneme – grapheme correspondences. They suggested that children make analogies between familiar and unfamiliar words and use these analogies to read the unfamiliar words. For example, say a child could read the word *light*, but had never seen the word *sight* before. *Sight* is not a word that can be sounded out phonetically. Instead, the child may be able to make an analogy between the two words because he / she recognizes that the two words share a common 'end' spelling and that the two words sound the same (onset – rime awareness). This hypothesis may have explained why children who are good at detecting rhyme may have an increased rate of reading acquisition. Goswami and Bryant (1990) argued that this method of learning to read has little to do with the alphabetic principle and learning single letter – sound correspondences. Further, they suggested that "once children have the idea that words which have sounds in common often share spelling sequences as well, they have a powerful way to work out how to read new words. They can use the spelling pattern in one word to work out the sound of another word with the same spelling sequence" (p. 78).

Treiman (1992) followed with support for Goswami and Bryant (1990) hypothesis and argued that "many investigators assumed that because the English writing system can be described, used and learned at the level of the phoneme, it must be described, used and learned at the level of the phoneme" (p. 158). She argued that the onset – rime unit, smaller than the syllable and larger than the phoneme, should be considered as important when learning to read. The English writing system consists of 26 graphemes but 41 phonemes. She argued that the number of exceptions to the rules can be reduced and the reading system made more predictable by teaching children to read using higher level rhyme rules. She argued that beginning reading is made easier by focusing on onsets and rimes because it is simpler to learn links between groups of letters and sounds than single letters and sounds. She hypothesized that younger children who lacked phoneme awareness and were, thus, unable to analyse words in terms of the individual phonemes, may be able to recognize the onset and rime units of the word. For example, the beginning reader may realize that the word *blast* can be divided into the onset *'bl'* and *'ast'*, but not recognize that the onset can be further divided into *'b'* and *'l'* and not recognize that the rime can be further divided into *'ar'*, *'s'* and *'t'*. The child may also more readily learn the written correspondences for *'bl'* and *'ast'* than for *'b', 'l', 'a', 's'* and *'t'*.

Despite some fairly convincing evidence, a number of researchers have reported contrasting findings that call into question the links between phonological awareness at the level of onsets and rimes and reading acquisition. Muter et al. (1998) conducted a longitudinal study investigating 38 children over the first two years of their formal education which included reading instruction. Rhyming (defined by measures of rhyme detection and production) and segmentation (defined by measures of phoneme identification and deletion) were tested. The researchers found that while segmentation was strongly correlated with reading acquisition at the end of the first year of schooling, rhyming was not. Consistent with these results was the study by Hulme et al. (2002). They assessed awareness of initial phoneme, final phoneme, onset and rime in five and six year old children. Reading was assessed at the same time and again 7 – 14 months later. The researchers found that while phoneme segmentation ability accounted for differences in word reading ability, rhyming ability did not. This effect persisted even once pre – existing reading ability and other extraneous variables had been controlled.

In response to the contradictory findings from Bradley and Bryant (1983), Bryant et al. (1989), Muter et al. (1998) and Hulme et al. (2002), MacMillian (2002) reported that those studies that found rhyme awareness to be a significant factor in reading success (Bradley & Bryant, 1983; Bryant et al., 1989; Goswami & Bryant, 1990; Treiman, 1992) used different measures to assess rhyme awareness than those that did not find an effect (Hulme et al., 2002; Muter et al., 1998). MacMillan (2002) suggested that those that did find a relationship may have measured onset – rime awareness and phoneme awareness. This may have occurred because children can score correctly on many items using a phoneme judgment to determine that two words do no share a final sound, rather than a rhyme judgment to determine that two words do not sound the same. For example, children may be able to use their phoneme awareness to determine that the word *cat* does not share the final sound with the word *map*. Therefore, perhaps the links between phonological awareness and reading do exist, but research design that led to contradictory findings.

1.6.4 The Role of Phoneme Awareness in the Acquisition of Reading

The notion that phoneme awareness leads to success in reading acquisition is based on the assumption that the ability to understand the alphabetic principle relies on the ability to understand that the ability to understand and be explicitly awareness that spoken words are comprised on individual phonemes (Blachman, 2000). There are several studies that report that phoneme awareness is correlated with success in reading (Hulme et al., 2002; Muter et al., 1998).

The prevailing view from many authors is that phoneme awareness correlates strongly with reading acquisition. Muter et al. (1998) found a strong correlation between segmentation (defined by measures of phoneme identification and deletion) and reading at the end of the first year of school, although awareness of rhyme was not (as described above). Further, Lundberg et al. (1988) showed that it is possible to train phoneme awareness outside the context of an alphabetic writing system and that such training had a facilitative effect on subsequent reading. This effect was evident until grade 2. The researchers ability to train phoneme awareness prior to formal reading instruction provided support for the notion that phoneme awareness facilitates reading acquisition. However, it is in contrast with the idea that phoneme awareness is a consequence of learning to read. Savage and Carless (2005) conducted a longitudinal study over two years with 351 children. They found that phoneme manipulation skills are age 5 correlated strongly with literacy skills are ages 5 and 7. In contrast, onset – rime awareness did not. Results are less consistent with the view that there is an additional route between onset – rime manipulation and later reading, as suggested by Goswami and Bryant (1990).

In contrast to the above studies, which suggested that phoneme awareness facilitates later reading acquisition, Blaiklock's (2004) study reported that those children who were able to score on rhyme awareness tasks before they began to read were unable to succeed on phoneme awareness tasks until at least halfway through the first year of school, by which time they were reading a number of words on the BURT Word Reading Test. This finding is consistent with a number of studies that have indicated that phoneme awareness is initially a consequence of developing reading skills (Morais, Cary, Alegria & Bertelson, 1979).

1.7 INTERPRETING THE DATA

A significant body of research has pointed to a relationship between phonological awareness, in particular onset – rime and phoneme awareness, and successful reading acquisition. Research has also shown that there are a number of ways of interpreting such a relationship.

The most prevalent interpretation of this relationship is that there is a complex and possibly causal link between phonological awareness and reading acquisition, whereby phonological awareness assists beginning reading skills. In English, and most other alphabetic languages, individual phonemes are usually represented by individual letters, or graphemes, and occasionally digraphs, such as 'cl' and 'br'. Thus, it is argued that children need to be aware of the individual phonemes in spoken words before they are able to learn about their correspondences with graphemes. Goswami and Bryant

(1990) have also shown that higher levels of phonological awareness skills, such as awareness of onsets and rimes, would allow children to map these sounds onto frequently occurring letter sequences, such as ‘ight’ in ‘light’, ‘sight’ and ‘fight’. Castles and Coltheart (2004) highlight the fact that it “is not that the awareness of phonological units will cause children to be able to read, but that it will cause them to be better at learning to read” (p. 79).

In contrast to the theory that phonological awareness assists the acquisition of reading, some research suggested that explicit awareness that speech is comprised of individual phonemes is a consequence of, rather than precursor to reading. Morais et al. (1979) found that Portuguese adults who could not read or write performed more poorly on phoneme awareness tasks than Portuguese adults who could read and write. This illustrated that explicit awareness that speech is made up of individual phonemes does not arise spontaneously, as a result of cognitive maturation, as previously theorized. Thus, they argued that “it is not right to say that awareness of the phonetic structure of speech is a precondition for starting learning to read” (p. 330). In support of this theory is Blaiklock (2004), who found that children were able to score on rhyme awareness tasks before they began to read, but were unable to succeed on phoneme tasks until at least halfway through the first year of school, by which time they were reading a number of words on the Burt Word Reading Test. This finding is consistent with a number of studies that indicated that phoneme awareness is initially a consequence of developing reading skills.

Research demonstrated that there are substantial orthographic influences on phonological awareness tasks that need to be taken into consideration when interpreting the relationship between phonological awareness and reading acquisition, as orthographic knowledge can influence the way in which children perform phonological awareness tasks (Castles, Holmes, Neath & Kinoshita, 2003; Ehri & Wilce, 1980). Castles et al. (2003) suggested that the process of learning to read does not change children's level or nature of phonological awareness but changes the way the children perform on phonological awareness tasks. They argued that children's performance on phonological awareness tasks once they had learned to read is modulated by their orthographic knowledge. They suggested that children use their reading and spelling knowledge to carry out the phonological awareness tasks and hence, performance on these tasks in correlated with reading ability. They went on to suggest that orthographic and phonological knowledge become combined during the process of learning to read. Ehri and Wilce's (1980) results were also consistent with Castles et al.'s theory that orthographic knowledge influences performance on phonological awareness tasks. They found that reading able children would report that words like *pitch* contained a greater number of phonemes than words like *rich*, although both words contain the same number of phonemes. It was suggested that children used orthographic knowledge (how the words spelled), which interfered with their phonological knowledge (how the words sounded). In support, was Burgess and Lonigan's (1998) study which provided evidence for the reciprocal relationship between phonological awareness and reading acquisition. That is, they found that phonological awareness facilitates reading acquisition and reading acquisition facilitates phonological awareness. They conducted a one year longitudinal study on 97 four and five year old children. The study revealed that there is a reciprocal relationship between phonological sensitivity (measured by recognition of rhyme and alliteration) and early reading skills (letter knowledge). They found that both higher levels of phonological sensitivity led to higher levels of early reading skills and higher levels of early reading skills led to higher levels of phonological sensitivity. In addition, this study supported both views of the relationship between phonological awareness and reading acquisition; that it is the process of learning to read that facilitates growth in phonological awareness and also that phonological sensitivity facilitates reading acquisition.

In a recent study, Blaiklock (2004) also found evidence that the relationship between phonological awareness and reading acquisition may be modulated by letter knowledge. His study involved following a group of 27 non – reading children aged between 5;0 and 5;3 through the first two years of schooling. The aim of the study was to examine the relationship between phonological awareness and beginning reading, whilst accounting for the extraneous variables of verbal ability, phonological memory, pre – existing reading levels and letter knowledge. The data reported significant concurrent correlations between onset – rime awareness and reading, and phoneme awareness and reading at various points throughout the 24 months of assessment. However, these correlations were reduced to mostly non – significant levels after controlling for letter knowledge. He also found that predictive correlations between rhyme awareness and reading during the first two years at school were non – significant. This data did not provide support for the earlier studies that did find a connection between rhyme awareness and learning to read (Bradley & Bryant, 1983; Bryant et al., 1989) but did not provide support for those studies that failed to find a relationship between the two skills (Hulme et al., 2002; Muter et al., 1998; Stuart, 1995).

An alternative interpretation of the relationship between phonological awareness and reading acquisition is that the association is not causal in either direction, but that the relationship is mediated by some third, unknown and unmeasured variable (Bradley & Bryant, 1983; Castles & Coltheart, 2004).

1.8 TRAINING PHONOLOGICAL AWARENESS

Training studies have the potential to reveal that instruction in phonological awareness leads to gains in reading ability. A number of training studies have demonstrated that such training in phonological awareness does lead to increased rate of reading ability (Ball & Blachman, 1991; Brady, Fowler, Stone & Winbury, 1994; Lundberg et al., 1988; Rivers & Lombardino, 1998), while others have not (Bryne & Fielding – Barnsley, 1995; Hatcher, Hulme & Snowling, 2004). Of these, many have also found that the beneficial effect of training of phonological awareness was increased when the training is combined with explicit connection to letters of the alphabet (alphabetic principle) (Ball & Blachman, 1991; Bradley & Bryant, 1983; Hatcher et al., 2004; Rivers & Lombardino, 1998).

The Bradley and Bryant (1983) training study examined the effects of rhyme and alliteration on reading acquisition. The authors found that those children who received training in sound categorization were 3 – 4 months ahead on standardized tests of reading than those who only received training in conceptual categorization. The children whose training in sound categorization was combined with training in the alphabetic principle outperformed all groups on standardized tests of reading. This suggested that training in sound categorization is more beneficial when there is an explicit connection with the alphabet.

In contrast with the above studies, which did find that training in phonological awareness had a beneficial effect on reading acquisition, Hatcher et al. (2004) did not. Their training program investigated whether reading acquisition in addition to explicit phonological awareness training would have beneficial effects on children's reading skills in the first two years of schooling. While the training did improve the phonological skills of the children, these improvements did not translate into overall improvements in reading skills. Training in phoneme skills produced improvements in phoneme skills and training in rhyming skills produced improvements in rhyming skills but training in phoneme skills did not produce improvements in rhyming skills and training in rhyming skills did not produce improvements in phoneme skills. This result suggested that phoneme awareness is not facilitated by onset – rime awareness. These results were consistent with the results of Byrne and Fielding – Barnsley (1995) who suggested that phonological awareness training may not cause an immediate gain in reading skills. However, they found that children at risk of reading failure did benefit from structured training and linking phonemes with graphemes. Consequently, this provided support for the theory that phoneme skills and not rhyme skills are critical for the acquisition of early reading skills.

Castles and Coltheart (2004) reviewed a number of training studies and set out a number of requirements that would need to be fulfilled if there was to be clear support for a casual link between phonological awareness and reading acquisition. The first requirement was that only phonological awareness be included in the training program. While they acknowledged the importance of other literacy skills (for example, the alphabetic principle), they concluded that doing so would interfere with the ability to infer a causal relation between phonological awareness and reading. Their second requirement was that gains from training should not only be in phonological awareness, but must be transferred to reading ability. The third requirement was that those gains must be specific to reading and not correspond to an increase in general ability which could be measured in mathematics, for example.

