INITIAL READING ACQUISITION AND PHONOLOGICAL DEVELOPMENT: A DEVELOPMENTAL SEQUENCE

RHONDA M. BREEN

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Rhonda M. Breen
in partial fulfillment of a Masters of Science Degree
Department of Psychology
Memorial University of Newfoundland
St. John's, NL, Canada
A1B 3X9

Acknowledgements

Rhonda M. Breen, Department of Psychology, Memorial University of Newfoundland (MUN.); Catherine G. Penney, Department of Psychology, MUN; Carrie Dyck, Department of Linguistics, MUN; Carol C. Peterson, Department of Psychology, MUN.

I would like to extend a special thank you to Dr. Catherine G. Penney for giving me the opportunity to do graduate research, and for her time, consideration, and continuous professional assistance throughout my thesis preparation. Thank you to Nicky Allen, for her professional assistance during the examinations conducted. Thank you to Brenda Crew, Secretary, Department of Psychology, MUN, for her professional assistance throughout my graduate studies at MUN, and to other people, professors and colleagues within the Department of Psychology, MUN who provided valuable assistance. Also, I want to thank the pertinent people in the primary schools or childcare facilities for their participation. Also a special thank you to the parents of the participants for allowing their children to participate.

Most important, I want to extend a very special honour and thank you to my family, my husband, Chris Galway, and my son, Liam Breen-Galway, for their infinite love, support, and encouragement. This dissertation is dedicated to you both, with love.

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ABSTRACT

The purpose of the study was to outline the development of children's initial reading and phonological-processing skills. As a first step towards literacy, children learn letter names, and then several months later, as a second step, children develop onset identity and onset phonetic-cue reading. These in turn are followed a few months later by coda identity and coda phonetic-cue reading. Grapheme-phoneme correspondences are acquired for onsets before codas, and knowledge of grapheme-phoneme correspondences develops before onset and coda deletion, respectively. Children can recognize which one word out of three does not rhyme before they can recognize which word has a different onset or coda. Grapheme-phoneme correspondences for onsets and codas are needed before children can identify the word with the different onset or coda. To read words by analogy, children need to know grapheme-phoneme correspondences for onsets and codas. However, only children with well-established onset- and coda-deletion ability were proficient in reading words by analogy. Although phoneme-counting ability and reading and spelling were significantly correlated, the significance disappeared when age was statistically controlled. The findings do not support the theory that there is a causal relationship between phoneme counting or phoneme awareness and reading and spelling ability.

INTRODUCTION

The focus of the proposed research is to determine how children first learn to read. Although there are many theories of reading development, there is a general consensus that children need to understand the underlying phonological structure of words to begin reading (Adams, 1990; Bradley & Bryant, 1983; Ehri, 1991; Liberman, Shankweiler, Fischer, & Carter, 1974; Morais, Cary, Alegria, & Bertelson, 1979; Rieben & Perfetti, 1991; Stahl & Murray, 1994). The ability to connect the underlying phonological structure of words to print is the acquisition of the alphabetic principle, the understanding that letters represent the sounds of speech.

There are two prominent phonologically based theories of early reading acquisition. According to the first theory, children need to learn the individual sounds or phonemes of words, letter-sound associations and how these letter-sounds are blended together to facilitate the acquisition of the alphabetic principle. For example, a child first learns grapheme-phoneme correspondences (GPCs), or individual sounds or phonemes such as /h/, /a/, /t/, and then how they are strung together to produce a word, such as *hat*. Children must therefore acquire phoneme awareness before learning to read (Bradley & Bryant, 1983). The research reported here demonstrates that this view is incorrect.

A second theory is that children learn to read first, before they can blend or segment individual phonemes in words (Ehri, 1984; Goswami, 1986; Perfetti, Beck, Bell, and Hughes, 1987). For example, Goswami (1986) proposed that preliterate children learn to read words by analogy, reading an unknown word, such as *hat*, by comparing its spelling sequence to a known word, such as *cat*. Goswami indicates that reading by analogy requires an understanding that the end of rhyming words are spelled the same because they sound the same, an understanding believed to facilitate the acquisition of the alphabetic principle. In Goswami's view, young children do not need phoneme awareness to learn how to read and write; instead children can learn reading by analogy skills. Although beginning readers can read by analogy for known words, especially when the known word is present, the research reported here demonstrates that reading by analogy is not part of the first step towards literacy.

In contrast to these prominent theories, a third theory called the ABC-GPC theory of reading will be proposed here that to begin reading preliterate children need basic letter knowledge and phoneme identity rather than phoneme awareness or reading by analogy. First, letter knowledge is the automatic recognition of letter names and their symbols. Second, phoneme identity is the awareness that, for instance, the *b* sound heard at the beginning of the words *book* and *ball* is the same *b* sound heard in the words *rabbit* and *crib*. The type of phoneme identity that is required or develops first is onset identity, the recognition that two words share the same initial consonant sounds, for example, *book* and *ball* share an initial *b* sound, or *please* and *plant* share the initial *pl* consonant cluster. Third, once children have letter knowledge and onset identity, they form grapheme-phoneme correspondences for word onsets by attaching letters of the alphabet to beginning word sounds. Grapheme-phoneme correspondences promote initial word recognition on the basis of one or two salient letter-sound cues.

According to the ABC-GPC theory, the first step in initial reading development is learning letter names and acquiring onset identity. Over time, children acquire letter-sound associations for letters at the beginning of words, and children partially recognize new words by using letter-names or letter-sound cues for word onsets. This latter strategy is believed to represent an early or rudimentary stage of reading called phonetic-cue reading (Ehri & Wilce, 1985; Penney, Drover & Dyck, n.d., 2007 submitted).

The key difference between each of the reading theories presented above is the mechanism that promotes initial alphabetic insight. However, each view accepts the notion that children must acquire the alphabetic principle in order to read an alphabetic script proficiently. I will first explain the concept of the alphabetic principle and how insight into the alphabetic nature of language is related to early reading. I will then provide a short summary of a few non-phonologically based reading strategies, which do not promote alphabetic insight. Following the non-phonological reading strategies, phonologically based reading theories will be reviewed. Evidence-based theories on the development of phonological awareness in young children will be discussed, and then the relationship between phonological development and reading acquisition. I will provide a brief review of the evidence supporting the two prominent reading theories, and show why both theories are incomplete. The final section of the introduction will present an overview of the third reading theory proposed, the ABC-GPC reading theory, and six research hypotheses will be formulated which arise from the theory.

Alphabetic Principle and Reading

It is widely accepted that insight into the alphabetic nature of written English is the key to reading development (Adams, 1990). Generally, the alphabetic principle is defined as the understanding that letters represent sounds or phonemes in spoken words.

The words phoneme and sound are not true synonyms, but they are used in the current document to mean the same, unless stated otherwise. A phoneme is defined as the basic unit of an alphabetic script or the smallest unit of sound that can change a word's meaning (Ladefoged, 2001). For example, changing the phoneme /p/ in *peak* to the phoneme /b/ produces *beak*, a different word with a different meaning. However, a phoneme is not one sound, but is typically "a group of sounds that cannot, separately, distinguish words in a given language" (Ladefoged, 2001, p.186). In the English language, for instance, there are two *p* sounds represented by the phoneme /p/, an unaspirated *p* and an aspirated p^h, heard in the words *spare* and *pear*, respectively. Normally, older children and adults who are native speakers perceive these two *p* sounds as the same sound, but young children or non-native speakers can perceive two different sounds.

While identifying individual phonemes in a word is difficult, the main advantage of having an alphabetic system is that the units of speech (phonemes) can be represented with symbols (letters); the disadvantage is that learning to read using an alphabetic code is hard for many children. Before learning to read, a child listens and focuses on the meaning of words rather than the exact sounds in the words. Then, in learning to read, the child must focus on the sounds in each word and represent those by letters.

Individual phonemes in a word are not easy to perceive because a phoneme, such as /b/, in a word can have a number of acoustically different sounds or will be produced differently in the context of different adjacent phonemes. For instance, the words *bead* and *bode* have two slightly different *b* sounds because of the vowels that occur after the initial /b/ phoneme.

During speech the vocal apparatus moves continuously from one position to another or "co-articulates" to produce different sounds. In other words, the position of the articulators and therefore the sound created during the production of a given phoneme in a word depends on the phoneme just articulated, the phoneme currently being articulated, and the phoneme to be articulated next. Co-articulation allows for a more efficient form of communication than would the slow process of individually producing each phonetic gesture. As a result of co-articulation, humans are able to produce strings of the elemental phonetic gestures at a rate of 10 to 15 segments per second and 200 syllables per minute (Ladefoged, 2001; Oakhill & Beard, 1999).

The disadvantage of co-articulation is that it can make perception of the phonemes and learning the alphabetic code difficult. Children do not segment the individual phonemes in a spoken word, and therefore have difficulty attaching them to a letter. This is because the phonemes are deeply embedded in the word pronunciation, and the acoustic cues for one phoneme overlap with the cues for preceding and subsequent phonemes. In other words, co-articulation affects children's ability to connect the letters in a word accurately to the constituent phonemes (Oakhill & Beard, 1999). However, children must learn the underlying phonological structure of words to begin decoding words written in an alphabetic script. Acquisition of the alphabetic principle occurs once children learn that individual letters correspond systematically to the phonemes in spoken words (Adams, 1990; Liberman et al., 1974; Liberman & Shankweiler; 1987; Oakhill & Beard, 1999).

Non-Phonological Reading Theories

Some researchers argue that the alphabetic principle is not necessary for initial reading acquisition (Goodman, 1965; 1986). Opponents of phonologically based reading theories reject the notion that initial reading relies on the transcription of letters to sounds. Non-phonologically based reading theories gained some support because of observations that beginning readers acquire non-phonological reading strategies more easily than phonological ones (Goodman, 1986). However, a review of the literature shows that non-phonological strategies, such as whole-word and visual-cue reading strategies do not promote true reading ability.

Whole-word theory involves reading words strictly as whole units or logograms; there is no analysis of words into letter-sound units. The whole-word method is based on the assumption that children will deduce the basis of the alphabetic principle as a result of learning to read. Those who support whole-word reading theories insist that breaking words down into individual phonemes confuses beginning readers, and therefore isolates print from its functional use of communicating a message (Goodman, 1986).

In a comprehensive study, Seymour and Elder (1986) examined reading errors of children entering a Scottish primary school who were taught whole-word reading strategies during the first year. At the beginning of the year, children did not know letter-sound associations and were not able to read. The first-year reading program did not include any phonics training. After the first year, Seymour and Elder (1986) tested the children's word reading ability. The children could decode familiar words that had been taught, but Seymour and Elder found that the majority of children could not read unfamiliar words. This suggested that the whole-word reading program was not generative; whole-word training did not generalize beyond the specific words taught. An examination of the children's reading errors revealed that the words produced were not similar in phonological structure to the target words. When the children erred on familiar words, synonyms were often produced that preserved the meaning of the written words, such as *tiger* for *lion*, or *girl* for *lady*. In the whole-word training, the children had learned the connection between written words and their meaning, but could not read the words through a phonological strategy.

In the second year of instruction, children were encouraged to "sound out" the initial letters of words, and children were given direct instruction in letter-sound associations and word-attack skills. Final testing, at the end of the second year, revealed that the children's reading errors were regularisations, (*e.g.* reading *of* as *off*), and neologisms, which reflected the underlying phonological structure of the target words read. On the basis of the reading errors made, the authors suggested that the target words were being "sounded out" through a phonological decoding mechanism. Seymour and Elder (1986) concluded that the children had learned to evaluate the phonological structure of words as a direct result of learning letter-sound associations through word-attack instruction. While whole-word reading instruction methods did not generate independent decoding skills, instruction in letter-sound associations and word attack skills generated a phonologically mediated decoding strategy that did result in independent word reading.