Another training study, conducted by Brady et al. (1994) found that training kindergarten children in phonological awareness led to both increases in phonological awareness and a trend for better reading progress. In this longitudinal study, children were divided into two groups; those who received training in phonological awareness (training group) and those who did not receive any intervention (control group). The phonological awareness of all children was assessed at the beginning of the year and again 18 weeks later, during which time the first group received training. One year later, reading ability and promotion to the first grade was evaluated. The authors found that those children in the training group had made significant gains in phonological awareness and were significantly more likely to advance to the first grade. They also found that those children promoted to the first grade had better reading skills (as measured by word identification task) compared to the small number of students who had been promoted to the first grade from the control group. The authors added that it would have been beneficial to provide instruction on phoneme grapheme correspondences but did not in the current study because they wanted to examine the effects of phonological awareness training in isolation. While they did admit that they could not determine how much letter training the teachers did outside the training activities, both groups were found to have equal letter knowledge and the authors concluded that it was likely that phoneme awareness was responsible for the differences in reading.

Also in agreement of the beneficial effects of training phonological awareness in addition to the alphabetic principle was Ball and Blachman (1991). The authors explored the effects of training phoneme awareness alone and in addition to letter names and sounds for a group of kindergarten children. They found that phoneme awareness combined with letter knowledge training produced more significant benefits on subsequent reading compared to training in phoneme awareness alone. Participants were divided into three groups. The first group received training segmenting words into phonemes as well as training in the correspondences between letter sounds and letter names (phoneme awareness group). The second group received only training in letter names and letter sounds (language activities group). The third group received no intervention (control group). Children in group 1 received training in segmenting words into phonemes as well as phoneme – grapheme correspondences, had significantly improved reading ability based on Woodcock Word Identification. However, instruction in letter names and letter sounds alone did not significantly improve the segmentation skills or the early reading skills of the children in group 2 when compared to group 3. These findings suggested that phoneme awareness training facilitates early reading skills, which the authors attributed to the phoneme segmentation group's superior ability to understand the alphabetic principle. In addition, this study supported the notion that phoneme segmentation training that is connected to the tasks of early reading have more significant effects on reading acquisition than those that did not (Lundberg et al., 1988). The results of a 1998 training study by Rivers and Lombardino were consistent with this prevailing idea that the beneficial effects of training in phonological awareness were increased when combined with an explicit connection to the letters of the alphabet (Ball & Blachman, 1991; Bradley & Bryant, 1983; Lundberg et al., 1988). In their 1998 training study, Rivers and Lombardino investigated that effects of training letter – sound correspondences and phonemic segmenting and blending on the decoding skills of three first graders at risk of reading failure. Following six training sessions, all three participants had learned the decoding strategy with 100% accuracy. The results suggested that phoneme segmenting and blending skills had a beneficial effect on reading ability.

While many researchers admit that it is more beneficial to train phonological awareness in combination with the alphabetic principle (Ball & Blachman, 1991; Blachman, 2000; Bradley & Bryant, 1983; Lundberg et al., 1988), Lundberg et al. (1988)

showed that it was possible to train phonological awareness outside the context of an alphabetic writing system and that such training has a facilitative effect on subsequent reading. This study also lent weight to the notion that phoneme awareness is a facilitator, and not a consequence of reading acquisition. However, the authors noted that explicit instruction was required.

1.9 ADDITIONAL FACTORS THAT CONTRIBUTE TO SUCCESSFUL READING ACQUISITION

In a process as complex as learning to read, it is unlikely that one single factor, such as phonological awareness, would be implicated. Justice and Pullen (2003) suggested that phonological awareness in addition to print awareness and oral language development is required for successful acquisition of reading. In support of Justice and Pullen (2003), Blaiklock (2004) reviewed a number of studies examining the relationship between phonological awareness and the acquisition of reading and claims that many neglected to control for extraneous variables such as verbal ability, phonological memory, pre – existing reading skills and letter knowledge. Letter knowledge is also known to be a robust predictor of reading ability (Adams, 1990; Burgess & Lonigan, 1998). While the importance of letter knowledge in learning to read should be not underestimated (Castles & Coltheart, 2004), it was controlled for in studies examining the relationship between phonological awareness and reading acquisition, it could not be determined whether phonological awareness alone, or in tandem with letter knowledge is important.

1.10 THE USE OF COMPUTERS

Despite the impact of computer technology in education, Pierce (1994) poses the question of why technology is not being used more effectively and consistently with young children?

Pierce (1994) outlines a number of criteria for selecting appropriate software. Firstly, programs should be developmentally appropriate, whereby children are able to easily navigate the program. Secondly, the software must be diverse and offer both exploratory and drill and practice activities. Appropriate software has stimulating visual and auditory information. Lastly, features should be able to be controlled by parent / clinicians so that the specific goals of the child may be met.

Computer-delivered intervention is most effective when coupled with clinician-delivered intervention and the activities in the software are prefaced with initial training of concepts (Pierce, 1999).

A study by Alfaro (1999) demonstrates the effectiveness of computer-based intervention when it is integrated as part of reading instruction. The study was designed in response to high number of grade one children who did not meet grade level reading abilities. 14 kindergarten classes across 4 schools took part in the study, in which Balanced Literacy (literacy instruction based on whole language and phonics instructions) was supplemented with the Waterford Early Reading Program (a computer-based reading program). For the full kindergarten year, each child received 15 minutes navigating the software's emergent literacy activities. This was supplemented with a range of classroom and take home activities. Results revealed that 90% of the children involved in the program met "reading readiness for the 1st grade" (p. 3). Software based on literacy acquisition research and extensive training and professional support for teachers was integral to the success of the program.

Nelson and Masterson (1999) believe drill and practice software is beneficial for a number of reasons; children are able to have instructions repeated as necessary, multimedia presentation provides a motivational form of drill and practice and provides time-efficient skill practice.

1.11 CONCLUSION

Despite more than thirty years of research, it appears that many of the questions raised in the original works on the relationship between phonological awareness and reading acquisition are still present. After an exhaustive review of more than three decades of research, Castles and Coltheart (2004) concluded that while "it is possible to design and carry out a study which could provide unequivocal evidence that there is a causal link from competence in phonological awareness to success in reading, we do not think that such a link exists in literature" (p. 105). While perhaps a little disappointing, this does not mean that the progress to date has been fruitless. In fact, the reverse may be argued if we are to consider the clinical implications of the findings. Each study that has been conducted has added to the understanding of the extent and nature of the relationship between phonological awareness and reading acquisition. The authors stress that while no one has yet established that there is a causal link between phonological awareness and later success in reading, it does not mean that such a link does not exist. They hope that in highlighting the requirements that would need to be fulfilled, such a study may be possible.

Castles and Coltheart (2004) closely scrutinized a number of studies and concluded that no study that assessed phoneme awareness and its relationship to reading ability failed to find a correlation between the two. This is in direct contrast with their examination of syllable and onset – rime awareness. They highlight a number of interpretations of the data on the relationship between phonological awareness. Firstly, that there may be a causal relationship between the two skills, whereby phonological awareness facilitates reading acquisition. While researchers have claimed to establish such a link (Bradley & Bryant, 1983), subsequent evaluation of methodology has suggested that such a claim may not be correct. Secondly, there may be a causal relationship in the opposite direction whereby the process of reading acquisition promotes the development of phonological awareness. Alternatively, the relationship between phonological awareness and reading acquisition may be modulated by some third, unknown and unmeasured variable.

In agreement with others (Blaiklock, 2004; Justice & Pullen, 2003), Rivers and Lombardino (1998) stressed that while many children are responsive to training in phoneme awareness and are able to transfer this knowledge to reading, others are not. They encourage clinicians, not to look at the general trends but, to assess individual children to "determine which children would benefit from letter – sound association and decoding training and which children need additional multi – sensory training, such as children with developmental – based specific reading disabilities" (p. 387).

A large amount of evidence has pointed to notion that phonological awareness, in particular phoneme awareness, is linked with the alphabetic principle in the relationship to reading acquisition. From this, Castles and Coltheart (2004) asked "what evidence is there that phoneme awareness ever exists as a separate pure language skill, independent of the graphemic knowledge to which it is linked?" (p. 104). They suggested that explicit awareness at the level of the phoneme might possibly only be made when there is an explicit connection to its corresponding grapheme. In accordance with this theory was Hatcher et al.'s (1994) 'phonological linkage' hypothesis which states that training in phonological awareness is most beneficial when it contains an explicit instruction of the alphabetic principle and the connection between graphemes and phonemes.

In summary, the literature suggests that at the very least, there is a complex, reciprocal relationship between phonological awareness and reading acquisition. In particular, phoneme awareness seems most strongly correlated with success in reading as it is at this level that the alphabetic principle is understood. The controversy that exists in research may be partly due to differences in methodology and those tasks used to assess phonological awareness at each level. Despite the body of research that acknowledges that phonological awareness does, indeed, play a pivotal role in the process of learning to read, it is widely acknowledged that a process as complex as learning to read is not and could not be explained by a single set of skills. The clinical implications of such is that while phonological awareness is important, it is not a one – skill – fits – all approach and each child must be analysed independently for reading success.

CHAPTER TWO RESEARCH DESIGN AND HYPOTHESES

2.1 INTRODUCTION

The current study utilizes a single-subject (empirical case) experimental design. Barger – Anderson et al. (2004) report that single-subject designs provide a beneficial way of conducting research into literacy as they allow personification of the data collection process, whereby data is collected and analysed for each individual participant. As such, it allows for a treatment program to be individually tailored to the participant. Research often investigates the efficacy of interventions on “groups” of participants. This means that the average effect of an intervention on one group is compared with the average effect of a different intervention on a different group. The result is such that, regardless of what the group average is, there will be significant differences between individuals in the groups and the result does not actually represent the performance of any one individual. In single-subject research, each participant serves as their own experimental control. This involves participants’ results post intervention being compared to their own results pre intervention. This is in contrast to group studies in which participants results or the results of a group of participants are compared with a different participant or a different group of participants. The population being examined (i.e. children with reading difficulties) is a heterogeneous group and a “one size – fits all” approach to treatment is unlikely to be beneficial. In, the current study there is a sample size of three, which will be reported as a case series.

The current study also utilizes a multiple baseline design across subjects. It will follow the basic A-B configuration. Polgar and Thomas (1988) state that multiple baseline designs "involve the use of concurrent observations to generate two or more baselines" (p. 87). These authors further discuss that the purpose of using a multiple baseline design is to allow "…the opportunity to introduce treatment affecting only one of the set of observations, while using the other (s) as a control." (p. 87). In this study, two baselines will be established; the first, measuring phonological awareness skills and the second, measuring math skills.

There will be one independent variable in this study:

1. The computer software intervention:
    - Phonological Awareness software (*Earobics*)

There will be three dependent variables in this study:

1. Changes in the phonological awareness skills in each of the participants.
2. Changes in the word recognition in each of the participants.
3. Changes in the math skills in each of the participants.

These changes will be measured through testing each of these skills prior to, during and following the intervention.

2.2 RESEARCH HYPOTHESES

There will be three sets of hypotheses:

Null Hypothesis H_0

1. There will be no improvement in specific phonological awareness skills (for example, phoneme discrimination and identification, syllable segmentation, phoneme segmentation, rhyme recognition, syllable blending, phoneme blending) of children with reading difficulties following training
2. There will be no improvement in word recognition of children with reading difficulties following training
3. There will be no improvement of other, non phonological awareness skills (for example, math ability) of children with reading difficulties following training

Alternative Hypothesis H_1

1. There will be improvement in specific phonological awareness skills (for example, phoneme discrimination and identification, syllable segmentation, rhyme recognition, syllable blending, phoneme blending) of children with reading difficulties following training
2. There will be improvement in word recognition of children with reading difficulties following training

3. There will be a improvement in other, non phonological awareness skills (for example, math skills) of children with reading difficulties following training

CHAPTER THREE METHODOLOGY

3.1 CONSENT PROCEDURES

This study took place within a primary school in the South Eastern suburbs of Metropolitan Melbourne. This school was chosen as it was within close vicinity of the residence of the primary researcher. This section describes the process of gaining consent from all of those who were either directly or indirectly involved with the study.

3.1.2 Gaining ethical approval

Commencement of the current study required ethical approval from both La Trobe University and the Department of Education and Training (DE&T). Copies of ethical approvals can be found for the above mentioned institutions is Appendix 1.

3.1.3 Gaining approval from the primary school

The current study was conducted within a primary school in the South Eastern region of Metropolitan Melbourne. A letter outlining the study and inviting participation was given to the principal of the school. The letter granting approval for the research project to be conducted at the primary school is included in Appendix 2.