Byrne (1991) examined whether whole-word strategies promoted alphabetic insight in preliterate children. Byrne taught children to read two words, *fat* and *bat*, by means of a whole-word reading strategy. The children were taught to associate each printed word with a picture that represented its meaning. Byrne argued that if whole-word reading generates alphabetic insight, the children will deduce that the letter *f* represents the /f/ phoneme and the letter *b* represents the /b/ phoneme. Children were given a forced-choice task after the training, in which they were asked to identify a printed word, either *fun* or *bun*, by laying the printed word next to the correct picture. Only 53 percent of the children produced the correct response, indicating that the children relied on a 'guessing' strategy to produce the correct picture-word combination rather than on a phonological strategy.

Byrne (1991) concluded that the whole-word training had failed to promote the understanding that the letters *f* and *b* represented the phonemes /f/ and /b/ in the words *fat* and *bat*, respectively. Learning to read whole words that differed in the first letter was not sufficient to produce letter-sound associations for onsets. The view that children learn letter-sound associations by first learning to read whole words was not supported.

Most whole-word reading theorists encourage children to use 'guessing', typically called prediction, as a critical early word-reading strategy. There is a difference between word prediction based on overall context, and learning to recognize words as whole units. Children taught to read by memorizing whole words can identify only the words taught

(Seymour & Elder, 1986), while prediction can help children identify words that may or may not have been taught before. However, prediction is not equivalent to decoding words on the basis of a phonological strategy. In prediction, children guess a word's pronunciation on the basis of salient contextual cues and maybe a limited knowledge of letter-sound associations for initial or final letters; they do not analyze the underlying phonological structure of the word and relate that to the printed letters. Although whole-word reading theorists maintain that prediction is critical for initial reading acquisition, the evidence that supports this view is not convincing.

Goodman (1965), the founder of the whole-word reading movement, was the first to observe that children made fewer reading errors when they read words in a running text than when they read words in isolation. The errors that the children made when reading words in a full text were syntactically and semantically consistent with the other words in the sentence, but this was not the case when children read isolated words. These observations lead to the belief that young readers relied on the story's context to read or predict the pronunciation of new words.

However, a significant problem with Goodman's (1965) study was that the isolated target words were words taken from texts that were read after the target words. This is problematic for two reasons; first, children read the isolated target words (context condition) before the texts (context condition), and second, different words were not used in each condition, in other words, Goodman did not control for practice effects. In the context condition, practice effects may have facilitated accurate word pronunciations rather than context effects, suggesting that Goodman's findings might not be valid.

Many researchers believe that the prediction strategy is unreliable for decoding unusual or unpredictable words and can cause serious comprehension errors. For instance, Gough (1993) argued that the use of prediction might help with reading highly predictable words, but context is rarely helpful for decoding new, unusual or untaught content words that have the least predictability. Beginning readers can easily memorize simple function words, such as *the* and *it*, which are words with the greatest predictability, but not content words, such as *cheetah*, which are words with the least predictability (Gough, 1993).

Donaldson and Reid (1985) explained that reliance on prediction often causes serious errors that alter the meaning of a story, affecting comprehension. The authors proposed that a sentence read two different ways would still have the same meaning only if the words used did not affect the syntax. Changing the verbal tense of a word in a sentence may not affect our understanding of the principle action, but a simple verb substitution can change the meaning of a sentence. For example, Donaldson and Reid reasoned that changing the sentence '*Tom followed Dick and waved his flag*' to '*Tom saw Dick and waved his flag*' changes the meaning of the sentence subtly, and will therefore alter comprehension of a story. In the first sentence Tom had *followed* Dick, but in the second sentence Tom only *saw* Dick; he may not have followed him (Donaldson & Reid, 1985).

To correct for reading errors caused by prediction, such as word substitution, a child must know the effects of different words on the meaning of a sentence. This will happen only when a child can read or decode the actual words in a sentence, and when a child knows what the differences between these words mean. Donaldson and Reid (1985) stated that prediction was an immature and ineffective word decoding strategy, and that reliance on prediction does not generate accurate decoding ability. Inaccurate word decoding resulting from the use of prediction causes serious reading and comprehension errors. Accurate word decoding is only obtained by teaching children an independent phonological decoding strategy.

Contrary to Donaldson and Reid (1985), Goodman did not regard word substitution, such as *plane* for *jet*, as a serious reading error. Goodman encourages young readers to substitute synonyms, or other similar words, for unfamiliar words, as long as the flow of a text is preserved. For example, producing the word *girl* for the printed word *lady* would be considered acceptable because it preserves the meaning of the story. Goodman (1965) believes that the primary benefit of letting children read text is that a less-skilled reader can begin to recognize unknown yet predictable words with the help of context in a way not possible from isolated word reading. However, such a child is still unable to decode new words. A child that uses prediction is merely guessing word pronunciations from pictures, themes or other contextual cues.

Stanovich, Cunningham, and Freeman (1986) conducted a longitudinal study to evaluate children's use of context to help them decode words in running text during their first year of school. The children were initially classified as either skilled readers or less-skilled readers. At the beginning of the year, Stanovich et al. (1986) found that the use of context benefited the skilled readers, but not the less-skilled readers. This suggested that prediction was a strategy best used by children who already know how to read.

Stanovich et al. (1986) found that once the less-skilled readers were able to read words, after nearly a year of reading instruction, the less-skilled readers also obtained the same benefits from prediction as the skilled readers had obtained. Stanovich et al. (1986) concluded that beginning readers could not grasp the context of a story, and thus use contextual cues, without some degree of reading ability.

The converging evidence from Byrne (1991), Donaldson and Reid (1985), Seymour and Elder (1986), and Stanovich et al. (1986) indicates that whole-word reading theory is not a comprehensive theory of initial reading acquisition. While prediction may help a child preserve the flow of a story, children must have some reading ability to understand the story context, which enables them to make predictions. Furthermore, although children can memorize spelling patterns and recognize words on the basis of these, no one has shown that whole-word reading, or prediction produces an independent decoding strategy.

Another non-phonological reading strategy that has gained recognition is visual-cue reading. Visual-cue reading is different than whole-word reading in that the child responds to only a salient part of the word rather than the entire word (Gough, 1993; Gough & Hillinger, 1980). Visual-cue reading does not include sounding out or phonologically decoding any part of a word (Gough & Juel, 1991) and children usually have little knowledge of letter-sound associations. For example, in visual-cue reading, a child learns to recognize the word *camel* because the letter M in the middle has two humps, like a camel. According to visual-cue reading theory, early word reading is direct and visual, while later word reading is mediated by letter-sound correspondences and is phonological (Gough, 1993).

The visual-cue theory proposes that early word reading involves learning sight words. Support for visual-cue reading comes from observations that preliterate children can recognize words by associating some part of a word or its context to its pronunciation. Children learn to recognize first words directly from exposure to street signs, store or toy logos, and books with caregivers. For example, a child can recognize the word *stop* only if it occurs with the red street sign, or the word *MacDonald's* only if it contains the big yellow "M" on the red background. The pairing of an arbitrary response to an arbitrary stimulus is usually called paired-associate learning. In this type of learning, words are treated as logograms, meaning the child recognizes the word pronunciations on the basis of their visual forms only rather than by letter-sound associations. A child can build a large set of visual-cue or sight words by rehearsing these word pronunciations several times. Then, when children learn letters and letter-sound associations, they can begin to notice letter-sound units in the known sight words that help distinguish the words from one another. This can lead to a later stage of reading that is based on alphabetic insight. In this later stage children read new words by analyzing their underlying phonological structure (Goodman, 1965; Gough & Juel, 1991).

In a classic study, Gough (1993) first examined whether beginning readers between 4 and 5 years of age sight read words by noticing or memorizing parts of the word, referred to as the Local Hypothesis, or as wholes, referred to as the Global Hypothesis. Two separate experiments were conducted to compare these hypotheses. In the first experiment, Gough (1993) tested whether the child associates the word's pronunciation with some extraneous visual-cue rather than its letters. If the child learns to sight read using visual-cues, once the cue is removed, the child should not recognize the word. Alternatively, if the child learns to sight-read words as wholes, then removal of the salient visual-cue should have no effect on word recognition.

Half of the children tested learned a list of four similar words (BAG, BAT, RAG, RAT), and the other half learned a list of four dissimilar words (BOX, LEG, SUN, RAT). The words were printed on individual flashcards, and one word in each set had an obvious thumbprint on the corner of the card. This meant that for each list, there were three 'clean' words and one 'thumbprint' word. The children were screened for their ability to read the four target words, and those who read any of the words were excused from the study. The remaining children were taught to produce and recognize the target words through repetition and reinforcement of correct responses. The experimental trial was conducted when the child was able to read the words twice without errors. After the training trial, and without interruption or warning, the child was tested on the word without the thumbprint, followed by two successive clean words, then the thumbprint only, then two more clean words, and finally on one of the clean words again, but with the thumbprint on it.

Gough (1993) found that the children learned the thumbprint-word item significantly faster than any of the other three words in each list, and that it was the only item learned on first sight. When shown the word without the thumbprint, less than half of the children could recognize the word. In contrast, nearly all of the children could recognize the thumbprint without the word. Furthermore, Gough found that the pairing of the thumbprint with a different word, a word that had previously been learned on its own resulted in almost all of the children disregarding the word and identifying the thumbprint or the word previously associated with the thumbprint.

Gough (1993) concluded that the children were not processing the phonetic features or letters of the training words, and that very few beginning readers learn to associate the word to its printed form. Instead, if an obvious or irrelevant cue was paired with a word, children learned to associate the spoken word with that cue and overlooked the word or its letters. This paired-associate learning can take place when a visual or salient cue is paired with a word's pronunciation, so that both are stored together in the child's long-term memory. A written word is recalled when a reader recognizes the paired visual-cue. The paired visual-cue, or the thumbprint, acts as the retrieval cue for the word's pronunciation.

While the results found in the first experiment described above are consistent with the Local Hypothesis, as proposed by Gough (1993), they do not eliminate the possibility that children may be able to learn words as wholes, the Global Hypothesis. Gough knew that the children could have learned the thumbprint and the word as two separate wholes, so that learning one whole and not the other tells us nothing of whether the word or its letters is recognized as a whole.

For the second experiment, Gough (1993) proposed that if words were learned as wholes, then hiding half of the word would destroy word recognition. However, if parts of words were learned, then hiding half of the word should not affect word recognition.

The child should recognize one half, but not the other half of the word. The flashcards and training procedures were the same as the first experiment. A different group of 4 to 5 year old children were individually taught to read four words (LAMB, DUCK, FISH, PONY) to a criterion of reading all words twice without errors. The child was then asked if he or she could recognize a word when part of it was hidden. The first and second halves of each word were shown separately. Gough (1993) counted the number of times children responded either to each half of the words, both halves, the first and not the second half, the second and not the first half, or neither half. Although selectivity was not absolute, every child showed at least some selectivity, and no children treated every word as a whole. This suggested that beginning readers typically use selective association when learning to sight-read new words rather than memorizing words as wholes, consistent with the Local Hypothesis.

Gough (1993) explained that preliterate children who learn to read by memorizing whole words or by connecting visual-cues unrelated to the phonological representation of the words might have difficulty remembering these words because such connections are arbitrary. Arbitrary connections are typically harder to store and retrieve than a set of structured connections. Also, visual-cue reading does not assist children in identifying or decoding new words. For instance, "knowing that ELEPHANT is the long word, or that CAMEL is the word with two humps, does not help the child to decode the word HORSE" (Gough, 1993, p.188). Until the child acquires the alphabetic principle, he or she will learn word pronunciations through visual-cues, an immature and inefficient reading technique.