3.2 PARTICIPANT SELECTION

3.2.2 Approaching Potential Participants

Following approval from the principal, the literacy coordinator at the primary school was approached in person by the principal researcher. She was asked to nominate, in conjunction with classroom teachers, three children who were judged as having difficulties in reading and phonological awareness. It was deemed that the literacy coordinator and the classroom teachers were suitably equipped to judge which students were displaying such difficulties (Codd, 2007). Further, at the time of recruitment, the students had been with their classroom teachers for three quarters of the academic year. This was judged as a sufficient time for the teacher to understand their students literacy skills.

In conjunction with the classroom teachers, the literacy coordinator yielded a list of six students. The parents were conducted on the basis of the order that their child's name was given to the primary researcher.

3.2.3 Obtaining informed consent

The parents of the first three participants received a letter outlining the basic details of the study (Informed consent form, Appendix 4). A parental questionnaire was also included in this information pack and contained questions about their child's developmental and academic history (see Appendix 5). This questionnaire served in partial fulfillment of the inclusion / exclusion criteria.

The first three parents, who were contacted, granted consent for their child to participate in the research project. This formed the sample set for the study.

3.3 DESCRIPTION OF THE SAMPLE

3.3.2 Details of the Sample

Two males and one female were involved in the study. Each participant was given an identification number to ensure confidentiality. Details of the participants are provided in Table 1. Year of schooling (YOS) is used to describe the number of years a child spent in formal education.

Table 1

Details of the sample.

	Gender	**Grade Level**	**YOS**	**Age**
Participant 1	Female	4	5	9; 11
Participant 2	Male	3	4	9; 10
Participant 3	Male	5	6	11; 5

3.3.3 Location of the Sample

The school involved in the study is located in a suburb of South Eastern Metropolitan Melbourne. Government statistics reveal that this area is a higher socio – economic area of Melbourne. The suburb has a very high percentage of English only speakers (77%) compared to 69% for metropolitan Melbourne average. It has high levels of mid – income levels and low levels of low – income levels. It also has a highly educated population, with 65% of its population having completed some form of formal, post school education.

3.4 INCLUSION/EXCLUSION CRITERIA

A number of inclusion/exclusion criteria were set by the primary researcher. The three participants involved in this study met the following criteria:

Inclusion Criteria:

As stated above, this study looked at the effects of a computer training program on children with reading difficulties. For this study, ‘reading difficulties’ referred to being more than 18 months behind on two standardized tests of reading:

- The Neale Analysis of Reading Ability (Neale, 1999)
- The Test of Word Reading Efficiency (Torgesen, Wagner & Rashotte, 1999)

Exclusion Criteria:

The following conditions formed the exclusion criteria for the study:

- Participants did not have English as a Second Language (ESL) – Children with ESL are likely to have a different phonological system from native English speakers
- Any known genetic / neurological history
- Any reported intellectual impairment
- Any vision impairment that had not been corrected (because the computer program involved the use of visual stimulation)
- Any hearing impairment (because the computer program involved the use of audio stimulation)
- Normally progressing reading ability (because the study is investigating the efficacy of the computer program on children with reading difficulties)
- Children below grade 1 (children in prep had not yet begun formal reading instruction and thus, are unable to be more than 18 months behind on standardized tests of reading)

All information related to the inclusion/exclusion criteria was gathered through the Parental Questionnaire (see Appendix 5) and battery of pre tests.

3.4.2 Peripheral Hearing Status

In order to control for peripheral hearing status, the parental questionnaire was used to determine if participants had experienced or currently had any known hearing loss or hearing difficulties. Two of the parents of the participants stated no known hearing loss or hearing difficulties, either currently or in the past. The parent of participant 2 stated that their child suffered from short term auditory processing difficulties. Children with auditory processing difficulties are typically able to hear but have difficulty attending to, storing, locating, retrieving and/or clarifying that information to make it useful for academic and social purposes (Katz & Wilde, 1994). Some characteristics typical of children with auditory processing difficulties include poor reading skills, poor phonics and poor speech sound discrimination (Baran, 1998). Thus, as auditory processing difficulties relate to how auditory information is processed rather than heard, it was felt that such a condition should not exclude the participant from the study. Additionally, the combination of auditory and visual presentation of learning material in the computer program would be well suited to a child with auditory processing deficits. It was also felt that a child with such difficulties may well be a typical candidate for such a program and given the use of single-subject design, he was able to be included without be matched to the other participants.

3.5 MATERIAL AND EQUIPMENT

3.5.2 Computer hardware

Three Apple Macintosh computers were used in the computer intervention. However, 'Earobics' is available for Windows (95, 98, 2000, ME, XP and NT). Basic system requirements for Macintosh include Mac OS System 7.6.1 or above / OS X compatible, 32MB RAM, 604 PowerMac or above, 10MB of available hard disc space and 256 colour display. A CD ROM is required to load the software package onto the computer. The software required the child to independent use the mouse and keyboard.

3.5.3 Computer software

The software program used in this intervention was 'Earobics Step 2 (Ages 7 – 10) – Specialist/Clinician Edition'. The software package was available as a CD ROM package and was commercially available on the Australian market from specialist computer retailers for $642. The Specialist/Clinician Edition was chosen as it includes professional management features including data tracking and it can be used with up to 12 students. Screen shots from 'Earobics Step 2' may be found in Appendix 8.

Table 2

The five activities of the 'Earobics Step 2' program (Cognitive Concepts, Inc., 2004b).

Name of Activity	Skills Targeted	Description of the game
Calling All Engines	Phoneme discrimination and identification Phonological blending,	Players put out fires by recalling and sequencing sounds and listening to verbal directions.

	segmentation and manipulation	
Paint By Penguin	Phoneme sequencing Phonological segmentation and manipulation	Players paint with Monsieur Penguin by using sponges and counting, sequencing and manipulation sounds.
Pesky Parrots	Phoneme discrimination Phonological blending	Players retrieve stolen treasure from parrots by blending syllables and phonemes into words.
Hippo Hoops	Phoneme discrimination and identification Phoneme sequencing	Players play basketball with Hippos and shoot hoops by discriminating between sounds in words and identifying sound positions within words.
Duck Luck	Phoneme discrimination and identification Rhyming Phonological blending, segmentation and manipulation	Players work with Lyle Kyle Crocodile at the Duck Luck Arcade on rhyming and blending and segmenting onsets and rimes.

3.6 PROCEDURES

3.6.2 Location of the intervention

All aspects of the study were conducted at one primary school. A quiet, vacant room was used for all testing and computer intervention.

3.6.3 Pre-Testing

Prior to commencement of the training program, pre-testing was conducted on each of the participants. As the current study looked at the effects of a computer training program on children with reading difficulties, part of the inclusion criteria regarded assessing the children's reading ability. For this study, "reading difficulties" referred to being more than 18 months behind on the two standardized tests of reading stated above.

In addition to assessing reading ability, the principal researcher completed a generalized phonological awareness assessment on all participants to determine which areas of phonological awareness required remediation. A copy of this general phonological awareness assessment can be found in Appendix 6.

Pre-testing was conducted on a single day, immediately prior to completion of the baseline testing. A final year master of speech pathology student assisted the primary researcher with pre-testing.

Each participant was tested individually in a quiet room at school during the day. Each participant was collected from their classroom and taken to a room for testing. Prior to beginning, the person testing explained her role to the child and explained what they were going to do. Rapport was built with participants through conversation prior to commencement of the testing. Conversation took approximately 5 – 10 minutes and was centered on the child's family, pets and hobbies. The pre testing took approximately 40 minutes and at the completion of the testing, the child was able to choose a sticker reward before being returned to their classroom.

3.6.4 Baseline

In the second stage of the study, the participants were required to undergo a phase of testing to establish baseline measures of their levels of phonological awareness and math ability, using the probes in Appendices 6 and 7, respectfully. These probes were used for the duration of the study. During this phase, the primary researcher met with each participant individually three times until a stable baseline was achieved. All participants established a stable baseline by the third baseline data point. No intervention occurred during this stage. Testing occurred during school hours and participants were taken out of the classroom for testing. Children were tested prior to lunchtime, to ensure results were not affected by fatigue.

The primary researcher also administered the Burt Word Reading Test (BWRT) (Gilmore, Croft & Reid, 1981) on each of the participants on the first day of baseline testing.

3.6.5 Computer Intervention

Participants began computer invention in the week following baseline testing. Computer intervention was conducted in small groups involving all three participants, with each child using a single computer simultaneously. Two participants received computer intervention for 30 minute sessions, three times a week, for a total of five weeks. The third participant was absent from school for the first week of the study and thus, received computer intervention for 30 minute sessions, three times a week, for a total of four weeks.

Computer intervention was conducted on different times of the day and on different times of the week depending on the schedule of the participant's classes and also when the principal researcher was able to be present.

Each child used the same computer for the duration of the study. Participants were collected from their classrooms and brought to the room at the beginning of each intervention session. The participants were able to open the correct activity within the computer program and begin using the program.

At the end of each intervention session, each participant was able to choose a sticker and was then escorted back to their classroom.

Once a week for the duration of the computer intervention, each participant underwent testing of their phonological awareness and math skills. In the last week of the computer intervention, each participant completed the BWRT.

3.6.6 Follow-Up Testing

At sixteen weeks after the completion of the computer intervention period, each participant was administered a battery of tests; the phonological awareness probe, the math probe and the BWRT.

Parents of each participant received a letter from the primary researcher outlining the details of their child's achievement throughout the study. The letter contained specific examples of skills which their child had developed throughout the computer intervention. A summary of the progress of the participants was also forwarded to the principal of the school where the project was completed and to each teacher involved in the project.

3.7 SUPPORT

The role of primary researcher was to provide "low support" to the participants as they worked through the computer program. The primary researcher was responsible for guiding the participants through the appropriate sections of the computer program and assisting them with any technical difficulties they had. The support did not include any "pre-teaching" of concepts related to phonological awareness skills. Additionally, the role was one of positive feedback and reinforcement.

CHAPTER 4 RESULTS

4.1 VISUAL ANALYSIS

Visual analysis was used to answer the first and third research questions; will there be an improvement in the specific phonological awareness skills of children with reading difficulties following training and will there be an improvement in other, non phonological awareness skills (for example, math ability) of children with reading difficulties following training.

Visual analysis of data in single-subject research is one of the most commonly used methods of analysis (Matyas & Greenwood, 1990; Portney & Watkins, 2000). Repeated measurement of the dependent variable allows data to be presented graphically, whereby one may make an immediate, meaningful judgment of the success of the intervention.

Kazdin (1982) states that "visual inspection refers to reaching a judgment about the reliability or consistency of intervention effects by visually examining the graphed data" (p. 232). In acknowledging the potential for subjectivity when using visual analysis, he provides the following rationale for its use in single-subject data analysis. While statistical analysis is more sensitive, it may report significant effects when the intervention effect is weak. However, the crude nature of visual analysis ensures that "only clear and potent interventions to be interpreted as producing reliable effects" (p.

232). His sentiments are echoed by Parsonson and Baer (1978), who argue that statistically significant findings are not synonymous with clinically significant findings. Thus, if a change in the dependent variable is not easily ascertained through visual analysis, they question whether such a treatment is of clinical value.

Data may be examined in within a phase or across phases. According to Portney and Watkins (2000) data within a phase may be described in terms of stability (variability of data) and trend (direction of change). Data across phases may be described in terms of changes related to magnitude (mean and level) and the rate of these changes (trend and latency) (Kazdin, 1982). These terms have been defined by Kazdin (1982) and presented below in Table 3.

Table 3

Definition of terms used in visual analysis (Kadzin, 1982)

Definition of Terms	
Changes in mean	The change in the average rate of performance between two adjacent phases (depicted by horizontal lines)
Changes in level	The change in the value of the dependent variable, measured by the shift in the dependent variable between the end of one phase and the beginning of the next phase.
Changes in trend	The slope or systematic increases or decreases in the dependent variable over time.
Latency of change	The period of time between the alteration in condition and

changes in the dependent variable.

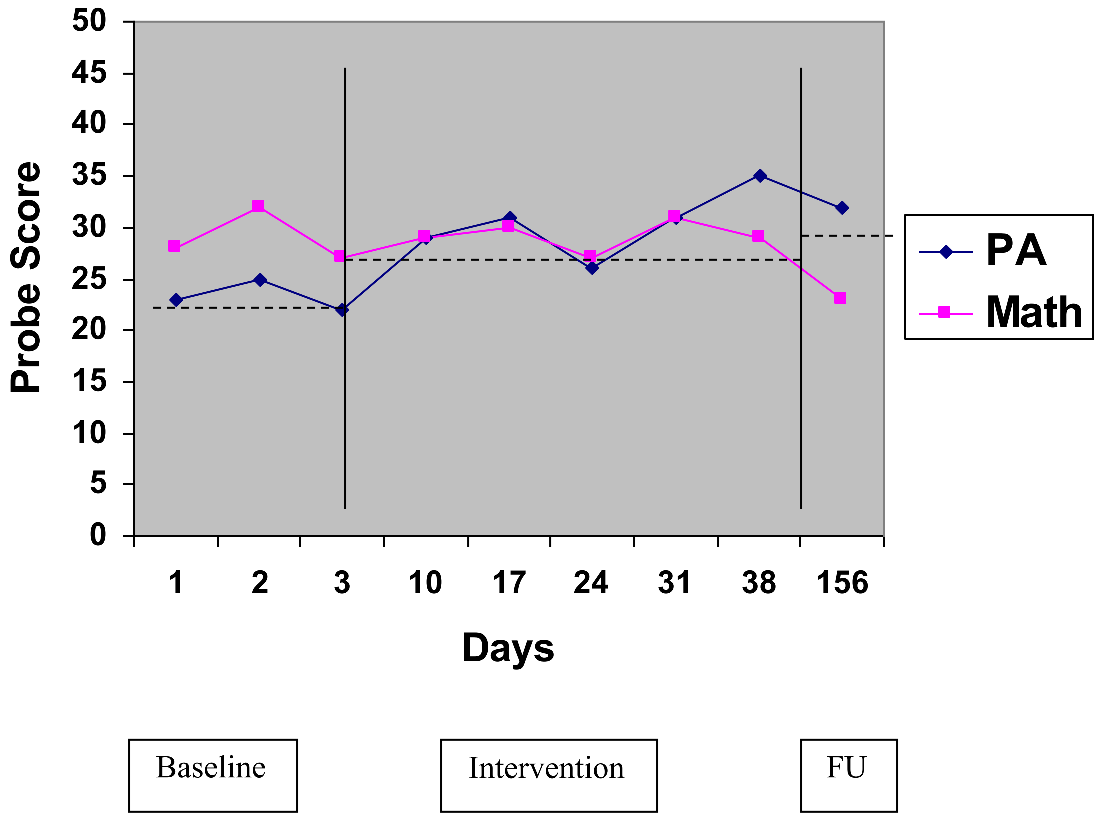

Figure 1. Overall changes in phonological awareness and math skills for participant 1 throughout the study. Vertical lines segment the various phases. Horizontal lines depict average scores in each phase; broken lines (phonological awareness) and continued lines (math skill).

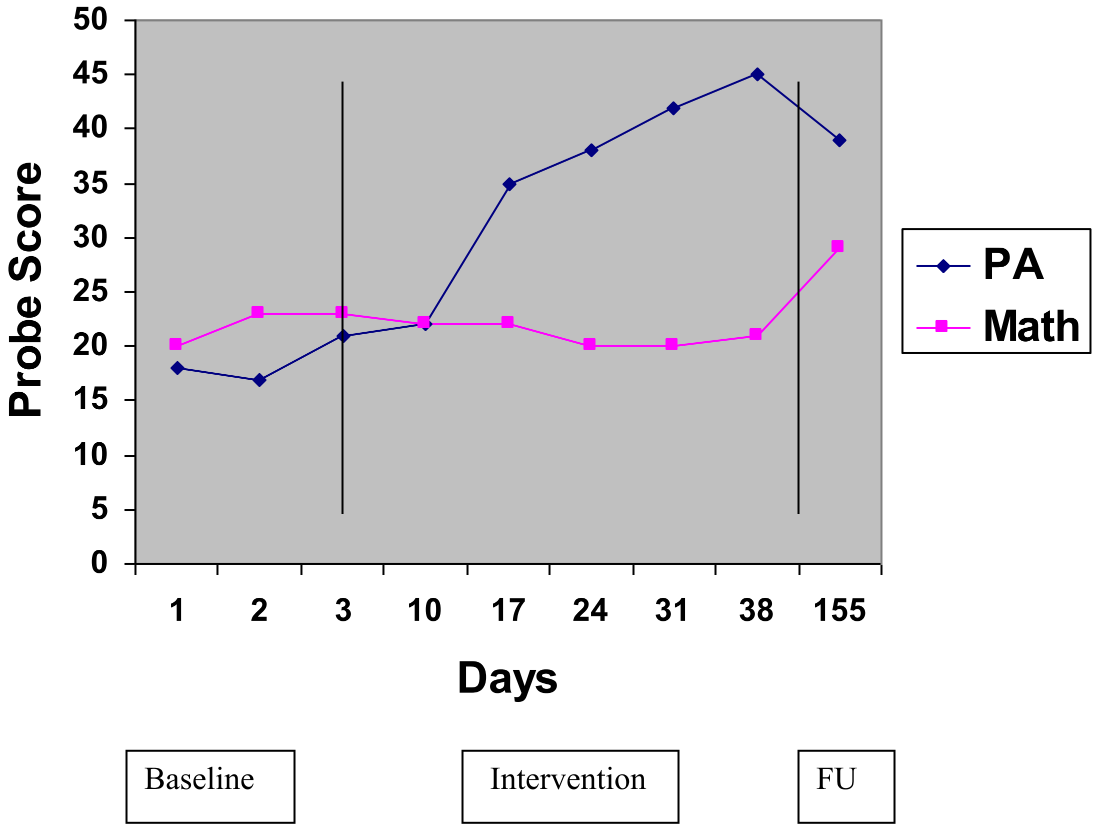

Figure 2. Overall changes in phonological awareness and math skills for participant 2 throughout the study. Vertical lines segment the various phases. Horizontal lines depict average scores in each phase; broken lines (phonological awareness) and continued lines (math skill).

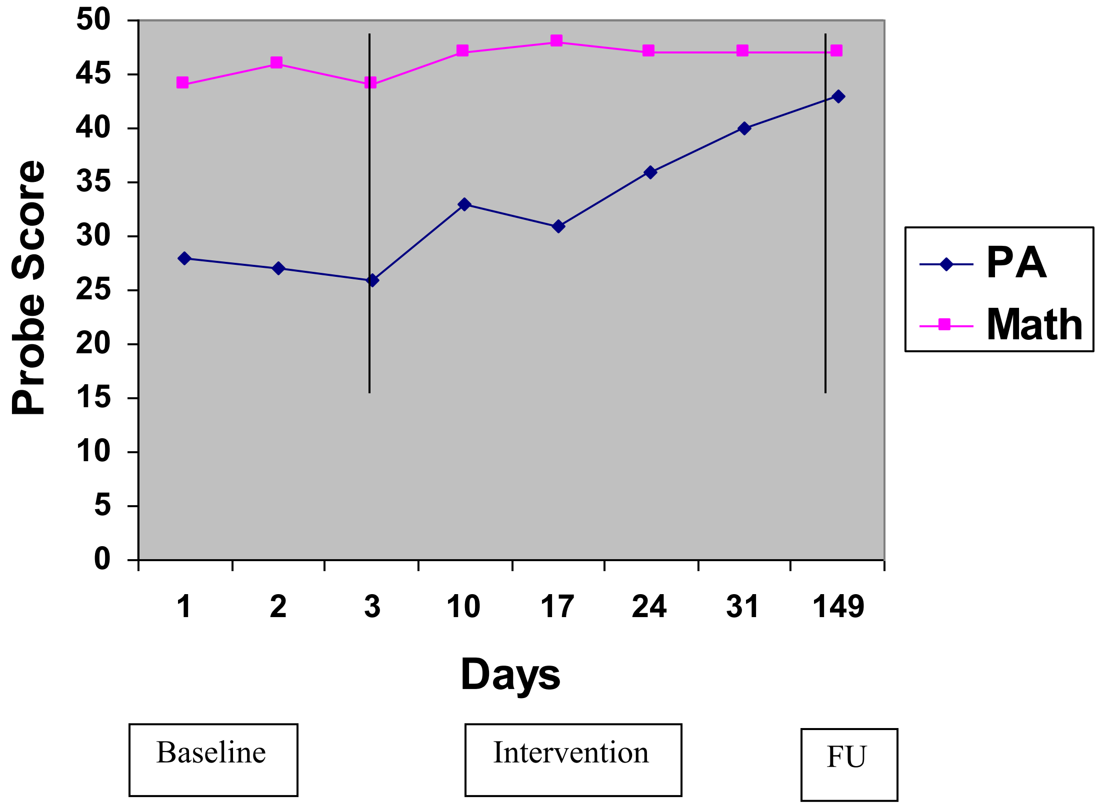

Figure 3. Overall changes in phonological awareness and math skills for participant 3 throughout the study. Vertical lines segment the various phases. Horizontal lines depict average scores in each phase; broken lines (phonological awareness) and continued lines (math skill).

4.1.2 SUMMARY OF VISUAL ANALYSIS

Baseline characteristics. Date for the baseline period was collected from three separate assessments over a one week period. The baseline provided information regarding the participants' level of phonological awareness and math skill prior to the commencement of intervention. All three participants had baselines which demonstrated stability (i.e. minimal variability of scores) and for both phonological awareness and math skill. No participant showed marked trend during the baseline period.

Change in mean and level. All three participants showed a positive change in their average phonological awareness scores between both the baseline and intervention periods, and the intervention and follow up periods. Participant 1 showed no change in their average math scores between the baseline and intervention periods, but a negative change in their average math scores between the intervention and follow up periods. Participant 2 showed no change in their average math scores between the baseline and intervention periods, but a positive change in their average math scores between the intervention and follow up periods. Participant 3 showed a positive change in their average math scores between the baseline and intervention periods, but no change in their average math scores between the intervention and follow up periods.

Change in trend. The phonological awareness scores of all three participants showed increasing trend when the intervention was introduced. The math scores of all three participants were relatively stable through the introduction of intervention.

Change in latency. All three participants showed immediate increases in phonological awareness scores when the intervention was introduced.

4.2 STATISTICAL ANALYSIS

Statistical analysis was used to answer the second research question; will there be an improvement in the word recognition of children with reading difficulties following training. Statistical analysis will be used to determine whether differences in performance on the BWRT between phases are significant, or whether they could have occurred by chance. The current study utilized the McNemar test and the binomial test. These tests were chosen to assess the "before to after" change on BWRT scores.

4.2.2 The McNemar test

The McNemar test is used to determine the significance of changes in which there is a pre-test-post-test design where participants serve as their own controls and the dependent variable is dichotomous (Pett, 1997; Siegel, 1988), thus evaluating the effectiveness of a particular intervention.

Siegel (1988) outlines the following steps in using the McNemar test. In order to determine the significance of any observed change, a four-fold table is created, which represent the participants' responses between two time periods. The table is illustrated below (Table 4), whereby A represents the number of responses which were correct on the first occasion but incorrect on the second, B represents the number of responses which were correct on both occasions, C represents the number of responses which were incorrect on both occasions and D represents the number of responses which were incorrect on the first occasion but correct on the second.

Table 4

Fourfold table used to test significance of changes.

		After	
		-	+
Before	+	A	B
	–	C	D

The McNemar test is only concerned with cells A and D, as they are the only values which represent change. If the null hypothesis is correct, the expected values for both A and D are (A+D)/2.

The McNemar equation, with correction for continuity, is;

$$X^2 = \boxed{\frac{[\,(A - D) - 1\,]^2}{A + D}} \qquad \text{with } df = 1$$

The calculated value of X^2 is then compared with the critical values of the chi-square distribution table, with *df* = 1. If the calculated value of X^2 greater than or equal to the critical value of the chi-square distribution table for a particular level of significance, the null hypothesis is rejected.

The McNemar test was used to test the hypothesis that there will be no significant improvement in the children's word recognition skills following training.

4.2.3 The binomial test

The distribution of X^2 in the chi-square and McNemar tests is only well approximated with a large sample size (Siegel, 1988). If the values of A + D are less than 10, the binomial test is used in place of the McNemar test. In the binomial test, N = A + D and *x* is the smaller of the two frequencies. The significance of *x* is tested using a table of probabilities for the binomial test. Thus, the binomial determines the significance of changes when the total number of changes is small, to correct for poor approximation by the chi-square distribution. Siegel (1988) states that the null hypothesis is rejected when the probability derived from the binomial test is equal to or less than the level of significance.

The probabilities examined in the current study were one-tailed. Two-tailed tests are used when it is predicted that change, in either direction, will occur, while one-tailed tests are reserved for when there is a prediction which way the change will occur (Siegel, 1988). Following examination of the literature, it was predicted that scores on the BWRT will increase (positive change) and thus, a one-tailed test was employed.

Participant 1 demonstrated a significant increase in BWRT score between the beginning of baseline and the completion of intervention. As the observed value of X^2 (2.08) is greater than the critical value of chi-square (1.92), the null hypothesis is rejected.

Table 5

McNemar test results for participant 1 BWRT scores.

		Correct following intervention?		
		No	Yes	Total
Correct at baseline?				
	Yes	4	35	39
	No	63	8	71
	Total	67	43	110

NOTE: $X^2 = 2.08$; critical value of 1.92 for one-tailed $p = 0.05$

There was no significant increase in BWRT scores between the end of intervention and the follow up phase for participant 1. As the one-tailed probability (0.145) is greater than the significance level (0.01), the null hypothesis cannot be rejected.

Table 6

Binomial test results for participant 1 BWRT scores.

	Correct at follow up?		
	No	Yes	Total

Correct following intervention?				
	Yes	2	42	44
	No	60	6	66
	Total	62	48	110

NOTE: One-tailed $p = 0.145$; $\alpha = 0.01$

Participant 1 showed a significant increase in BWRT scores from the beginning of the baseline period to the follow up phase. As the observed value of X^2 (10.08) is greater than the critical value of chi-square (3.32), the null hypothesis is rejected.

Table 7

McNemar test results for participant 1 BWRT scores.