Non-phonological reading strategies may be used in the early stages of reading, but neither the whole-word nor visual-cue theories explain how children gain insight into the phonological structure of words, or how they learn associations between letters and sounds. Acquisition of the alphabetic principle is essential for developing independent decoding skills, and initial reading achievement (Byrne, 1991; Gough, 1993; Gough & Hillinger, 1980; Seymour & Elder, 1986; Stanovich et al., 1986). Accurate word decoding, either in isolation or in a text, requires the ability to analyze a word phonologically to the degree that letters can be decoded into sounds (Adams, 1990; Ehri, 1992; Oakhill & Beard, 1999; Rieben & Perfetti, 1991). For beginning readers, knowledge of associations between letters and sounds provides the basis for a strong self-directed learning of unfamiliar word pronunciations (Byrne, 1991; Gough, 1993; Ehri & Robbins, 1992; Perfetti, 1995; Rack, Hulme, & Snowling, 1993; Ehri, 1984).

Phonological Development

Phonological awareness is a heterogeneous skill that develops progressively over the course of children's language development (Treiman & Zukowski, 1996). Usually, the detection of syllables in a spoken word is the earliest phonological skill to develop (Liberman et al., 1974). Syllables are the fundamental units of speech production and perception, and they are the natural processing units of speech during infancy (Jusczyk, Houston, & Goodman, 1998). After syllables, children develop an ability to recognize and produce rhymes (Goswami & Bryant, 1990). Children develop a sense of rhyme through singing songs, reciting nursery rhymes, and playing rhyming games. Goswami and Bryant (1990) found that preliterate children could recognize and produce rhyming words, such as *beak, seek, leek,* and *peek*. After rhymes, the next phonological skill to emerge is the ability to segment or blend onsets and rimes in words. For example, *truck* can be broken into two phonological units; one is the onset or the *tr* unit, while the second is the rime or the *uck* unit. Onsets and rimes are phonological units that can be larger than the phoneme but smaller than the syllable (Stahl & Murray, 1994, p. 222). Awareness of phonemes – the ability to recognize or manipulate phonemes in spoken words – is considered to be the most difficult and final sound awareness to develop (Adams, 1990; Liberman et al., 1974; Stahl & Murray, 1994).

Liberman et al. (1974) used a tapping task to examine preliterate children's ability to tap out syllables and phonemes in a word. For example, in the phoneme-tapping task, a child hearing the word *dog* should tap three times for each of the three phonemes, /d/, /a/, /g/. In an analogous syllable-tapping task, a child should tap three times for the three syllables in 'hospital'. Liberman et al. (1974) reported that many of the children could tap out the syllables of the target words, but not the phonemes. Liberman et al. noted that only the first-grade children who had received reading instruction in school were able to segment the target words into phonemes. This suggested that reading instruction might somehow be directly related to their ability to detect phonemes. Liberman et al. (1974) therefore proposed that while syllable counting emerged before reading instruction, phoneme-tapping ability developed only after some reading instruction had taken place.

The awareness of other smaller phonological elements of speech, that of onsets and rimes, has been shown to emerge sometime between children's awareness of syllables and their awareness of phonemes (Treiman, 1988). Treiman, in a series of studies (Treiman, 1983; 1985; 1988; 1992), showed that children and adults naturally combine parts of words in logical and predictable ways. For instance, participants would combine the onset *fr* from the word *frail* with the rime unit *at* from another word, *slat*, to produce the new word *frat*. They did not break up the rime *ail* from *frail*, and the rime *at* from *slat* to get *frai* + *t* = *frait*. The subjects did not break up the onsets or rime units of the two words arbitrarily to produce new words. Treiman concluded that children and adults naturally break words into onsets and rimes first rather than breaking onsets, and rimes, into constituent phonemes.

Treiman and Zukowski (1996) conducted five separate experiments to test their Linguistic Status Hypothesis. According to this hypothesis, the linguistic level or status of the unit and its size influences performance on different phonological tasks. In the first experiment, Treiman and Zukowski used a same-different task to determine whether preschool and kindergarten children could more easily recognize the similarity between two words when the similar unit was single consonant onset, such as /p/ in *pact-peel*, than when the similar unit was part of a cluster onset, such as *plan-prow*. If the linguistic status of the unit influences the child's performance, then the child should find it easier to recognize the shared sound when it is the whole onset than when it is part of the onset. The reasoning behind this prediction is that the linguistic unit onset is easier to access than are individual phonemes within onsets. In contrast, if only the size of the unit influences performance, then the child should equally recognize the shared sound when it is the whole onset or part of the whole onset because the size of the unit is one phoneme, such as /p/, in either type of word pair.

Four practice word-pairs were given first, two 'yes' pairs and two 'no' pairs. The children were told that a puppet became happy when it heard two words that sounded the same, and sad when it heard two words that sounded different. Corrective feedback was given only during the practice trials. In the experimental trials, the child had to judge whether the puppet liked each of the word pairs. There were 30 monosyllabic test word-pairs, of which 20 were 'yes' words, or words that shared an initial sound, and 10 were 'no' words, or words that did not share any sounds, such as *bomb-drip*. Ten of the 'yes' word-pairs each shared a similar single-consonant onset, such as the *pact-peel* word pair. The other 10 'yes' word-pairs each began with a cluster onset, but each pair shared only the first consonant of a cluster onset, such as the *plan-prow* word pair.

Treiman and Zukowski (1996) found that the children could recognize a shared sound more easily if it was a whole consonant onset than when it was part of a cluster onset. For example, the children were able to easily recognize that the words *pacts* and *peel* shared the same beginning sound, but not for the words *plan* and *prow*. This is because the cluster onsets *pl* and *pr* are cohesive units, making it difficult to separate out the individual target /p/ sound. This suggests that beginning readers access and compare whole onsets more easily than individual phonemes within a cluster onset, consistent with the linguistic status hypothesis. The size of the unit did not influence the children's performance; the size of the target sound, such the single /p/ phoneme, was the same across all word pairs. In addition, although the children did not always understand why some word pairs sounded the same, they could recognize that the 'no' word pairs were different sounding words. This suggests that preschool children develop some degree of sensitivity for word onsets, single consonant onsets or cluster onsets.

MacLean, Bryant, and Bradley (1987) examined the relationship between children's early nursery rhyme knowledge and reading development. These authors proposed that preliterate children should produce nursery rhymes, requiring only the comparison of whether words sound the same or not, more easily than separating onsets or phonemes in words, which requires the ability to analyze and manipulate individual components within words. MacLean et al. reasoned that the latter ability demands extensive orthographic knowledge, and more analytical or phonological processing abilities than simply accessing and comparing words with similar sounds. MacLean et al. investigated whether preschool children were able to produce common nursery rhymes more easily than a pair of rhyming words, and whether rhyming tasks were easier than separating onsets or phonemes in words.

MacLean et al. (1987) found that children who knew nursery rhymes at the age of three could not remove onsets of words in phoneme segmentation tasks. This suggested that young children's knowledge of nursery rhymes develops before their ability to separate individual sounds or onsets in words. MacLean et al. concluded that younger children find it easier to recognize and produce rhymes, nursery rhymes or rhyming words, than to remove onsets or phonemes in words.

A comprehensive definition of phoneme awareness is the ability to recognize or manipulate the individual phonemes in a word. Phoneme awareness at this level is considered the final level of phonological awareness to develop (Adams, 1990; Liberman et al., 1974; Stahl & Murray, 1994). In Liberman's et al. (1974) phoneme tapping study that assessed children's ability to count the constituent phonemes in a word, the majority of the preschool and kindergarten children could not count the phonemes in spoken words. In contrast, the older first-grade children, who had a year of reading instruction, could tap out the phonemes (Liberman et al., 1974). Liberman et al. suggested that reading instruction facilitated the children's ability to recognize phonemes, and that preliterate children do not have phoneme awareness. Other researchers have found that preliterate children tend to be unsuccessful in tasks of phoneme awareness as well (Goswami & Bryant, 1990; Murray, 1998; Perfetti et al., 1987; Stahl & Murray, 1994; Treiman & Zukowski, 1996).

Children's awareness of phonemes, as determined by the phoneme-tapping task, measures only one aspect of phoneme awareness. A phoneme-tapping task requires that a child recognize and identify all the phonemes in a spoken word by tapping once for each phoneme. Other phoneme awareness tasks, such as phoneme blending, segmentation, deletion, and substitution, measure different aspects of a child's emerging awareness of phonemes. These phoneme-manipulation tasks require that a child blend, segment, delete or reorder individual sounds to form new words (Stahl & Murray, 1994). Phoneme-deletion tasks require that a child recognize, separate or remove one or more phonemes in a spoken word to create a new word. For example, a child asked to say *goat* without /g/ needs to know how to remove the *g* sound to produce the new word *oat*. In contrast, phoneme-blending tasks require the ability to blend different sounds together in order to produce a word. Sometimes these sounds are two real words, such as *foot* and *ball* for *football*, or individual sounds and real words, such as /h/ and *at* for *hat*, or *go* and /t/ for *goat*, or individual sounds and a rime, such as /s/ and *ight* to produce *sight*. Because of the many ways in which phoneme awareness is measured, accurately defining phoneme awareness remains an unresolved problem in reading research.

Treiman and Zukowski (1996) showed how success on different tasks of phonological awareness depended on the linguistic status being accessed by the task. For example, deletion of the phoneme /s/ in the word *nest* is a more difficult task than the deletion of /p/ in *pink*, an onset-deletion task. The position of the phoneme /s/ in *nest* makes it harder to delete than the phoneme /p/ in *pink* because /s/ is deeply embedded in the rime unit *est*, and is therefore not as accessible as the beginning sound or onset /p/ in *pink*. However, both tasks require that a child remember the target word, the target sound being deleted, and the sounds 'left over' once the target sound has been removed. In some cases, a child's spelling experience might influence his or her ability to manipulate phonemes. If a child knows the spelling sequence of a word, it might be easier to manipulate or blend the letters in the word rather than the sounds to produce the new target word.

Performance on phonological awareness tasks, such as rhyming, onset-rime segmentation, syllable or phoneme counting is influenced by the cognitive demands of the task (Adams, 1990). Performance on many phoneme awareness tasks, such as phoneme substitution or deletion, demand more than the ability to substitute or remove phoneme in words; memory is a critical factor too. For example, phoneme-substitution tasks require the ability to select, remember and delete the target phoneme, the ability to remember the new phoneme that is to replace the old phoneme, the ability to replace the old phoneme in the word with the new phoneme, and then the ability to blend the new phoneme with the remaining sounds from the old target word in order to produce the new target word. Adams (1990) stated that phoneme manipulation tasks require "all manner of memory skills and gymnastics" (p.72).

Perfetti (1991) maintains that preliterate children need direct instruction to draw their conscious attention towards phonemes. Phoneme awareness is not simply a "working knowledge" of phonemes, which includes the ability to perceive differences between phonemes or to imitate a sequence of phonemes. Instead, phoneme awareness requires directing attention and analytical abilities to the manipulation of the abstract sounds in a word (Adams, 1990). Reading instruction received in the first few years of school can and often does direct children's attention to phonemes, and children learn how letters map onto these sounds. Consequently, rather than phoneme awareness developing before reading acquisition, children's awareness of phonemes might result from formal reading instruction or reading acquisition.

Phonological Awareness and Learning to Read

Although many researchers agree that reading is related to phoneme awareness, these same researchers disagree about the nature and importance of this relationship (Adams, 1990; Ehri, Numes, Willows, Schuster, Yaghoub-Zadeh, & Shanahan, 2001; Goswami & Bryant, 1990; Oakhill & Beard, 1999; Perfetti, 1991). A strong correlation between phoneme awareness and reading ability is now well established in the literature (Blachman, Ball, Black, & Tangel, 1994; Bradley & Bryant, 1983; Ehri et al., 2001;

Goswami & Bryant, 1990; Liberman et al., 1974; Stanovich, Cunningham, & Cramer, 1984), but a correlation does not indicate a causal connection. Instead, the results from some training studies, longitudinal studies, and studies of children and adults with reading disabilities are drawn on as support for a causal relationship between reading and phoneme awareness (Bradley & Bryant, 1983; Juel, 1988; MacLean et al., 1987; Morais et al., 1979; Perfetti et al., 1987).

According to the Committee on the Prevention of Reading Difficulties in Young Children, "phonemic awareness is the key to understanding the logic of the alphabetic principle and thus to the learnability of phonics and spelling" (Snow, Burns, & Griffin, 1998, p.15). Subsequently, beginning readers must develop awareness of phonemes first, and only then can they learn how the letter names represent those phonemes in a word. The assumption is that segmentation of a word into phonemes, or the manipulation of phonemes in a word facilitates alphabetic insight. In order to read a new word, a child must translate each letter into its phoneme and then blend the phonemes together to reconstruct the word. Support for this theory comes from evidence obtained in several phoneme-awareness training studies (Bradley & Bryant, 1983; Lundberg, Frost, & Peterson, 1988; Treiman & Baron, 1983).

As part of a longitudinal study, Bradley and Bryant (1983) examined whether there was a causal relationship between sound categorization of phonemes and reading. First, the children were each tested for sound-categorization ability in an oddity task. In this task, the child was asked to identify the word with a different initial, middle, or end sound that distinguished it from two other words. For example, upon hearing the words *hill*, *pig*, and *pin*, the child should identify *hill* as the word with the odd initial sound.

Next, the children from the original group who could not read, and who scored at least two standard deviations below the mean on the oddity task were divided into four separate groups. There were two experimental groups, a Sound Only and a Combination Letter-and-Sound group, and two control groups, a Conceptual group and a No Training group. Children in the two experimental groups were shown how words could be sorted by common initial sounds (hen, hat), middle sounds (hen, pet), and final sounds (hen, man). However, only the Combination Letter-and-Sound group was shown how letters represented the common sounds taught. Children in the Conceptual control group were shown how words could be categorized in several different ways. The children in the No Training control group received no special training.

Bradley and Bryant (1983) predicted that the two sound-training conditions would promote an awareness of phonemes, resulting in higher reading achievement than for the two control groups. As expected, Bradley and Bryant (1983) found that the two control groups did not differ significantly in later reading or spelling achievement. The reading and spelling scores for the Sound-Only group were consistently higher than either of the control groups, but this difference was significant only between the Sound-Only group and the No Training group. An unexpected finding was that the Combination Letter-and-Sound group achieved significantly higher reading and spelling scores than either of the two control groups, and significantly higher spelling scores than the Sound-Only group.

Bradley and Bryant (1983) discovered that the sound training was more effective when there was explicit instruction showing how the sounds were connected to the alphabet, and stated that the Combination group "succeeded even better than group I [Sound-Only] in reading and particularly spelling" (p.420). Bradley and Bryant failed to explain the significantly higher reading and spelling scores of the Combination Letter-and-Sound group adequately. The researchers concluded that sound-categorization training facilitates children's progress in reading and spelling.

While other researchers have found similar results supporting the view that a child who can recognize phonemes in words will be a better reader than a child without phoneme awareness (Bradley & Bryant, 1978; Frost, 2001; Liberman *et al.*, 1974; Lundberg, Frost, & Peterson, 1988), Bradley and Bryant's (1983) study is often cited as strong evidence that phoneme awareness training promotes reading development. Bradley and Bryant's methodology will be further examined in the section exploring different phonological reading theories in order to demonstrate that their inference of causality was not justified.

In contrast to Bradley and Bryant's work, there are several researchers who support another theory of reading development. According to this theory, children acquire phoneme awareness after learning to read and spell words (Adams, 1990; Morais et al., 1979; Perfetti, 1985; Rieben & Perfetti, 1991). According to this view, phoneme awareness is not a prerequisite for reading; instead, reading promotes phoneme awareness (Ehri, 1979; 1984; Ehri et al., 2001; Goswami, 1986; Goswami and Bryant, 1990; Perfetti, 1985; 1991; Perfetti et al., 1987).

Perfetti et al. (1987) conducted a longitudinal study to test the hypothesis that reading and phoneme awareness develop in a reciprocal relationship. At the beginning of the school year, the children in Perfetti et al.'s study were classified according to their reading ability. Children in the Basal Rockets group were the best readers, and the Basal Readiness readers were the poorest readers. There was a Direct Code group of readers that were comparable to the Readiness readers on study-entry reading ability. The distinguishing feature between the children in the Rockets and Readiness groups and the Direct Code readers was that the latter group had been given direct phonics instruction, while the former groups had not. Although both the Direct Code and Readiness children had direct phonics instruction and could read a few words, comparatively, the Readiness children were the poorest readers. All children were given three phoneme-awareness tasks (tapping or segmentation, deletion and blending), and one pseudo word-reading task. These tasks were administered at the beginning of the school year, at 8 weeks, 19 weeks, and 33 weeks into the school year. At the end of the year, two separate reading assessments were used to determine the children's reading achievement.

Overall, at the beginning of the year, Perfetti et al. (1987) found that all the children performed poorly on phoneme synthesis or blending, deletion, and tapping tasks. For example, only five children from the Rockets and Direct Code groups were able to reach the success criterion of 75 percent on phoneme blending, one of the simplest tasks given. Although some children were able to do some phoneme blending before true reading began, many were not able to do phoneme deletion. This suggested that children might require a basic ability to blend simple sounds before learning to read.

After a year of formal reading instruction, Perfetti et al. (1987) found that many children were able to reach the success criterion for each task, even on the most difficult phoneme-tapping task. While all the children showed improvement in phoneme synthesis and deletion, the children still had difficulty doing a few deletion items, such as the /s/ in *sp* for *spin* to produce *pin*, or tapping out phonemes in words. In addition, the children found it easier to do final deletions than initial deletions. Perfetti et al. stated that the relationship between reading and phonological awareness could not be defined easily in prerequisite terms, but that in general, the results obtained were consistent with the view that reading and the ability to blend and delete phonemes develop in a mutually supportive relationship.

Perfetti et al. (1987) concluded that a rudimentary ability to blend sounds could develop before reading, but in general, both reading and phoneme awareness increase reciprocally in complexity. Also, with progress in reading, children transition from being able to do easy synthesis or blending tasks, to doing difficult phoneme deletion or tapping tasks. However, Perfetti et al. could not confirm whether reading developed before phoneme awareness or *vice versa*. Instead, these researchers concluded that progress in reading is directly related to progress in phoneme awareness, and *vice versa*, rather than one skill emerging before the other.

Ehri (1983) re-examined published evidence regarding the relationship between reading and letter-name knowledge, and found that learning letter names or letter-sound associations facilitated initial reading acquisition more than learning the phonemic elements of a word. Based on these findings, Ehri suggested that letters might provide children with visual symbols to attach to phonemes, and that acquiring letter-name knowledge can help direct children's attention to the phonemes in words. These speculations about the relationship between letter names and phoneme awareness were supported by results from Ehri's et al. (2001) recent meta-analysis.

Ehri et al. (2001) reviewed the results of more than fifty phoneme-awareness studies conducted between 1976 and 2000. The studies included in the review each assessed the effect of phoneme-awareness instruction on the reading and spelling achievement, for both average and poor beginning readers, by using an experimental design and an adequate control group. Ehri et al. (2001) found that phoneme-awareness training had a significant effect on the children's reading and spelling achievement, but only when letter-name instruction was incorporated as well. Ehri et al. (2001) concluded that while phoneme-awareness training could improve children's reading, letter-name instruction significantly boosts the effect of phoneme awareness training.

Goswami (1986) and Goswami and Bryant (1990) proposed a theory of reading acquisition that takes into account children's emerging awareness of common sounds in different words. According to this view, children's early awareness that different words can have a common onset (e.g. boat-bike) or a common rime (e.g. train-rain) plays a critical role in learning about spelling, which in turn promotes reading development.

Goswami (1986) conducted a study examining children's ability to use an analogy spelling strategy to read real and nonsense words. The primary school children were first assigned to three different reading groups. Group 1 could not read any words, while Groups 2 and 3 were both able to read, and Group-3 children, who were a year older than the children in Group 2, were the best readers. All children were pretested on the words to be read. The children were individually tested six times in six separate sessions, and each session represented a different condition. For each session, the child was shown a printed clue word, and was asked to read seven real or nonsense words that were either analogous or not to the clue word shown. The nonsense words were created from the real words with only one letter changed, thus keeping the letter sequence needed for the analogy intact. In each session, the child was shown two clue words and the associated target words.

There were three types of test words. The first type was called Target words that shared the same orthographic sequence as the clue words either at the beginning of words, such as *bea*k (clue word)-*bea*n (target word), or at the end, such as b*eak* (clue word)-p*eak* (target word), and were called Beginning and End words, respectively. The second type was called Common-Letter words and shared three common letters with the clue words, such as *beak-bask* or *beak-lake*. The third type was called Control words (three given) that were real and nonsense words. These were the Target and Common-Letter clue words, such as *beak* (clue word) paired with *rain*, *tail*, *real* (test words), or *beak* with *rait*, *kail*, *roal*.

There were three experimental conditions: a Beginning condition that showed the target words analogous to the clue words at the beginning; an End condition that showed the target words analogous to the clue words at the end; and a No Clue condition, where no clue words were shown. Children in the No Clue condition received all four target words in a given set, and an additional three Control words. All children experienced each of the three conditions twice, once for the real words and once for the nonsense words, for a total of six experimental conditions per child. Overall, in each experimental session, each child was shown two clue words before having to read the two test words except for the No Clue condition, where no clue words were shown.

Goswami (1986) reasoned that if children can make analogies between clue words and test words, they should score higher on the target words than on both the Common-Letter words and Control words in the Beginning and End conditions, and higher than target words in the No Clue condition. Goswami (1986) found that the children in Groups 2 and 3 successfully read more Target words in the Beginning and End conditions than words in the No Clue conditions. In addition, Goswami (1986) found that reading by analogy was easier in the End condition than the Beginning condition, independent of the children's reading level. Goswami concluded that during the initial stages of reading, if given a clue word that was analogous to unfamiliar words, both younger and older children are equally capable of reading words by analogy, and rime analogies were more effective than analogies at the beginning of words.

The results for the first Group, the non-readers, were less clear than those for Groups 2 and 3. The youngest children in the first group read a few words or no words, but they were occasionally able to give correct responses for the End conditions. No significant difference was found between words read in the Beginning and the No Clue conditions, but there was a significant difference between the End and both the Beginning and No Clue conditions. The non-readers in the first Group therefore found it easier to make analogies between the endings of words (*beak-peak*) than between the beginnings of words (*beak-bean*). This finding was comparable to the results found for the children in groups 2 and 3. Goswami (1986) concluded that the older children, who were already reading words, could read unfamiliar words by analogy with clue words when shown unfamiliar words that shared either the first or last three letters. If given clue words, even the younger children who were not yet reading could also make analogies between words that shared common orthographic sequences for the rime unit.

Goswami and Bryant (1990) theorized that a child develops a large number of words in his or her mental lexicon to permit him or her to make analogies. Goswami and Bryant (1990) did not deny that phoneme awareness plays an important role in reading and spelling development. However, these researchers supported the view that awareness of rhymes is the phonological skill that is essential for initial reading, while phoneme awareness was a phonological skill that emerged after reading instruction.

In summary, Perfetti et al. (1987) believes that some basic phoneme-blending skills promote initial reading, and Ehri et al. (2001) believes that learning letter-names together with basic phoneme segmentation and blending promotes initial reading. Both Perfetti et al. and Ehri et al. believe that there is some basic level of phonological skills available to the child before reading, and that advanced phonological skills, such as phoneme awareness, comes after reading. Both of these researchers support a reciprocal relationship between reading and phoneme awareness.