		Correct at follow up?		
		No	Yes	Total
Correct at baseline?				
	Yes	1	39	40
	No	59	11	70
	Total	60	50	110

NOTE: $X^2 = 10.08$; critical value of 3.32 for one-tailed $p = 0.01$

Participant 2 did not demonstrate a significant increase in BWRT scores between the beginning of baseline and the end of intervention. As the one-tailed probability (0.637) is greater than the significance level (0.01), the null hypothesis cannot be rejected.

Table 8

Binomial test results for participant 2 BWRT scores.

		Correct following intervention?		
		No	Yes	Total

Correct at baseline?			
Yes	4	33	37
No	69	4	73
Total	73	37	110

NOTE: One-tailed $p = 0.637$; $\alpha = 0.01$

There was a significant increase in the BWRT scores of participant 2 between the end of the intervention and the follow up phase. As the observed value of X^2 (4.08) is greater than the critical value of chi-square (3.32), the null hypothesis is rejected.

Table 9

McNemar test results for participant 2 BWRT scores.

	Correct at follow up?		
	No	Yes	Total
Correct following intervention?			
Yes	3	34	37
No	64	9	73
Total	67	43	110

NOTE: $X^2 = 4.08$; critical value of 3.32 for one-tailed $p = 0.01$

Participant 2 showed a significant increase in BWRT scores between the beginning of baseline and the follow up period. As the observed value of X^2 (4.08) is greater than the critical value of chi-square (3.32), the null hypothesis is rejected.

Table 10

McNemar test results for participant 2 BWRT scores.

	Correct at follow up?		
	No	Yes	Total
Correct at baseline?			
Yes	3	34	37

	No	64	9	73
	Total	67	33	110

NOTE: $X^2 = 4.08$; critical value of 3.32 for one-tailed $p = 0.01$

Participant 3 did not demonstrate a significant increase in BWRT scores between the beginning of the baseline and the end of intervention. As the observed value of X^2 (0.36) is less than the critical value of chi-square (3.32), the null hypothesis cannot be rejected.

Table 11

McNemar test results for participant 3 BWRT scores.

		Correct following intervention?		
		No	Yes	Total
Correct at baseline?				
	Yes	5	71	76
	No	28	6	34
	Total	33	77	110

NOTE: $X^2 = 0.36$; critical value of 3.32 for one-tailed $p = 0.01$

There was not a significant increase in the BWRT scores of participant 3 between the end of intervention and the follow up phase. The value A + D (the total number of changes) was too small (2) for a significant comparison to be made.

Table 12

Binomial test results for participant 3 BWRT scores.

		Correct at follow up?		
		No	Yes	Total
Correct following intervention?				
	Yes	0	77	77

No	31	2	33
Total	31	79	110

NOTE: One-tailed $p = 0.01$

Participant 3 did not demonstrate a significant increase in BWRT scores between the beginning of baseline and the follow up period. As the observed value of X^2 (1.45) is less than the critical value of chi-square (3.32), the null hypothesis cannot be rejected.

Table 13

McNemar test results for participant 3 BWRT scores.

		Correct at follow up?		
		No	Yes	Total
Correct at baseline?				
	Yes	4	72	76
	No	27	7	34
	Total	31	79	110

NOTE: $X^2 = 1.45$; critical value of 3.32 for one-tailed $p = 0.01$

CHAPTER FIVE DISCUSSION

5.1 SUMMARY OF RESULTS

The results for the visual analysis revealed the computer training was successful in improving the phonological awareness skills of all three participants, over the course of the study. This was demonstrated through a positive trend and an increase in mean and level of phonological awareness scores from the baseline period to the intervention period. At follow up testing, the phonological awareness scores of all participants were greater than that demonstrated at baseline. Math scores remained stable across baseline and intervention phases, indicating that the effect of the computer training was specific to phonological awareness skills.

Results from the statistical analysis showed that two of the participants had a significant improvement in the BWRT scores between baseline and follow up. This indicates that gains made in phonological awareness were transferred to an increase in word recognition.

These findings will be explored in greater detail in subsequent sections.

5.2 RESEARCH QUESTIONS

5.2.2 Research question number one

The first research question investigated whether there would be an improvement in the phonological awareness skills of mid – primary school aged children with reading difficulties, following training with a phonological awareness computer training program. Visual analysis of figures 1, 2 and 3 showed that all three participants demonstrated an increase in their phonological awareness skills following introduction of the computer training program.

Kazdin (1982) states that “As a general rule, the shorter the period between the onset of intervention and behaviour change, the easier it is to infer that the intervention led to the change.” (p. 237). All three participants showed an immediate increase in phonological awareness scores, which indicates that the intervention is responsible for the increase in phonological awareness scores.

All three participants showed an increase in the mean phonological awareness scores from the baseline phase to the intervention phase. A pattern of increased mean between baseline and intervention is indicative of an intervention effect (Kazdin, 1982). The increase in phonological awareness scores varied between participants from as low as 7 points (14% increase) for participant 1 to as high as 18 points (36% increase) for participant 2. Additionally, the three participants showed an increase in the mean phonological awareness scores from the intervention phase to the follow up phase. The increase in mean phonological awareness scores between the intervention and follow up phases were much lower; 2 point (4%) increase for participant 2 and 8 point (16%)

increase for participant 3. This suggests that the results were maintained up to the 16 week follow up.

While, all three participants showed an increase in level following introduction of the intervention phase, the amount varied between participants; as low as one point (2%) for participant 2 to as high as 7 points (14%) for participants 1 and 3. Interestingly, while participant 2 demonstrated the lowest immediate change in level following introduction of the intervention, his overall performance on the phonological awareness probe was increased from 36% to 90%. This serves to highlight that initial performance is not always indicative of the trend that will follow. Two of the three participants showed a decrease in level (3 and 6 points, respectfully) between the intervention and follow up phases. Only participant 3 showed an increase (3 points) in phonological scores when tested at the follow up period. This contrasts with results from the change in mean, which showed that all participants had increased phonological awareness scores between the intervention and follow up phases. However, change in level is independent of change in mean (Kazdin, 1982). So, while the average phonological awareness score in the intervention phase was lower than the phonological awareness score in the follow up phase, the phonological awareness score in the follow up phase was actually lower than the final phonological score in the intervention phase. Despite a decrease in the level of phonological awareness scores between intervention and follow up of participants 1 and 2, follow up scores were still higher (18% and 42% respectfully) than initial baseline scores.

While minor variations are evident in the phonological awareness scores obtained during baseline for all participants, baseline scores were otherwise stable and no trend was observed. The trend for phonological awareness during the intervention phase was positive for all participants. Thus, the change in trend occurred between the baseline and intervention phases.

5.2.3 Research question number two

The second research questions explored whether improvement would occur in word recognition for the participants with reading difficulties following training. Statistical analysis revealed that two of the participants had a significant increase in BWRT scores between the baseline and follow up phases.

Participant 1 had a significant increase in BWRT scores between the baseline and intervention phases and the baseline and follow up phases. However, there no significant change between the intervention and follow up phases.

Participant 2 did not demonstrate a significant change in BWRT scores between the baseline and intervention phases. However, there was a significant increase in scores between the intervention and follow up phases and the baseline and follow up phases.

Participant 3 did not demonstrate a significant change in BWRT scores at any stage throughout the study. Participant 3 had the highest BWRT scores (77 at baseline), which corresponds to a reading equivalent age band of 11;09 – 12;03. As participant 3 was 11;5 at the commencement of the study, this score places him within normal limits for his age. Thus, it may have been less likely for him to significantly increase his score.

There did not appear to be any direct relationship between scores on the phonological awareness probe and BWRT. For example, participant 2 has the highest phonological awareness score but the lowest BWRT score at the end of the intervention phase. This supports the view held by Castles and Coltheart (2004), who argued that phonological awareness does not make children better at reading, but better at learning to read. Thus, the participants may have required explicit instruction on using phonological awareness to segment and blend words when reading in order to make further gains on the BWRT.

5.2.4 Research question number three

The third research question asked whether there would be an improvement in other, non-phonological awareness skills (for example, math ability) for children with reading difficulties following training. Visual analysis of figures 1, 2 and 3 revealed that all participants maintained stable math scores through the introduction of the computer training program. Two of the participants showed changes in math scores in the follow up phase.

There was a wide range in the math scores between participants. These differences are likely to be due to the fact that the participants range from YOS 4 to YOS 6. The math questions were taken from a math exercise book based on the Australian YOS 4 curriculum. Initial selection criteria required participants to be YOS 4. However, due to difficulties with participant selection, a wider age range was selected.

In order to explore whether the effects of the computer training were specific to phonological awareness, math skill was assessed throughout the study as a control. Visual analysis of the math scores of the participants showed that the mean math scores of all three participants were stable across baseline and intervention phases. Math scores of each participant varied across the two phases by small values (from 0.5 point for participant 1 to 3 points for participant 3). Thus, there was no obvious increase in math scores when the intervention was introduced. Visual comparison using figures 1, 2 and 3 showed that the mean change in phonological awareness from the baseline and intervention phases is much larger than that for math. The change in mean for phonological awareness compared to the change in mean for math skill is large enough to indicate that the computer training was specific to phonological awareness.

Mean math scores across the intervention and follow up phases were less consistent. Participants had progressed to the next year of schooling at the time of the follow up testing and, as math is a continually developing skill, it was expected that if math scores were to change, they would increase. The 8 point increase in mean math score showed by participant 2 may be explained by this. It is not understood why participant 1 demonstrated a 6.5 point decrease in mean math scores, but it may be explained by extraneous variables of which the primary researcher was not aware.

Change in trend was also equally varied across participants. Participant 1 showed a two point increase in math scores between the baseline and intervention phases and a six point decrease in math scores between the intervention and follow up phases. The same pattern of change in trend was also seen for participant 1's phonological awareness scores. This may indicate that both scores were affected in a similar manner by extraneous variables (e.g. time of day testing occurred etc). In contrast, the pattern of change in trend for the math scores of participant 2 was opposite to that for phonological awareness scores. He showed a one point decrease in math scores between the baseline and intervention phases and an eight point increase in math scores between the intervention and follow up phases. As mentioned, it is likely that this large increase in math score at the time of follow up testing be attributed to the fact that he was in a higher year of schooling. Participant 3 demonstrated a three point increase in math score between the baseline and intervention phases, while his math scores between the intervention and follow up phases remained constant.

No participant demonstrated trend across either the baseline or intervention phases throughout the study. This is reflective of the stable scores obtained by participants in these two phases.

5.3 LIMITATIONS

A number of limitations have been identified in the current study.

The length of the study may have contributed to the lack of significant findings for some participants. Participant 2 made large gains (54% increase) in phonological awareness scores between the beginning of baseline and the end of intervention but did not show a significant increase in BWRT in the same time period. However, by the follow up period, the scores on the BWRT had increased by a significant level. The lack of significant increase on the BWRT at the end of the intervention phase may be because there was not enough time for phonological awareness skills to be consolidated and extended to reading tasks. This finding is supported by a 2004 study by Pokorni et al., who failed to demonstrate increases in reading following computer-based phonological awareness intervention by 6 weeks after the completion of the intervention.

At each testing point, the same phonological awareness and math assessments were used to probe the participant's skills. Each participant completed the probes either eight or nine times and it is possible that through repeated exposure, a practice effect may have occurred. The primary researcher made all attempts to prevent this by not informing the participant of the accuracy of their answer and ensuring that her response to participants answers were neutral.

Each participant underwent regular testing of phonological awareness and math skill throughout all phases of the study. Participants 1 and 2 completed each phonological awareness and math probe nine times, while participant 3 completed each eight times. Each probe consisted of 50 test items. The children were initially willing to be tested, but over the course of the study, some participants appeared to find the testing monotonous and repetitive. This may have also prevented them from performing to the best of their ability. In multiple baseline designs, testing generally occurs at each intervention point (Kazdin, 1980). It was expected that participants would be reluctant to undergo such frequent testing, and in addition to time constraints, a decision was made to probe phonological awareness and math skills once every three intervention sessions. While the number of testing sessions was limited, it still remained a challenge for the participants.

In addition to finding testing procedures repetitive, towards the end of the intervention, two of the participants appeared to become frustrated using the same activities. And while the publisher pushes the high number of levels as opportunities for practice, it may be questioned whether children would be willing to engage in so many activities. The effectiveness of computer-based interventions in real-world settings must also be evaluated in terms of practical considerations. Armstrong and Casement (2000) are critical of the repetitive nature of drill and practice software and believe that interest in using the software declines after an initial novelty period.

The participants recruited for the study may not have been selected using the most appropriate criteria for the intervention. The main inclusion criteria included being at least 18 months behind on two standardized tests of reading. Learning to read is widely recognized as a complex process and while phonological awareness is considered a pivot part of learning to read, alone, it is not enough to guarantee success in reading. It is possible that the participants, who did not show significant gains in improvement in reading ability, may have reading deficits that do not stem primarily from phonological awareness deficits. All participants were tested prior to commencement in the study and all showed significant reading difficulties. However, a more detailed investigation may have been beneficial to determine more specifically the cause of the reading difficulties. In addition, factors which may have indicated that children may have required additional support (for example, family history of reading difficulties) were not investigated.