In contrast to Perfetti et al., Goswami (1986) believes that rhyme awareness, in particular rhyme analogy between the ends of words, plays a critical role in acquiring the alphabetic principle. Children's early awareness that different words can have a common rime, such as *tr<u>ain</u>* and *r<u>ain</u>*, or a common initial sound, such as *<u>b</u>oat* and *<u>b</u>ike*, can help children learn about the spelling sequences of words. This learning can facilitate children's understanding of why some words sound similar, which in turn is important in extracting rules about how words are spelled or pronounced. While Perfetti et al., Ehri et al. and Goswami each have different views of initial reading development, each author believes that some phonological skills, such as syllable or onset-rime blending, or rhyme analogy, come before reading while other skills, such as phoneme awareness, comes after reading; phoneme awareness is therefore not an initial reading prerequisite.

Examination of Methodologies used in Key Training Studies

The studies reviewed and discussed above each used different phonemic elements or phonological tasks, and methods to train or test children's phonological development. For example, some studies taught children to identify various sounds in words, while others taught children to segment or blend different sounds. Across studies different standardized and non-standardized reading tests were used to assess children's reading ability. However, some key phonological training studies did not measure children's initial knowledge of letters, letter sounds or early reading ability. These skills have been shown to facilitate initial reading acquisition (Ehri et al., 2001). A closer examination of the methodologies from some key studies could help clarify which phonemic element or task, or level of literacy promotes reading acquisition.

Bradley and Bryant (1983) tested preliterate children on their ability to categorize sounds before conducting the sound-categorization training. The children, four or five years old, had to identify the different sounding word from a list of words in the Odd

Man Out task. Bradley and Bryant asked children to point out the word with the different beginning, middle, or end sound. Although often interpreted as a phoneme-awareness task, the Odd Man Out task used by Bradley and Bryant could be considered a task that involves identification of onsets and rimes. For example, selecting *hill* as the odd man out in the list *hill, pig,* and *pin* could be done on the basis of choosing the word with the different onset, and selecting *hat* in the list *cot, pot*, and *hat*, and the word *doll* in the list *doll, hop,* and *top*, could be done on the basis of choosing the word with the different rime. Given that preliterate or beginning readers can analyze words into onsets and rimes much easier than into phonemes (Treiman, 1988), it is likely that the children in Bradley and Bryant's study were able to do the odd-man-out task by choosing the word with a different onset or rime rather than a different phoneme. The level at which the children were actually able to do the odd-man-out in the Bradley and Bryant (1983) study is therefore ambiguous, and their interpretation of the results found may not be valid.

If the children succeeded on the odd-man-out task by identifying words on the basis of different onsets and rimes, then Bradley and Bryant's (1983) findings support the theory that early onset and rime awareness predicts later reading success. Also, Bradley and Bryant's study has been interpreted as showing that phoneme-awareness training using the oddity task caused greater reading success. However, the training administered might have increased the children's awareness of onsets and rimes in words; therefore, onset- and rime-awareness training and not phoneme-awareness training might have caused greater reading achievement.

Recall Perfetti et al. (1987), who support the view that reading develops before phoneme awareness, but found that preliterate children possessed a rudimentary ability to blend individual phonemes into words or into syllables before they made progress in reading. Then, once the children's reading progressed, their ability to do complex phoneme-awareness tasks progressed. Perfetti et al. concluded that reading and phoneme awareness develop in a reciprocal relationship rather than one emerging before the other.

Unfortunately, Perfetti et al. (1987) failed to examine children's pre-literacy skills, such as letter-name knowledge or letter-sound associations that have also been related significantly to initial reading development (Ehri et al. 2001). Perfetti et al. reported that before the children received reading instruction, many of the preliterate children were able to read a few words, and two children in the Rockets group were able to read sentences.

In a similar fashion, Goswami (1986), who found that non-readers were able to use reading by analogy to decode unknown words, failed to measure children's early literacy skills, such as knowledge of letters or letter-sound associations. This was an unfortunate oversight by both Perfetti et al. (1987) and Goswami (1986) because other research shows that letter-name and letter-sound knowledge are related to both independent-word reading or reading by analogy success (Ehri & Robbins, 1992; Ehri et al., 2001). Therefore, one cannot rule out that early literacy skills, that is, letter-name and letter-sound knowledge, are the critical prerequisites for reading rather than phonological skills of phoneme blending or reading by analogy.

Ehri and Robbins (1992) compared preliterate children's ability to read by analogy to their early literacy and phonological recoding skills. The children were initially classified as readers or non-readers on the basis of their letter knowledge and word-reading ability. Participants in the study knew at least 11 of the16 letters given to them on a letter-naming pretest, but only the children who were able to read between two and five non-words on the reading pretest were able to read by analogy. The non-readers who could not read any words realized why the analogy words were different; that is, they knew the words had different beginnings letter-sounds than the clue words. However, the non-readers could not complete the necessary step of removing the clue word onset and then blending the target onset onto the clue word rime to produce the target word.

Ehri and Robbins (1992) explained that reading by analogy requires a child to know enough letters to recognize, for instance, that the letters in *beak* are the same as those in *peak* except for the first letter in each word. The child must also appreciate that *beak* and *peak* rhyme. To produce an unfamiliar word (*peak*) from reading by analogy with a clue word (*beak*), the child must remove the onset from the clue word to produce the rime, know the pronunciation of the first letter of the target word, and must be able to blend the target onset onto the rime unit from the clue word (Ehri & Robbins, 1992). Children therefore need letter-sound associations for simple onsets, and onset-rime segmentation and blending skills to successfully read by analogy. Ehri and Robbins (1992) concluded that the children who were readers or children who had sufficient letter-name knowledge and some basic phonological-recoding skills could produce an analogous target word using rime analogies.

In my review of the available literature, no studies were found that clearly showed which orthographic or phonological element(s) had the greatest effect on initial reading development. The extensive meta-analytical study undertaken by Ehri et al. (2001), one goal of which was to uncover the key phonological or orthographic element or skill that had the greatest impact on initial reading development, failed to determine the critical trigger(s) for reading acquisition. Ehri et al. could not perform the critical analyses of which training tasks were the most effective in promoting reading development. Two main reasons for this was that there were too few phonological-training studies that applied a true experimental design with an appropriate control group, and that there was a wide variation in the phonological training tasks used in the studies reviewed. However, Ehri et al. did find that teaching letter-name or letter-sound knowledge together with phonological skills was more important for increased reading achievement than phoneme-awareness training alone. According to the ABC-GPC theory of reading proposed here, letter-name knowledge is the first critical step towards reading acquisition. This view will be described in the following section.

A Third View of Initial Reading Acquisition

A comprehensive theory of initial reading acquisition needs to take into account children's knowledge of letter names and letter-sound associations as well as their phonological skills. According to the ABC-GPC theory of reading acquisition, preliterate children first acquire letter names, phoneme identity and grapheme-phoneme correspondences for word-initial onsets. Knowledge of letter names is often acquired in the preschool years, between age 3 and 5. Letter-name knowledge is critical because letter names can provide clues for helping the child identify words on the basis of initial letter names heard in the word's pronunciation, such as *b* for *beach*, and for connecting letters with their sounds. For example, during shared parent-child alphabet learning, the child hears repeatedly that letter b is for ball, book, or bed. This type of reading experience will help the child to create connections between the initial sound heard in a word and the first letter of the word. Also, by hearing that certain letters go with certain words, the child may realize letter b represents the first sound heard at the beginning of the words ball, book, and bed (Adams, 1990; Penney et al., n.d.; Stahl & Murray, 1994).

Evidence that letter-name knowledge is a critical factor for reading achievement comes from the work of Share, Jorm, Maclean, and Matthews (1984). Share et al. (1984) used different cognitive, language, and home-life measures in order to determine which factor best-predicted children's reading achievement after kindergarten and first grade. These researchers found that letter-name knowledge measured at school entry was the single, best predictor of reading success at the end of kindergarten compared to 39 other variables. Letter-name knowledge predicted subsequent reading achievement better than intelligence, vocabulary, phoneme segmentation, and memory for sentences, father's occupational status, parental home reading, and TV-watching.

Treiman and Rodriguez (1999) investigated preschool and kindergarten children's use of letter names in learning to read. All of the children were tested on three word-learning conditions, Name, Sound, and Visual. In the Name condition, the stimuli were words in which the names of the first letters in the words could be heard, such as *BT* for *beet*. In the Sound condition, the stimuli were words in which the sounds of the first letter in the words could be heard, such as *BT* for *bait*, and in the Visual condition, the stimuli were words that were visually distinct, such as *BT* for *ham*.

After completing the three word-learning tasks, the children performed a word and picture-reading task to assess reading ability. A child was shown a number of cards, each with two words and a colored picture on it, and were asked to identify the items he or she knew. In a fourth session, children's letter name-knowledge was measured for 26 capital letters. The child was shown a card and was asked to produce the name of the letter on it. To assess children's letter-sound knowledge, a letter-sound task was given that used the cards in the letter-name task, but instead of giving the letter name each child was asked to say the sound of each letter.

Treiman and Rodriguez (1999) classified the children into two groups. The first group was called Pre-Readers who were unable to read any of the words on the word- and picture-reading task, and the second group was called Novices who were able to read at least one word. For the Novices, performance on the word-learning task was significantly better in the letter-name condition than the letter-sound, and the latter was significantly better than performance in the visual condition. While the Novices could use letter-sounds to read words, they learned to read the stimuli more easily when letter-names could be heard in the words. For the Pre-Readers, performance in the Name condition was significantly higher than both the Sound and Visual conditions, between which there was no difference. The Pre-Readers were able to use letter-name cues for learning to read new words, but not letter-sound cues. Treiman and Rodriguez (1999) concluded that knowledge of letter names helps beginning readers form connections between letters and sounds.

Blaiklock (2004) found evidence that letter-name knowledge is a critical factor for initial reading and phonological development. In a longitudinal study, Blaiklock measured the effects of general verbal ability, phonological memory, pre-existing reading abilities, and letter-name knowledge on the relationship between phonological awareness and reading over the first two years of school. In the first year of the study there were six testing sessions, and in the second year there were three. Tests for receptive vocabulary, letter naming, letter sounds, phonological memory (digit span in the WISC-R), rhyme oddity, and phoneme deletion were administered, as well as two word-reading tests. The children's reading program in school was based on a whole language approach that focused on the importance of reading meaningful texts and using contextual cues to decode unknown words. In school, the children were taught letter names, but not letter sounds. However, the children were taught some grapheme-phoneme correspondences during writing or spelling activities, if necessary.

Replicating earlier findings, Blaiklock (2004) found that phonological awareness was significantly related to reading development even after controlling for verbal ability and phonological memory. However, the ability to read a number of words developed before the children could do phoneme deletion. More important, once the children's age and letter knowledge was controlled for, many of the concurrent and predictive connections between phonological awareness and later reading became insignificant.

Letter-name knowledge was a better predictor of reading achievement at each time point in his two-year study than either rhyme or phoneme awareness.

Blaiklock (2004) concluded that most of the connections, concurrent or predictive, often found between measures of phoneme awareness and reading are mediated by letter-name knowledge. Blaiklock's (2004) findings suggest that learning orthographic skills, letter names and letter sounds, encourages reading development and phonological awareness rather than the reverse.

In one of only a few letter-name training studies, Carroll (2004) taught a small group of preliterate children several letter names in order to determine whether letter knowledge is a precursor for phoneme awareness, or not. First, Carroll conducted an eight-month longitudinal study in which she tested 56 preschool-children between three and five years of age twice, seven months apart. Three tests were given at each time point, a test of letter knowledge and receptive vocabulary, an onset-deletion task, and a phoneme-completion test in which children were asked to produce a new word, such as *gate*, by adding a /t/ to the end of the word *gay*.

Carroll (2004) found that the children who knew at least one letter name could achieve some success on phonological tasks. She also found that expert letter-name knowledge at the beginning of school was significant predictor of phoneme awareness eight months later. Children with good letter-name knowledge showed greater phoneme awareness skills than children with poor letter-name knowledge. However, because the phonological tasks measured the children's ability to separate onsets and to add codas, Carroll's findings suggest that early letter-name knowledge promotes phonological awareness at the level of onset-rime segmentation, and the blending of vowels and codas.

Next, Carroll (2004) conducted a letter-training experiment. Carroll hypothesized that knowledge of letter names would increase children's ability to isolate and identify phonemes in words. Using a small group of 10 preschool children, Carroll taught eight letter names, letter shapes and their distinctive features daily over a four-week period. The letters were explicitly linked to sounds, and children were asked to identify pictured objects that began with the letter-sounds taught.

There were three testing sessions, one before the training began, one at the end of the training, and a follow-up session seven weeks after the training ended. In the first two sessions, a letter-knowledge task and an initial phoneme-matching task were administered. In the follow-up session, a letter-knowledge task, initial phoneme-matching task, and the phoneme-deletion and phoneme-completion tasks used in the longitudinal study were administered.

In the initial post-test results, Carroll (2004) showed that while the children's letter knowledge had significantly increased, the children's ability to do the onset phoneme-matching task had not. Therefore, letter knowledge did not appear to increase the children's success in the onset phoneme-matching task. However, because this task measured two skills, children's ability to segment phonemes in words and onset identity, it was possible that letter-name knowledge influenced the sub-skills needed in only one of these tasks and not the other. Carroll concluded that letter knowledge did not increase the children's performance on the composite tasks of phoneme identity and phoneme segmentation.

In contrast, on the basis of the follow-up testing, Carroll found that only the children who knew between three and eight or more letters at post-test showed increased phoneme-awareness skills. For example, the children who knew at least three letters at post-test achieved success on the phoneme-completion task, while the children who knew eight or more letters achieved success on the initial phoneme-matching task (a composite test of phoneme segmentation and phoneme identity) at follow-up.

Carroll (2004) concluded that early letter-name knowledge may not have an immediate effect on phonological development, but did have a long-term effect. Carroll proposed that only children who could do the initial phoneme-matching task, mediated by their knowledge of letter names or letter sounds, could succeed in tasks of phoneme awareness. Knowledge of letter names and letter sounds is essential for learning to read, and facilitates phonological awareness rather than the reverse.

The findings reviewed here suggest that knowledge of letter names develops first, and is a critical prerequisite for reading acquisition. Although a causal relationship between letter-name knowledge and reading development cannot be ascertained, the converging evidence from important causal studies (Blaiklock, 2004; Bradley & Bryant, 1983; Byrne & Fielding-Barnsley, 1990; Carroll, 2004; Ehri et al., 2001; Murray, 1998; Penney et al., n.d.; Treiman & Rodriguez, 1999; Stahl & Murray, 1994; Wagner et al., 1997) support the hypothesis that letter-name knowledge is the first step towards literacy.

In the ABC-GPC theory of reading, the acquisition of phoneme identity for beginning sounds of words is the critical prerequisite for initial reading acquisition. Phoneme identity is the identification of phonemes regardless of where they are located in a word. For example, a child with phoneme identity would understand that the *b* sounds heard in *ball*, *rabbit*, and *disturb* represent the same sound, the phoneme /b/. Several researchers support the notion that phoneme identity is the phonological element necessary to facilitate alphabetic insight – the acquisition of letter-sound associations (Byrne & Fielding-Barnsley, 1990; Murray, 1998). Using the definition of phoneme identity described above, Byrne and Fielding-Barnsley (1990) conducted an extensive study that showed how phoneme-identity training combined with letter-sound training for beginning and ending sounds in words encouraged the acquisition of alphabetic insight in preliterate children.

In Byrne and Fielding-Barnsley's (1990) investigation, two groups of preliterate children were given either phoneme-segmentation or phoneme-identity training to determine how each training program influenced the acquisition of the alphabetic principle. Before training began, the children's knowledge of some letter-names and letter-sounds was measured. For the phoneme-identity training, the children were taught to recognize four target phonemes, /m/, /s/, /t/, and /ʃ/ (the latter sound is a voiceless palatoalveolar fricative typically spelled as *sh*), in the onset and coda position of words. For each of the four target phonemes, contour drawings were made of six familiar items, the names of which contained the target phonemes in the beginning or ending position of words. For each target phoneme, the experimenter showed each child six items or cards in an array, and then named each item in the array and commented that each item began or ended with the target phoneme. The names on each card were repeated twice, and then the children were asked to name the items on each card three times. The children were frequently reminded that all the items in the array began with or ended in the target phoneme, such as /s/.

Immediately following the phoneme-identity training there was a test phase where each child was shown two pictures. The experimenter named each of the two pictures, told the child that only one of items in the pair of pictures began with (or ended with) the target phoneme, such as /s/, and then asked the child to indicate which one began with (or ended with) the target phoneme. For the training and testing phases, word position and phoneme were counterbalanced. The training and test phonemes were the same, but the sets of training and test items were different. The training and testing phases took four days, with two target phonemes being trained and tested on each day.

The final phase consisted of two alphabetic-training sessions, and each of these sessions was followed by a transfer task. For the first alphabetic training session, the children were taught to read two words, *sat* and *mat*, and then were taught the sounds that represented the letters *s* and *m*. In the transfer task, the children were shown one target word, such as *mow*, and were asked to choose either *mow* or *sow* as the correct pronunciation of that target word. There were eight target words. For the second alphabetic-training session, the children learned to read *fin* and *bin* and to pronounce the letters *f* and *b*; these phonemes had not been taught in the phoneme-identity training. In the second transfer task, children were shown a word such as *fat*, and asked whether the word said *fat* or *bat*. If a child succeeded in this last transfer task, then he or she was considered to have gained alphabetic insight. In both alphabetic phases, the children were taught letter-sounds for the phonemes /s/, /m/, /f/, and /b/.

Byrne and Fielding-Barnsley (1990) found that the phoneme-identity trained children knew an average of only 4.5 letter names from a total of 14 tested, and only 1.3 sounds from a total of eight letter sounds tested, indicating low literacy skills. For the phoneme-identity task, all scores were above chance with the exception of one child, and 11 out of the 16 children reached the success criterion. This suggested that they were able to learn to identify the target phonemes easily in onset and coda positions in words. Phoneme identity is therefore highly teachable, and once it is acquired, it can generalize to all sounds. For the *sm* transfer task, all the children who succeeded on the phoneme-identity task, succeeded on the transfer task, indicating that phoneme identity was sufficient to induce the alphabetic insight necessary for matching a printed word, *sow* or *mow*, to a spoken word, *mow*.

On the *fb* transfer task, Byrne and Fielding-Barnsley (1990) found that many of the children who learned the pronunciations for only two words, *fin* and *bin*, along with the pronunciation of their beginning letters, *f* and *b*, were able solve the *fb* alphabetic-transfer tasks without any prior training for the target sounds. Byrne and Fielding-Barnsley (1990) concluded that minimal phoneme-identity training with relevant letter-sound instruction was sufficient to establish the alphabetic principle, and that once children understood the concept of phoneme identity, it could generalize to other sounds or letter sounds easily.

For the phoneme-segmentation training, the children were taught to break-up words by separating the beginning or ending sounds in spoken words. A frog puppet that spoke strangely together with pictures of objects to represent the words being segmented were used to teach phoneme-segmentation. For word-initial phonemes, the children were shown three times how to segment a word, such as *sun* into "s....un", and for word-final phonemes, the children were shown how to segment a word, such as *bus* into bu....s". After the experimenter demonstrated each word, the children were asked to say the target word just like the frog puppet while a picture of the word was in view, and corrective feedback was provided. There were six training words for each target phoneme, and each word was paired with a picture of an object that represented the word. The segmentation training had the same design as the phoneme-identity training, but the children in the segmentation training were not taught the sounds for the target phonemes.

After the training, the children were tested using six new words. The procedure for the test phase was the same as the training phase, except the experimenter did not demonstrate how to segment the word. The experimenter said the word while the word-picture was in view, and then asked the child to say the target word just like the puppet would say it. The experimenter encouraged the child to segment the word three times without corrective feedback. The training and test items, as well as the alphabetic-training sessions and transfer tasks were the same as those in the phoneme-identity experiment. The alphabetic phases tested for transfer of the /s/, /m/ and /f/, /b/ phonemes, the two latter phonemes were not taught during training.

The children in the phoneme-segmentation experiment were given a phoneme-identity task that had been used in the pilot study for the phoneme-identity experiment, but not in the actual experiment. This task assessed whether the children had inadvertently gained phoneme identity through learning phoneme segmentation during the training sessions. Awareness of the /s/ and /m/ phonemes was measured using three pictures of common objects. For example, a target picture, such as a *saltshaker* was placed above two different pictures, such as *soup* and *toothbrush*, and the child was asked which word, *soup* or *toothbrush*, began with the same sound as *salt*. There were 12 comparison pairs for the /s/ and /m/ phonemes and the same target picture was used for each 12 pairs of the /s/ and /m/ trials, a motorbike was the target picture for the /m/ phoneme trials.

Byrne and Fielding-Barnsley (1990) established that the segmentation-trained children knew 3.4 letter names from a total of 21, and 0.3 sounds from a total of three, indicating low literacy skills. For the segmentation training, Byrne and Fielding-Barnsley (1990) found that although all the children were able to learn some degree of onset and coda phoneme segmentation, there was no consistency across phonemes. Children commonly scored high on one phoneme, but low on another. Across phonemes, performance on phoneme awareness tasks for the segmentation-trained children was therefore less stable than for identity-trained children. The concept of phoneme segmentation does not seem to generalize to other sounds easily.

For the *sm* alphabetic training and transfer tasks, there was high intra-subject variability. Five out of 16 children achieved both the *sm* transfer criterion and a mean segmentation score of 64 out of 96. However, for the remaining 11 children who were unsuccessful on the *sm* alphabetic-transfer task, the mean segmentation score of 49.6 was not significantly different than segmentation score for the children who reached *sm* criterion. Learning to separate initial and final phonemes in words did not help the unsuccessful *sm*-transfer children learn how to match a printed word, *sow* or *mow*, to the spoken word, *mow*. In contrast, the nine children who achieved the *sm* transfer criterion in the phoneme-identity experiment were the nine highest scorers on the identity task, indicating a high consistency in the children's performance across tasks. Byrne and Fielding-Barnsley (1990) concluded that although all the children showed some knowledge of phoneme segmentation, the consistency of children's performance was lower than for phoneme identity.

For the *sm* phoneme-identity transfer task, Byrne and Fielding-Barnsley (1990) found that most of the children either reached the success criterion for both the /s/ and /m/ phonemes, or not. The children who received phoneme-segmentation training therefore achieved the same consistency on the *sm* transfer task as the children in the identity experiment. However, the children who did not acquire phoneme identity for /s/ and /m/ were always inconsistent or entirely unsuccessful on the transfer tasks, and the children who acquired phoneme identity for /s/ and /m/ phonemes, as a result of the segmentation training, were always successful on the /s/ and /m/ transfer tasks. Byrne and Fielding-Barnsley (1990) concluded that the positive effects of the phoneme-segmentation training were mediated by acquisition of phoneme identity. The phoneme-identity training therefore resulted in a firm understanding of phoneme identity, but the same result did not occur by learning to segment phonemes.

On the *fb* transfer task, four of the five children who were able to reach criterion also reached criterion on the *sm* transfer task. This was a critical finding because the children who always succeeded on the *sm* transfer task were those who had inadvertently acquired phoneme identity for the /*s*/ and /*m*/ phonemes. Therefore, alphabetic insight was gained through learning phoneme segmentation, but mainly only for the children who had acquired phoneme-identity as well. Therefore, preliterate children appear to grasp the principle of phoneme identity better than phoneme segmentation, and once the concept of phoneme identity is acquired, it generalizes easily.