Nelson and Masterson (1999) believe that successful integration of computer-delivered intervention into practice is based upon a Speech Pathologist's ability to know when computer-delivered is appropriate – particularly, matching intervention goals with appropriate software. Further, they suggest that computer-delivered intervention is similar to clinician-delivered intervention and success is dependent on "the knowledge and skills of the clinician, the setting or contextual variables, and the individual child" (p. 70). This may explain why some participants responded to the computer-delivered intervention and others did not. One may assume that use of computer software in intervention may reduce treatment variables, but Nelson and Masterson (1999) argue that these may actually be compounded as computer software is still managed by the clinician.

Nelson and Masterson (1999) state that "children are most successful with computer-based skill practice when they have already acquired the skill, but need additional practice to improve or consolidate their performance" (p. 77). The computer training may have been more successful in improving the participants phonological awareness scores if it was used as an adjunct to traditional, clinician-delivered therapy and not as the sole course of treatment. Similarly, research has demonstrated that training phonological awareness is more beneficial when combined with explicit instruction in the alphabetic principle (Ball & Blachman, 1991; Bradley & Bryant, 1983; Hatcher et al., 2004; Rivers & Lombardino, 1998). Inclusion of such instruction in the program may have lead to more significant gains on the BWRT. However, as the aim of the study was to investigate the effects of the computer program, this variable was not included. It may be important in future research.

Authors have highlighted the fact that software such as 'Earobics', which utilizes a drill and practice, should be used for reinforcement opportunities *after* the concepts have already been taught (Diehl, 1999; Pierce, 1994). Initial performance on phonological awareness probe indicates that the participants did demonstrate minimal skill levels. This suggests that the program was responsible for providing opportunities to practice and consolidate these skills. In agreement, Diehl (1999) states that the activities "do not focus on strategies for learning how to learn but are based on reinforcement principles" (p. 114). As a result, it is not known whether the computer program is able to teach a skill that a child does not already have some level of.

A potential limitation of the current study is that it utilized American software, which contains voices with American accents and intonation. Whilst most of the items on the software are easily understood, some items are pronounced using different or additional phonemes. For example, Australians pronounce *'car'* with two sounds *'c'* and *'ar'*, but this is pronounced with three sounds *'c'*, *'a'* and *'r'* in the software.

In studies utilizing a multiple baseline design across participants, intervention does not begin at the same time for each participant. Initially, baseline measures are taken for all participants and when baseline is stable for the observed behaviour and across participants, the intervention is applied to the first participant. The behaviour of that participant is expected to change with the introduction of the intervention, while the behaviour of the other participants is expected to remain as it was during the baseline period. When the behaviour is stable across the participants, the intervention is applied to the second participant and so on, until all participants involved have received the intervention. By "staggering" the introduction of the intervention, it can be shown that the change in behaviour is due to the intervention and not extraneous variables (Kazdin, 1982). Due to time constraints, the introduction of intervention was not able to be staggered across the participants.

5.4 STRENGTHS

Despite the limitations highlighted above, the current study has a number of strengths.

Nelson and Masterson (1999) suggest that multimedia, computer-delivered instruction may be effective because the learner uses more than one sensory mode (e.g. auditory and visual stimulation) to code information. In this sense, each mode will “support, rather than oppose, the others” (p. 76). This may partially account for the success the participants had with the computer training program, particularly participant 2 who has auditory processing difficulties.

‘Earobics’ utilizes a drill and practice intervention mechanism. Drill and practice allows skill acquisition through repetitive practice. As discussed in the literature review, the use of drill and practice as treatment for reading has received opposing views. Pierce (1994) opposes the use of drill and practice software in young children. In contrast, Nelson and Masterson (1999) discuss the positive aspects of drill and practice software, particularly repetitive trials on a specific skill, feedback on responses and reinforcement of success in the form of accumulation of points and / or animations. Activities in ‘Earobics’ are broken down into different levels and players’ progress through the levels is displayed on the screen. This was found to be a motivating factor in the program as participants would often make comments on their progress, for example “I’m almost finished level three!”

While the literature surrounding the nature of the relationship between phonological awareness and reading is abundant, research specifically into computer-based phonological awareness intervention is limited. The current study endeavored to provide information on the efficacy of one commercially available phonological awareness program.

Despite the design limitations mentioned above, increased phonological awareness scores are still attributed to the computer training. All three participants showed an increase in phonological awareness skills at the start of the intervention, while their math skills remained stable. The three participants were different ages, so it is unlikely that the effects were due to an age-related developmental change. Additionally, the three participants were in different grades and taught by different teachers, so it is unlikely that the effects were due to the participants receiving input from classroom teachers.

In their 2004 review, Castles and Coltheart outlined a number of criteria that must be met in training studies for a casual link between phonological awareness and reading; only phonological awareness should be trained, training should result in gains in phonological awareness and reading ability and training should be specific to reading. The current study met these requirements for two participants, supporting the view that phonological awareness is casual factor in the development of reading.

5.5 CLINICAL IMPLICATIONS

In conjunction with the literature, the results from the current study supports the use of 'Earobics' as an adjunct to additional phonological awareness and / or reading therapy. The results suggest that children are able to use the program and make gains in phonological awareness without extensive adult support. While some participants demonstrate additional significant increases in word recognition, the literature suggests that the benefits of phonological awareness intervention are increased when they are linked to reading activities (Alfaro, 1999; Ball & Blachman, 1991; Bradley & Bryant, 1983; Hatcher et al., 2004; Rivers & Lombardino, 1998).

The participants were able to make gains in phonological awareness with minimal adult support during the intervention. This finding is in agreement with Cox (2001), who found that children's learning when using computer-based phonological awareness was not significantly increased when they received high support whilst using the program. Clinically, this suggests that the program may provide a time- and resource-efficient means of intervention, whereby adult supervision is not required to engage and guide children through the program. This suggests that 'Earobics' may be successfully used in the home or school environment without requiring extensive knowledge of phonological awareness from the teacher or parent.

This study suggests that phonological awareness intervention has the ability to improve word recognition without additional instruction in decoding at the word level. This supports findings of previous studies (Ball & Blachman, 1991; Brady, Fowler, Stone & Winbury, 1994; Lundberg et al., 1988; Rivers & Lombardino, 1998). However, it is widely accepted that phonological awareness intervention is more beneficial when combined with explicit instruction in the alphabetic principle and decoding (Alfaro, 1999;

Ball & Blachman, 1991; Bradley & Bryant, 1983; Hatcher et al., 2004; Rivers & Lombardino, 1998).

As computers begin to play an increased role in speech pathology intervention, Nelson and Masterson (1999) offer a cautionary note; “Like clinician-delivered intervention, the success of computer applications is dependent on the knowledge and skills of the clinician, the setting or contextual variables, and the individual child.” (p. 70).

5.6 FUTURE RESEARCH

The literature has shown that phonological awareness can be successfully trained (Ball & Blachman, 1991; Bradley & Bryant, 1983; Brady, Fowler, Stone & Winbury, 1994; Bryne & Fielding – Barnsley, 1995; Hatcher et al., 2004; Lundberg et al., 1988; Rivers & Lombardino, 1998). However, only a small body of literature exists pertaining to computer-based intervention for phonological awareness (Pokorni et al., 2004). As a result, many questions remain and the potential for future research in this area is huge.

The current study explored the efficacy of a computer program to improve phonological awareness as an isolated means of therapy. Further research may explore whether larger gains could be made in phonological awareness and / or transferred to reading ability if the program was used in conjunction with traditional, clinician-delivered therapy.

Further studies may examine what type of computer-based intervention is most appropriate and how long and often the software needs to be used for optimal results. Additionally, further research may involve determining at what age computer-based intervention is most effective and whether it is best utilized as a preventative or remedial tool for phonological awareness and reading.

CHAPTER SIX SUMMARY AND CONCLUSIONS

Nelson and Masterson (1999) “foresee a future in which many SLPs choose to use computer – assisted treatment” (p. 84). However, they point out that the extent to which computer technology is embraced for use in speech and language intervention is dependent on research demonstrating its effective and superior results. Yet, despite existing in an increasingly technological society, the literature on computer-based phonological awareness intervention remains scarce.

This study explored whether a computer program was effective in improving phonological awareness in mid-primary school aged children with reading difficulties and whether such gains were transferred to an increase in word recognition. Three children received up to 4.5 hours of intervention using ‘Earobics’ software over a period of up to 5 weeks. Visual analysis revealed that all three participants demonstrated increases in phonological awareness. Statistical analysis showed that two participants had additional, significant increases in word recognition. The results suggest that the computer program was both effective and specific in increasing the phonological awareness skills for the participants in this study. Additionally, results suggest that increases in phonological awareness are able to be applied to decoding in reading tasks.

In combination with a review of the literature, these results support the use of 'Earobics' as an adjunct to additional therapy for remediation of phonological awareness and / or reading deficits. The viability of computer-based intervention in speech pathology remains, however, further research is required to maximize its potential.

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CHAPTER EIGHT APPENDICES

8.1 Appendix 1 Ethics forms

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8.1 APPENDIX 1

Ethics forms

FHEC Ethics form

DET Ethics form page 1

DET Ethics form page 2

8.2 APPENDIX 2

Consent letter from the principal of the primary school

***Consent letter from principal at PS**

8.3 APPENDIX 3

Informed consent form

Project Title:

The Efficacy of a Computer Program to Improve Phonological Awareness in Mid Primary – School Aged Children.

Primary Researcher:	Ms. Michelle Boyall Final Year Student – Master of Speech Pathology School of Human Communication Sciences La Trobe University, Melbourne
Supervisors:	Ms. Tanya Serry Lecturer / Speech Pathologist Primary Project Supervisor School of Human Communication Sciences La Trobe University, Melbourne
	Dr. Carl L. Parsons Speech – Language Pathologist Project Supervisor Centre of Advanced Assessment and Therapy Services

Introduction:

My name is Michelle Boyall and I am completing my final year in the Master of Speech Pathology program at La Trobe University. As part of this program, I am undertaking the above stated research. This project aims to examine the effectiveness of a commercially available computer software package. This computer program aims to teach children about the structure of words, as part of the process of learning to read. This is known as 'Phonological Awareness'. Some examples of learning about Phonological Awareness include:

- The ability to determine if words sound the same or different. For example, 'boat' and 'coat' sound the same at the end.
- The ability to segment the individual sounds of words. For example, dividing the word 'bat' into its sounds 'b – a – t'.
- The ability to identify the beginning or end sound of a word. For example, the word 'dog' begins with a 'd' sound.

Project Aims:

My research project will measure the effectiveness of a computer program on teaching certain phonological awareness skills and whether the skills learned from the computer program are able to assist children with their word reading ability.

This project aims to investigate three specific research questions:

1. Does a computer program improve specific phonological awareness skills of children with reading difficulties over a five week period?
2. Does a computer program improve word reading skills of children with reading difficulties over a five week period?
3. Does a computer program improve other, non – phonological awareness skills (for example, math ability) of children with reading difficulties over a five week period?

I will complete this project as the primary investigator, under the supervision of Ms. Tanya Serry and Dr. Carl Parsons.

Please sign the form overleaf if you give consent for your child to participate in this project.

What will be required of my child if I grant consent?

If you consent to your child taking part in this project, he / she will participate in a period of testing of phonological awareness, as well as math ability. The aim of this project is to examine the effects of a computer program on phonological awareness. Phonological awareness testing allows me to measure phonological awareness skills before, during and after the training. Math assessment allows me to determine the effect of a computer training program, by being a 'control' measure. This testing will take approximately 15 minutes and I will carry this out three times a week until stable results have been produced. At this stage, I can start the training program.

The children selected to be in this project will be then required to attend training sessions run by me. These training sessions will use a computer program. Training will take place in your child's school, during school time and children will participate in 30 minute sessions, three times a week for a total of five weeks. Your child will use the software program, which focuses on learning about sound structure and the manipulation of sounds. My role will be to guide the children through the program and assist them with any difficulties they may be having. In any one session, there will be two other students working on individual computers along with me. I will be working with all three children at once.

Phonological awareness and math skills will be tested once a week during the training period and again approximately 4 – 6 weeks after the completion of the training program.

If you grant consent, I also ask that you complete the attached questionnaire regarding the medical and family history of your child. All details in the questionnaire will remain confidential.

How will confidentiality be maintained?

Although the researchers will know who your child is during the study, your child's name will not be included on any written forms or computer records relating to the project. To retain the highest level of confidentiality, each student who participates in the study will have their name coded with a number that only researchers will have access to. Your child will, therefore, remain anonymous, except to researchers. During the research, the written forms will be stored in a secure, lockable filing cabinet at my home and computer records will be kept on a password – locked computer at my home. After the project has been completed, the written forms and computer records will be kept in the office of Ms. Tanya Serry. No one apart from Ms. Tanya Serry, Dr. Carl Parsons and myself will have access to the written forms or compute records.

How will the results be presented in the future?

The results of this project will appear in a thesis written by me. The findings may also appear in professional journal publications, as well as at conference presentations. However, no child participating in my study will be able to be identified in any reports or publications arising from this research. The results of both your child and of the study will be made available to you at the completion of the study, at your request.

What are the benefits of this research project?