While the transfer scores were consistently better for word onsets than for word codas, Byrne and Fielding-Barnsley (1990) found that this was not a significant difference. The researchers concluded that children could learn phoneme identity and phoneme segmentation skills using either the word onset or word coda positions. However, it is possible that the intensity of Byrne and Fielding-Barnsley's training encouraged the acquisition of phoneme identity or segmentation equally in both positions. In the absence of such direct or intense instruction, such as in a classroom, children might acquire phoneme identity or segmentation in the onset position of words first, and then later in the coda position. This speculation is supported by the series of work conducted by Treiman (1983, 1985, 1988, & 1992) and the investigation by Treiman and Zukowski (1996), which together demonstrated that children and adults are highly sensitive to onsets and process word onsets much easier than other word positions.

In summary, Byrne and Fielding-Barnsley (1990) found that phoneme identity was more strongly related to gaining alphabetic insight than was phoneme segmentation. Also, the positive effects gained from the phoneme-segmentation training were mostly mediated through the acquisition of phoneme identity together with relevant letters to represent the sounds taught. The authors concluded that, in combination with letter-name or letter-sound knowledge, phoneme identity for only a few phonemes rather than phoneme segmentation was the phonological prerequisite for gaining alphabetic insight.

Murray (1998) conducted a double-blind teaching study – neither the participants nor the posttest examiners knew who was in each treatment conditions – to determine whether phoneme manipulation or phoneme identity was causally related to the acquisition of alphabetic insight. Initially, all the children received a standard word-reading test, a phonetic-cue reading test for word onsets, an oral vocabulary test, an alphabet-knowledge test, and a test of children's ability to identify and manipulate phonemes. All of the children included in the experiment were true non-readers.

The children were divided into three groups with each group receiving only one type of training, phoneme-identity training, phoneme-manipulation training, or language-experience training. The phoneme-identity children were taught eight phonemes for word-initial and word-final sounds, for both isolated words and words in a context. The phoneme-manipulation children were taught how to segment and blend onsets and rimes, and then phonemes in spoken words. The children were not taught the particular phoneme identities for the sounds being manipulated. The language-experienced children heard and discussed different stories, and they created their own stories. There were no significant group differences on any of the pretests administered.

Once the individual training sessions were completed, the children first were taught letter-sound associations for eight letters through a paired-association task. These letters were included in words seen on the posttests. The post-tests included a phoneme-manipulation task that measured children's ability to blend, isolate, and segment phonemes; a phoneme-identity task that measured their ability to recognize a specific phoneme in a spoken word; a letter-sound correspondence task that measured how easy it was for children to match letters and phonemes; and a phonetic-cue reading task. For the phonetic-cue reading task, the child was shown a word printed on a card, for example *soon*, and was asked which word in a pair of spoken words, *moon* or *soon*, matched the written word. The children were given a real word-decoding task, in which the target words were constructed from the letter-sound correspondences that had been taught.

Of the three training conditions, Murray (1998) found that children in the phoneme-manipulation condition scored the highest on the phoneme-manipulation test. This indicates that the children could be taught phoneme-manipulation skills with training, but they did not learn these in the other training conditions. Learning phoneme identity did not appear to improve the children's ability to segment phonemes. These findings indicate that phoneme identity and phoneme segmentation skills might be skills that develop independently.

For phonetic-cue reading, Murray (1998) found that the phoneme-identity children scored the highest and there was no significant difference between the other two conditions. This indicated that only the phoneme-identity trained children gained alphabetic insight. Murray suggested that teaching children to recognize certain phonemes in words can help children acquire alphabetic insight and early word recognition. Murray (1998) concluded that neither mere exposure to words (i.e. language experience), nor an ability to manipulate the phonemic segments of words (i.e. phoneme awareness training) was sufficient to acquire alphabetic insight or early word recognition.

As part of his study, Murray (1998) taught all the children letter-sound associations. There were no significant group differences on learning the eight letter-sound correspondences taught, in neither the number of trials required to master them, nor in accuracy. Murray (1998) interpreted this finding as evidence that learning letter-sound associations is independent of learning phoneme identity or phoneme segmentation. Although this may be true, Murray did not consider that teaching children grapheme-phoneme correspondences together with phoneme-identity training lead to significantly greater gains in alphabetic insight than from phoneme-identity training on its own. Instead, Murray concluded that phoneme identity causes alphabetic insight. However, if Ehri's et al. (2001) findings are correct, that phoneme-awareness training with letter instruction increases reading outcome better than without letter instruction, another interpretation of Murray's findings is that learning phoneme identity together with letter-sound connections facilitates alphabetic insight.

In the ABC-GPC theory of reading, children acquire letter-sound associations after letter-name knowledge and phoneme identity are established. Ehri and Wilce (1985) demonstrated that preliterate children could use letters or letter sounds to begin reading words by salient phonetic cues or phonetic-cue reading. Preschool and kindergarten children were classified as either Pre-Readers who could read no words or only one word; Novices who could read one to 11 basic words; or Veterans could read 11 to 36 words. Novice and Veteran readers scored higher for letter-name and letter-sound knowledge, and word reading in text than did Pre-Readers. In the latter group, the children did not know many letters or letter sounds.

All the children learned two different types of word spellings for a spoken word through paired association. The visual-word spellings used letters that did not correspond to sounds, but the letters were visually distinct, such as *uHe* for the word *mask*. The phonetic spellings used letters that did correspond to sounds, such as *MSK* for *mask*. The children had several trials with corrective feedback to learn the words associated with each spelling pattern. Each child practiced reading six phonetic spellings and seven visual spellings.

Ehri and Wilce (1985) found that only the Novice and the Veteran groups learned to read the phonetic spellings more easily than the visual spellings, while the Pre-Readers learned to recognize the visual spellings more easily than the phonetic spellings. This suggested that the Pre-Readers with poor letter-name and letter-sound knowledge relied on salient visual-cues to learn word spellings, while the Novices and Veterans with good letter-name and letter-sound knowledge relied on letter-sound cues. Ehri and Wilce (1985) concluded that children could move from being pre-readers who use visual-cues to recognize words, to beginning or novice readers who can match a spoken word to a written word using one or two salient letter-name or letter-sound cues. This latter stage of reading was defined as phonetic-cue reading.

Penney et al. (n.d.) mapped the initial reading and phonological development of a child, referred to as TM, who at seven years of age had a severe reading disability. At the end of the first grade, TM could not recognize letters, could not read or spell words, and had a number of phonological processing difficulties. For example, TM had difficulty producing rhyming words and he could not discriminate many phoneme contrasts, particularly for vowels.

Penney et al. (n.d.) began an intensive reading intervention program that went on for four and a half years. The program focused on teaching TM first to recognize and write letter names, and then later how to select a written word to match a spoken word using initial and final letter sounds – phonetic-cue reading. Using Glass-Analysis drills (Glass & Glass, 1976), TM was presented groups of words with common orthographic rimes, and was asked to pronounce and spell the words or rimes. For example, TM was shown the word *be* and told that the letters *b* – *e* say the word *be*, and when *b* is taken away, it says *e*, and then TM was asked to spell the word *be*. This drill was then repeated for words *we*, *he*, *me*, and *the*. The final part of the program consisted of Glass-Analysis drills based on words TM read incorrectly in books.

Penney et al. (n.d.) found that after 14 months of tutoring, TM could decode some initial consonant sounds, and blend these onto the rime, but that he still had difficulty recalling the pronunciation of onsets and rimes. This suggests that TM acquired onset letter-sound associations as his knowledge of letter names and initial consonant sounds strengthened. These researchers also found that TM learned to select a printed word to match a spoken word by onsets or codas before he learned to read isolated words independently. This supports Ehri and Wilce's (1985) theory that an early stage of word-reading or phonetic-cue reading develops before true reading begins. On the basis of the converging evidence from Ehri and Wilce, Penney et al. concluded that the formation of grapheme-phoneme correspondences for simple consonants might therefore be prerequisite to a phonetic-cue reading stage of reading development that is necessary before true reading.

In addition, Penney et al. found that TM could match spoken words to written words using initial consonant sounds well before final consonant sounds. This does not support Byrne and Fielding-Barnsley's finding that children acquire phoneme identity in the initial or final position of words. Penney et al. suggested that word-initial consonant sounds or onset letter sounds develop first. Therefore, one should see initial consonant sounds (onset identity) or onset letter-sound associations develop before final consonant sounds (coda identity) or coda letter-sound associations.

Penney et al. (n.d.) suggested that early reading might begin with letter-name knowledge, an ability to identify beginning sounds in words (onset identity), and the formation of grapheme-phoneme correspondences for single-consonant onsets, followed later by single-consonant codas. According to Penney et al., once a child has a sufficient set of grapheme-phoneme correspondences for word onsets and codas, he or she can begin to match spoken words to written words using letter-sound associations for onsets and codas; this skill corresponds to Ehri and Wilce's (1985) phonetic-cue reading stage of early reading. The findings of Penney et al. (n.d.) supports several inferences made by Ehri and Wilce (1985), Murray (1998), Stahl and Murray (1994), and Treiman and Rodriguez (1999).

In the ABC-GPC theory of reading acquisition, phoneme-awareness skills develop after children have gained alphabetic insight. Presently, true phoneme awareness is defined as the awareness of each individual phoneme in a spoken word, and the ability to manipulate these sounds in words (Adams, 1990; Stahl & Murray, 1994). This level of phoneme awareness is not likely to be available to children who have not received reading instruction and have no knowledge of letters and sounds (Adams, 1990, Liberman et al., 1974; Treiman & Zukowski, 1996).

In the 21st month of Penney's et al. tutoring program, TM was not able to delete onsets of words even though he could often produce a letter to represent the onset, and he could select a printed word to match a spoken word using initial consonant sounds. Penney et al. (n.d.) proposed that onset-rime segmentation might develop after a child can represent the phonemes by the letters rather than before. This does not coincide with the popular view that children must know how to segment initial or final consonants (phoneme manipulation) before they can learn to represent the phoneme by a letter. Penney et al.'s findings suggest that phoneme identity might develop before phoneme segmentation. In addition, Murray's (1998) work suggests that the development of phoneme identity and manipulation (blending and segmenting) might be independent of each other. This indicates that phoneme identity may not subsume phoneme segmentation, as suggested by Byrne and Fielding-Barnsley (1990).

Phoneme identity appears to be easier to acquire than phoneme manipulation (Byrne & Fielding-Barnsley, 1990; Murray, 1998), and performance on phoneme-manipulation tasks often seems unstable compared to performance on phoneme-identity tasks (Byrne & Fielding-Barnsley, 1990). Additionally, Byrne and Fielding-Barnsley (1990) found that on the *fb* transfer task, the children who were able to reach *fb* criterion also reached criterion on the *sm* transfer task. Therefore, children who always succeeded on the *sm* transfer task were the children who had inadvertently acquired phoneme identity for the /*s*/ and /*m*/ phonemes. It appears that alphabetic insight was gained through learning phoneme segmentation, but mainly for children who had acquired phoneme identity also. Byrne and Fielding-Barnsley (1990) concluded that preliterate children acquire phoneme identity more easily than phoneme segmentation, and whereas phoneme identity generalizes, phoneme segmentation does not. However, recall that the children were taught the relevant letters for the initial and final consonant sounds, indicating letter names with phoneme identity may have promoted alphabetic insight, which in turn may have encouraged phoneme segmentation. The converging evidence (Byrne & Fielding-Barnsley, 1990; Murray, 1998; Penney et. al., n.d.) supports the view that phoneme segmentation of initial sounds, onset deletion or onset-rime segmentation, may develop after a child acquires alphabetic insight.

For several reasons, the findings of Stahl and Murray (1994) are the last to be reviewed in this section. First, the work of Stahl and Murray support the idea that children learn letter names before they develop an awareness of phonemes, and the latter develops only after children learn to read. Second, Stahl and Murray raised the issue that the type of phonological task, as well as the linguistic level being accessed for each task are important factors to consider when examining the relationship between phonological awareness and reading. Finally, these authors applied a unique, comprehensive approach in the analysis their data that was used to analyze the data obtained in the research conducted here.