Your child will directly benefit from participating in this research project by:

- Working on phonological awareness skills. This will supplement the work being done in the classroom.
- Working with a Speech Pathology student.
- Having the opportunity to use an educational software program.
- Learning / advancing their computer skills.

By giving consent for your child to participate in my research project, you will be helping researchers to better understand the effects of computer programs on children's ability to improve phonological awareness and word decoding skills.

There is no obligation for you to grant consent. Should you not wish for your child to participate in this study, you may be assured this decision will not prejudice your child at school. This decision will remain confidential.

- Any questions regarding this project may be directed to the Primary Project Supervisor, Ms. Tanya Serry, School of Human Communication Sciences, La Trobe University, Melbourne, Phone: (03 9479 1818) or t.serry@latrobe.edu.au In the unlikely event that you have a query / complaint about the project and do not feel that it has been handled in a satisfactory manner by Ms. Tanya Serry, you may contact the Faculty of Health Sciences Ethics Committee on (03) 9479 1794.

Thank you for taking the time to read this consent form. Please sign overleaf if you wish to proceed.

I ___________________________________ have read and understood the information above, and any questions I have asked have been answered to my satisfaction. I agree to give consent for my child, __________________________, to participate in this project, knowing that I may withdraw my child at any time, without prejudice. I agree that research data collected during this project may be included in a thesis, presented at conferences and published in journals, on the condition that my child's name is not used. I understand that my child's personal data and the results of the study will be made available to me, upon my request, at the completion of the study.

NAME OF PARTICIPANT / CHILD (in block letters): ___________________________

NAME OF PARENT / CAREGIVER (in block letters): ___________________________

TELEPHONE NUMBER:

(Home:) _________________________ (Mob:) _________________________

Signature:________________________ (Date:) _________________________

NAME OF SENIOR SUPERVISOR: Ms. Tanya Serry

Signature: ________________________ (Date:) _________________________

NAME OF RESEARCHER: Ms. Michelle Boyall

Signature: ________________________ (Date:) _________________________

Thank you, I will be in contact with you within three weeks.

Yours Sincerely,

MICHELLE BOYALL.

8.4 APPENDIX 4

Parent / Guardian questionnaire

Project Title:

The Efficacy of a Computer Program to Improve Phonological Awareness in Mid – Primary School Aged Children.

Primary Researcher: Ms. Michelle Boyall
Final Year Student – Master of Speech Pathology
School of Human Communication Sciences
La Trobe University, Melbourne

Supervisors: Ms. Tanya Serry
Lecturer / Speech Pathologist
Primary Project Supervisor
School of Human Communication Sciences
La Trobe University, Melbourne

Dr. Carl L. Parsons
Speech – Language Pathologist
Project Supervisor
Centre of Advanced Assessment and Therapy Services

SECTION 1: Your Child

Please complete the following details about your child.

Name: ______________________________ **Date of Birth:** ______________

Grade: ___________ **Teacher:** _____________

1. **Was your child born in Australia?**

   ☐ Yes
   ☐ No

2. **Is English your child's first language?**

   ☐ Yes
   ☐ No

SECTION 2: Your Child's developmental and medical history

3. **Does your child have any known visual difficulties? If yes, please provide further details.**

☐ Yes
☐ No

---

4. **Does your child have any known hearing difficulties? If yes, please provide further details.**

☐ Yes
☐ No

---

5. **Has your child ever suffered from recurrent ear infections? If yes, please provide further details.**

☐ Yes
☐ No

---

6. **Does your child have a significant medical history? If yes, please provide further details (including serious illness, diseases, syndromes and / or other conditions).**

☐ Yes
☐ No

SECTION 3: Your Details

Your name: ______________________________

Contact details:

Phone number: **(Home):** ______________________________
(Mobile): ______________________________

Email address: ____

The main language spoken at home is: ________________________________

All information given in this questionnaire will be kept strictly confidential. Please return this questionnaire and the consent form to me using the attached stamped and self – addressed envelope.

Thank you for your time and participation.

8.5 APPENDIX FIVE

General phonological awareness assessment

GENERAL PHONOLOGICAL AWARENESS ASSESSMENT

Participant:
Date:
Total Score: / 50

PHONEME IDENTIFICATION

a) "Show me the letter of the sound you hear. If I said /p/, you would point to the letter 'p'. You try, what letter goes with /m/?" _____

i. /k/ - k _____
ii. /s/ - s _____
iii. /b/ - b _____
iv. /r/ - r _____
v. /l/ - l _____

Score: / 5

b) "The letters 'sh' make a /sh/ sound. I'll tell you a word and you tell me where you hear the /sh/ sound – at the beginning of the word, in the middle of the word or at the end of the word. Listen. In the word 'shower', the /sh/ sound is at the beginning of the word. In the word 'smashing', the /sh/ sound in the middle of the word. In the word 'rash', the /sh/ sound is at the end of the word. You try, where is the /sh/ sound in the word 'mash'?" _____

i. shovel (beginning) _____
ii. wish (end) _____
iii. fishing (middle) _____
iv. shopping (beginning) _____
v. dash (end) _____

Score: / 5

c) "I'll say a word and you tell me what the sound at the beginning is. Listen. The word 'dog' starts with a /d/ sound. Now you try one. What is the sound at the beginning of 'cow'?" _____

i. rat /r/ _____
ii. lake /l/ _____
iii. make /m/ _____
iv. stair /s/ _____
v. clean /c/ _____

Score: / 5

PHONEME DISCRIMINATION

a) "I'll say a word and you tell me if they are the same or different. Listen. If I say 'ay, ay', they sound the same. But if I said, 'ay, ore', they sound different. Do these sound the same – 'ee, ee'?" _____

i. ew, ew (same) _____
ii. ore, ay (different) _____
iii. ah, ah (same) _____
iv. ai, ai (same) _____
v. ee, ew (different) _____

Score: / 5

SEGMENTING WORDS INTO SYLLABLES

a) "Now, I'll say a word and you break it up into its separate syllables. Say each syllable separately as you tap the table. Listen. The word 'pyjamas' can be broken up into 'py – ja – mas'. You try one. Break the word 'kitten' up into its separate syllables." _____

i. magic (ma – gic) _____
ii. kingdom (king – dom) _____
iii. together (to – get – her) _____
iv. butterfly (bu – tter – fly) _____
v. supermarket (su – per – mar – ket) _____

Score: / 5

SEGMENTING WORDS INTO PHONEMES

a) "I'll say a word and you break it up into its separate sounds. Say each sound separately, tap the table once for each sound. The sounds in 'dog' are d – o – g. What are the sounds in 'gate'?" _____

i. ice (i – ce) _____
ii. sun (s – u – n) _____
iii. fight (f – igh – t) _____
iv. table (t – a – b – le) _____
v. blast (b – l – a – s – t) _____

Score: / 5

BLENDING SYLLABLES INTO WORDS

a) "I'll say a word broken up into syllables. You join the syllables together and tell me what the word is. Listen. If I say 'rain – bow', that makes 'rainbow'. What is this word 'ra – bbit'?" _____

i.	ki – tchen (kitchen)	_____
ii.	blan – ket (blan – ket)	_____
iii.	ba – na – na (banana)	_____
iv.	screw – driv – er (screwdriver)	_____
v.	te – le – vis – ion (television)	_____

Score: / 5

BLENDING PHONEMES INTO WORDS

b) "I'll say a word broken up into separate sounds. You join the sounds together and tell me what the word is. If I say c – a – t, that makes 'cat'. What is this word s – u – n?" _____

i.	r – ow (row)	_____
ii.	m – a – ke (make)	_____
iii.	c – a – p (cap)	_____
iv.	s – a – n – d (sand)	_____
v.	s – t – r – aw (straw)	_____

Score: / 5

RHYME

a) "Words that rhyme sound the same. I'll say three words and you tell me which one doesn't rhyme. If I said, 'mat, fish, cat', 'fish' doesn't rhyme. Now you try one. 'Coat, boat, dog'." _____

i.	pick, lick, mash (mash)	_____
ii.	fin, red, skin (red)	_____
iii.	pet, pink, get (pink)	_____
iv.	sun, fun, gate (gate)	_____
v.	door, dog, frog (door)	_____

Score: / 5

c) "This time, I'll say a word and you tell me which sounds the same. If I asked which word sounds the same as 'gate' – 'late or pink', you would say 'late'. Now you try one. Which word sounds the same as 'trash' – 'high or flash'? _____

i.	lamb – rabbit, jam, bell (jam)	_____
ii.	bed – sun, red, fly (red)	_____
iii.	bell – nut, smell, shoe (smell)	_____
iv.	brush – bone, hat, flush (flush)	_____
v.	bite – light, man, cat (light)	_____

Score: / 5

8.6 APPENDIX 6

PHONOLOGICAL AWARENESS PROBE

PHONOLOGICAL AWARENESS PROBE

Participant:
Date:
Total Score: / 50

1. **How many sounds do you hear?**

"I'll say a word and you break it up into its separate sounds. Say each sound separately as you tap the drum. The sounds in 'dog' are d – o – g. What are the sounds in 'gate'? _____

1.	ape (a – pe)	_______
2.	sun (s – u – n)	_______
3.	cat (c – a – t)	_______
4.	boy (b – oy)	_______
5.	mash (m – a – sh)	_______
6.	catch (c – a – t – ch)	_______
7.	soil (s – oi – l)	_______
8.	spoon (s p – oo – n)	_______
9.	block (b – l – o – ck)	_______
10.	track (t – r – a – ck)	_______
11.	scrum (s – c – r – u – m)	_______
12.	crunch (c – r – u – n – ch)	_______
13.	wand (w – a – n – d)	_______
14.	stripe (s – t – r – i – pe)	_______
15.	brake (b – r – a – ke)	_______

Score: / 15

2. In what order are the sounds presented?

"I'll say a word and you use these tokens to show me how many sounds you hear. Use the same colour for sounds that are the same and different colours for sounds that are different. Colours can be changed are each answer. I would show the word 'dad' like this (shows tokens). See the tokens at the beginning and end are the same because they are the same sound /d/. But I would show the word 'dab' like this (shows tokens). See the tokens at the beginning and end are different colours because they are different sounds. How would you show me 'bob'?" _____

1.	up (u – p)	_______
2.	mum (m – u – m)	_______
3.	phone (ph – o – ne)	_______
4.	box (b – o – x)	_______
5.	dive (d – i – ve)	_______
6.	couch (c – ou – ch)	_______
7.	dinner (d – i – nn – er)	_______
8.	magic (m – a – g – i – c)	_______
9.	blob (b – l – o – b)	_______
10.	crash (c – r – a – sh)	_______
11.	scream (s – c – r – ea – m)	_______
12.	wind (w – i – n – d)	_______
13.	smack (s – m – a – ck)	_______
14.	cross (c – r – o – ss)	_______
15.	script (s – c – r – i – p – t)	_______

Score: / 15

3. Making new words by manipulating the sounds.

"I'll show you a word using these tokens. I want you to rearrange the sounds into a new word. Use the same colour for sounds that are the same and different colours for sounds that a different. If this (shows tokens) makes 'on', then I could rearrange the tokens to make 'no' (switches tokens). If this (shows tokens) makes 'ge', show me 'eg'." ______

1.	If ab makes 'at', show me 'ta'	_____
2.	If abc makes 'lit', show me 'til'	_____
3.	If ab makes 'ma', show me 'mama'	_____
4.	If abab makes 'tata', show me 'atat'	_____
5.	If abc makes 'min', show me 'man'	_____
6.	If abc makes 'god', show me 'go'	_____
7.	If abcd makes 'talk', show me 'walk'	_____
8.	If abcd makes 'crab', show me 'cab'	_____
9.	If abc makes 'dog', show me 'dig'	_____
10.	If ab makes 'up', show me 'cup'	_____

Score: / 10

"I'll say a word. Then I'll take away a sound and you tell me what word is left. It might be a real word or a nonsense word. Listen. If I had the word 'rote' but took away the /t/ sound, 'row' would be left. You try one. What's 'cape' without the /c/?" _____

1.	leaf - /l/ (eaf)	_____
2.	ape - /p/ (ay)	_____
3.	shore - /sh/ (ore)	_____
4.	fish - /f/ (ish)	_____
5.	root - /t/ (roo)	_____
6.	word - /r/ (wod)	_____
7.	stripe - /s/ (tripe)	_____
8.	star - /s/ (tar)	_____
9.	block – /l/ (bock)	_____
10.	trash - /r/ (tash)	_____

Score: / 10

8.7 APPENDIX 7

MATH PROBE

MATH PROBE

Participant:
Date:
Score: / 50

ADDITION

1. 45 + 35 = _____

2. 17 + 38 = _____

3. 11 + 12 = _____

4. 46 + 35 = _____

5. 34 + 46 = _____

SUBTRACTION

1. 35 – 12 = _____

2. 96 – 56 = _____

3. 50 – 20 = _____

4. 70 – 34 = _____

5. 24 – 18 = _____

MULTIPLICATION

1. 6 X 5 = _____

2. 4 X 6 = _____

3. 9 X 3 = _____

4. 2 X 8 = _____

5. 4 X 7 = _____

DIVISION

1. $16 \div 4 =$ ______

2. $3 \div 3 =$ ______

3. $40 \div 4 =$ ______

4. $100 \div 2 =$ ______

5. $20 \div 5 =$ ______

ROUNDING

What is each number rounded to the nearest 100?

1. 256 = ______

2. 539 = ______

3. 471 = ______

4. 707 = ______

5. 177 = ______

SIMPLE FRACTIONS

What is 2 / 3 of each number?

1. 6 = ______

2. 3 = ______

3. 24 = ______

4. 15 = ______

5. 12 = ______

ORDERING

Write the numbers in order, starting with the smallest.

1.	270	720	207	702
	________	________	________	________
2.	560	506	650	605
	________	________	________	________
3.	345	543	53	34
	________	________	________	________
4.	78	9	302	407
	________	________	________	________
5.	842	587	99	88
	________	________	________	________

DECIMALS

Write these amounts as cents only.

1. $ 2.09 ______

2. $ 12.00 ______

3. $6.40 ______

4. $30.00 ______

5. $18.50 ______

Write each length as centimeters.

1. 3m ______

2. 8.06m ______

3. 13m ______

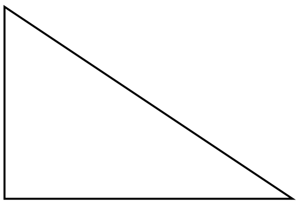
4. 4.75m ______

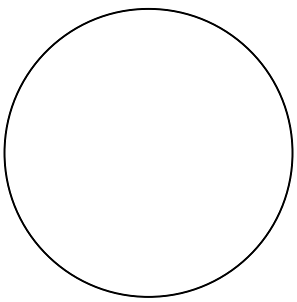
5. 3.2m ______

NAMING SHAPES

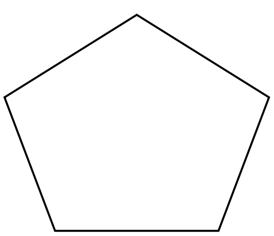
Name each of these shapes.

1.  ____________

2.  ____________

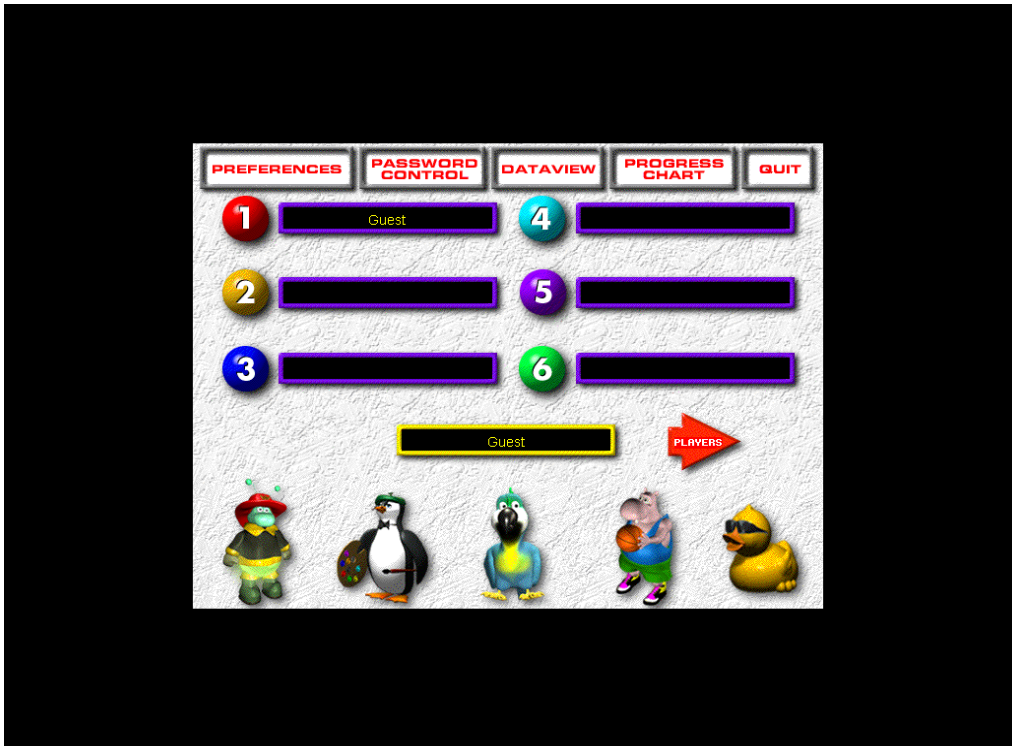
3.  ____________

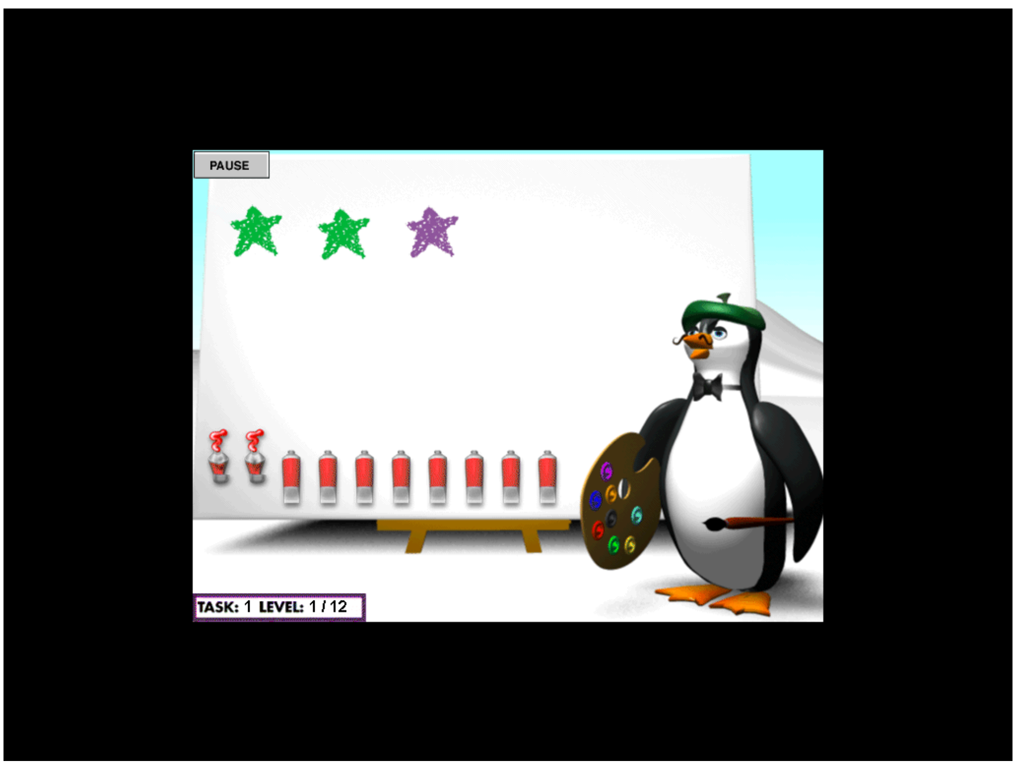
4.  ____________

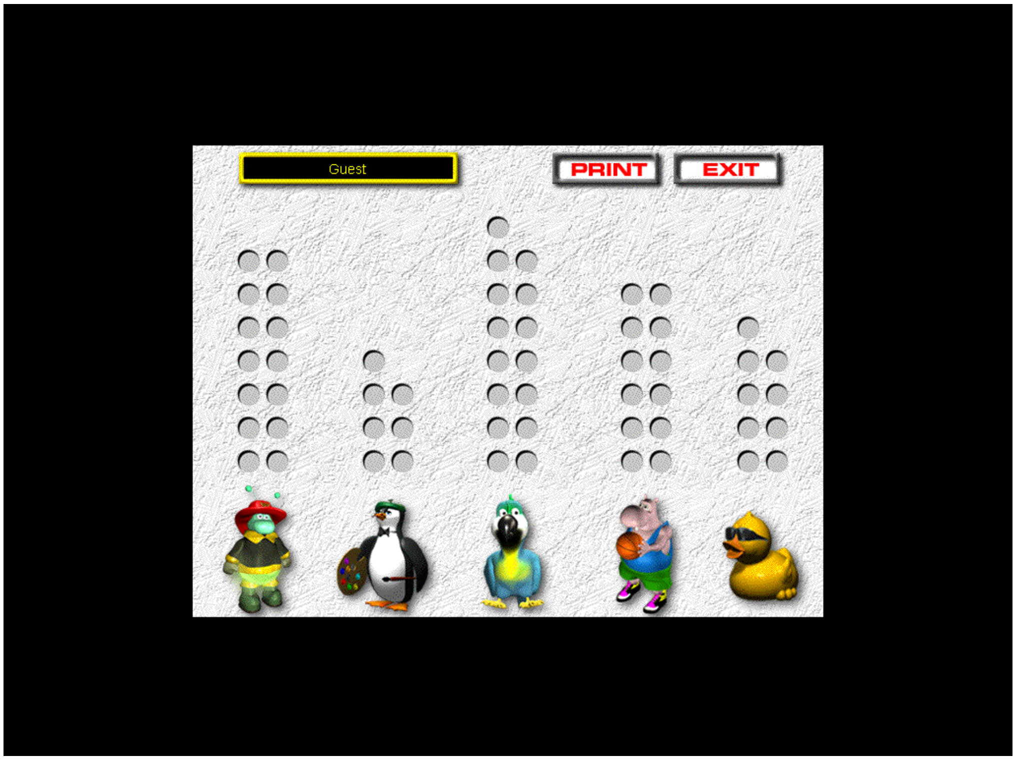
5.  ____________

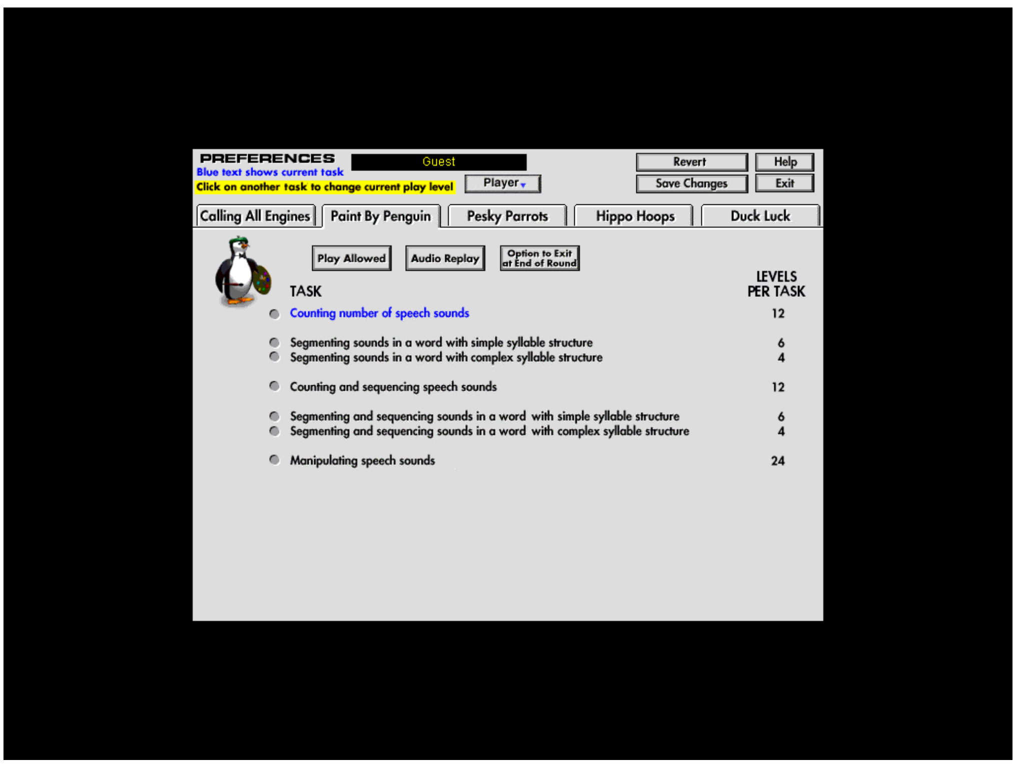
8.8 APPENDIX 8

Screen shots from 'Earobics – Step 2'


PREFERENCES
PASSWORD CONTROL
DATAVIEW
PROGRESS CHART
QUIT
1
Guest
4
2
5
3
6
Guest
PLAYERS


PAUSE
TASK: 1 LEVEL: 1 / 12


Guest
PRINT
EXIT


PREFERENCES
Guest
Blue text shows current task
Click on another task to change current play level
Player
Revert
Help
Save Changes
Exit
Calling All Engines
Paint By Penguin
Pesky Parrots
Hippo Hoops
Duck Luck
Play Allowed
Audio Replay
Option to Exit at End of Round
TASK
LEVELS PER TASK
Counting number of speech sounds 12
Segmenting sounds in a word with simple syllable structure 6
Segmenting sounds in a word with complex syllable structure 4
Counting and sequencing speech sounds 12
Segmenting and sequencing sounds in a word with simple syllable structure 6
Segmenting and sequencing sounds in a word with complex syllable structure 4
Manipulating speech sounds 24