Stahl and Murray's (1994) principle goal was to determine whether linguistic complexity was an important factor to consider when measuring phonological awareness. First, Stahl and Murray re-examined test items in a previous study conducted by Yopp (1988). Yopp (1988) examined the reliability and relative difficulty of 10 different phonological awareness tasks, and their validity as predictors of reading. However, the one variable that Yopp did not control was linguistic level of the tasks given. In each task, Stahl and Murray (1994) took all of Yopp's items and assigned weights for the different levels of linguistic complexity in order to get a measure of task difficulty. Task difficulty was then correlated with participant's mean score on each task. A strong correlation (.95) was found, suggesting that linguistic complexity might be a critical factor in phonological awareness.

Stahl and Murray (1994) separated task difficulty from linguistic complexity in their own investigation of the relationship between phonological awareness and reading. The researchers gave kindergarten and first-grade children four phonological-awareness tasks (phoneme blending, isolation, deletion, and segmentation) at four different levels of linguistic complexity (onset-rime, vowel-coda, cluster-onset, and cluster-coda). As an example, the blending task required a child to blend the phonological elements to recognize a word, but the phonological elements to be blended could be onsets and rimes, vowels and codas, or consonants within an onset cluster or coda cluster. The phoneme isolation task, for example, required a child to say the initial or final "sound" in a word, that sound being a simple onset or coda, or one of the consonants within an onset or coda cluster. The children also completed a letter-naming test for all upper and lower-case letters, a spelling task, three different reading tasks, and a working-memory task (WISC-R; Wechsler, 1974).

Stahl and Murray (1994) found that phoneme isolation was the easiest task, followed by blending, deletion, and segmentation, similar to Yopp's findings. The analysis of linguistic complexity showed that onsets and rimes were the easiest linguistic level to analyze, followed by vowels and codas, cluster codas, and cluster onsets. This replicates earlier findings that preliterate children find it easier to break words into onsets and codas rather than phonemes (Adams, 1990; Treiman, 1988). Stahl and Murray (1994) found that most of the children were not aware that onset and coda clusters could be separated into smaller sounds. For example, most children treated onset clusters, such as *st* and *pl*, as whole units and had difficulty separating the clusters into phonemes. Of the errors made on the phoneme-manipulation tasks, 61 % involved treating onset clusters as un-analyzable wholes. This indicates that beginning readers can readily analyze words into onsets and rimes, but not into phonemes. Accessing phonemes to do different tasks of phoneme awareness does not seem easy or natural for preliterate children.

Stahl and Murray (1994) conducted a factor analysis in which the scores for the four tasks were collapsed across linguistic levels. This analysis resulted in a single factor of task that accounted for 72.6 % of the variance in children's reading ability. A factor analysis was conducted on linguistic level as well, in which the scores at the four levels of linguistic complexity were collapsed across tasks. This resulted in a single factor of linguistic complexity that accounted for 81.7 % of the variance. In defining phonological awareness, the authors concluded that both factors of linguistic complexity and tasks produced a single common factor. However, the linguistic complexity of a task accounted for more variance in the common factor than the nature of the task. Therefore, the level of linguistic complexity was the single factor that best described the concept of phonological awareness. The authors concluded that linguistic complexity might be a better way of defining phonological awareness than nature of tasks.

During their examination of the relationship between phonological awareness and initial reading acquisition, Stahl and Murray (1994) found that the distribution of their data from the phonological and reading tests was skewed. This made the interpretation of the results from standard correlation and regression analyses difficult. For example, nearly all the children knew the letters of the alphabet and could manipulate onsets and rimes easily, but very few of these children were able to read words. Therefore, in order to interpret the results in a comprehensive manner, Stahl and Murray (1994) analyzed their data using scatterplots and adopted a logical analysis approach to determine the possible relationships. They reasoned, for instance, that if skill A is a necessary but insufficient prerequisite for skill B, and skill A is at a very low level, then skill B will also be at a low level. However, because skill A is not sufficient for skill B, a very high level of skill A does not necessarily mean there will be a high level of skill B. As a result, a scatterplot will show a curvilinear relationship (a 'j' shape or 'r' shape curve) between the prerequisite skill (skill A), and the developing or emerging skill (skill B). Participants with low levels of Skill A will all have low levels of Skill B as well; however, participants with high levels of Skill A will have a wide range in Skill B.

Stahl and Murray (1994) plotted letter-name scores as a function of onset-rime scores and found that the majority of children could do both tasks at a high level, a smaller number of children could not do either of the tasks, and some of the children could only identify letters. There was only one child with poor letter-name knowledge who could do onset-rime manipulation. Stahl and Murray concluded that knowledge of letter-names developed before onset-rime segmentation, suggesting letter names may be prerequisite to onset-rime segmentation.

When the total number of words read was plotted as a function of onset-rime scores, Stahl and Murray found that there were only two children with poor onset-rime segmentation (below 70 % success criterion) who were able to read 20 or more words, but the other children (40) who were able to read 20 or more words all had good onset-rime segmentation above the pre-determined success criterion. The remaining children (53) with poor or no reading ability had a wide range of onset-rime segmentation ability. Stahl and Murray (1994) concluded that the ability to segment onsets and rimes of words was available before word reading, and may therefore be a prerequisite for reading. In contrast, many children (29) were able to read more than 21 words, but had difficulty segmenting rimes into vowels and codas, and some children (8) were able to separate rimes into vowels and codas, but read fewer than 21 words. The researchers concluded that the ability to read words might facilitate segmentation of rimes into vowels and codas, rather than the other way around.

Stahl and Murray (1994) found that the task of phoneme isolation rather than phoneme blending, deletion, or segmentation best distinguished readers from non-readers. There were 20 children with low phoneme-isolation scores, and 18 of these children read 21 or fewer words. In contrast, of the 81 children with high phoneme-isolation scores, 42 read 21 or more words, while the remaining 39 children read 21 or fewer words. However, 32 of out 39 poor readers were kindergarten children who may not have had any reading instruction. Phoneme isolation may therefore develop before children learn to read, and perhaps is a critical prerequisite for reading.

In contrast, the ability to manipulate blends in the onset or in the rime, a task of phoneme awareness, was not related to reading achievement at all. Many children who were not able to manipulate sounds in consonant blends were still able to read 21 or more words. The children typically treated blends as single units, for instance, when asked to say *flight* without the /f/, a child produced *ight* rather than *light*. Stahl and Murray (1994) concluded that preliterate children may not need to know that sounds, such as /fl/, can be separated into the individual sounds /f/ and /l/ in order to begin reading. This finding is in direct contrast to results found from a number of studies that support and promote phoneme awareness as the key to reading acquisition. Instead, it supports the view that phoneme awareness develops after reading has begun.

Stahl and Murray (1994) concluded that letter-name knowledge may be a prerequisite for the acquisition of onset-rime segmentation, and that the ability to analyze words by onsets and rimes was more strongly related to reading than analyzing words by phonemes. These researchers speculated that preliterate children first learn individual letter names, and that teaching letter names might also promote sound awareness for those letters. Such awareness can then encourage the understanding that letters in printed words represent the sounds heard in the word's pronunciation, which in turn may facilitate the formation of letter-sound associations necessary for acquisition of alphabetic insight. Finally, it was the isolation or recognition of a simple onset or coda, the easiest of the phonological tasks administered, that distinguished readers from non-readers better than phoneme blending or segmentation did. Nearly all the children with low phoneme-isolation scores were poor readers. Therefore, the hypothesis that phoneme isolation or identification is a prerequisite for reading cannot be ruled out.

Overview of Early Reading Development

The evidence reviewed in the previous section suggests a sequence of initial reading and phonological development. The following hypotheses are proposed on the basis of the literature review, and will be tested here. First, preliterate children need to acquire letter-name knowledge. Treiman and Rodriguez (1999) showed how letter-name knowledge permitted beginning readers to acquire grapheme-phoneme correspondences. Treiman and Rodriguez suggested that children could use letter-name knowledge either to learn about the sounds of letters or to learn grapheme-phoneme correspondences. Ehri et al. (2001) found that phoneme awareness training with letter instruction promoted increased reading achievement than phoneme awareness training alone. Letter-name knowledge is the first step towards initial word recognition.

Developing phoneme identity for word onsets is the critical phonological-awareness prerequisite for initial reading acquisition. Byrne and Fielding-Barnsley (1990) found evidence that phoneme-identity training with relevant letter instruction resulted in greater gains in alphabetic insight and early word reading than did phoneme-segmentation training. Although Byrne and Fielding-Barnsley found no difference between children's acquisition of phoneme identity for onsets or codas, Penney et al. (n.d.) found TM developed phoneme identity for word onsets first, and later for codas.

Other studies have shown in various ways that preliterate children are more sensitive to onsets than to any other position in a word. Treiman and Zukowski (1996) showed that young children could easily judge whether two words shared an initial sound when the sound was a single consonant onset, such as *pacts* and *peel*, than when it was part of a cluster onset, such as *plan* and *prow*. Preliterate children naturally analyze single consonant onsets before phonemes in words. Therefore, when children learn letter names, they should acquire phoneme identity for onsets, onset identity, which in turn develops before phoneme identity for codas, coda identity.

After a child gains sufficient letter-name knowledge and onset identity, he or she can form grapheme-phoneme correspondences for onsets. Ehri and Wilce (1985) found that preliterate children who could read some words could identify unfamiliar words by salient phonetic cues. Penney et al. (n.d) found that a reading-delayed child, TM was able to learn how to match spoken words to written words using letter-sound associations, and this skill occurred for onsets before codas. The acquisition of grapheme-phoneme correspondences may therefore encourage early-word recognition or phonetic-cue reading ability for onsets first, and later for codas.

The evidence presented above, as well as in the previous section, generated the first two main hypotheses. Hypothesis One proposes that substantial letter-name knowledge and phoneme identity for word onsets are prerequisites for phonetic-cue reading based on initial sounds. Similarly, letter-name knowledge and phoneme identity for word codas are prerequisites for phonetic-cue reading based on final sounds. Hypothesis Two proposes that phoneme identity and grapheme-phoneme correspondences are established for single-consonant onsets first, and then later for codas.

The acquisition of phoneme segmentation skills develops after children gain alphabetic insight. As previously discussed, Byrne and Fielding-Barnsley (1990) found that children gained alphabetic insight through learning phoneme segmentation, but mostly for the children who had inadvertently acquired phoneme identity also. However, Byrne and Fielding Barnsley's (1990) phoneme segmentation tasks were actually onset-rime segmentation, such as *s…un*, and the vowel-coda segmentation, such as *bu…s*. I interpret this to mean that onset identity and coda identity for *s* and *m* phonemes, acquired inadvertently through onset-rime or vowel-coda segmentation-training respectively, generated alphabetic insight rather than segmentation training on its own, or mediated by phoneme identity.

Stahl and Murray (1994) showed that letter-name knowledge may be prerequisite to onset-rime segmentation, which in turn may be prerequisite to reading. Only one child with poor letter knowledge could do onset-rime segmentation, and the remaining children either had good letter knowledge and onset-rime segmentation, good letter-knowledge and poor segmentation, or neither skill. Therefore, letter-name knowledge may develop before onset-rime segmentation.

Stahl and Murray found that only two children with poor onset-rime segmentation were able to read 20 or more words, but the other children (40) who were able to read 20 or more words all had good onset-rime segmentation. The remaining children (53) with who read fewer than 21 words had a wide range of segmentation scores. Onset-rime segmentation appears to develop before independent word reading.

In contrast, Stahl and Murray (1994) showed that alphabetic insight is prerequisite to vowel-coda segmentation. When vowel-coda segmentation scores were plotted as a function of total words read, 29 of the children could read 21 or more words, but could not do vowel-coda segmentation tasks, while eight children were able to do vowel-coda segmentation, but read 21 or fewer words. The researchers concluded that reading ability probably facilitates vowel-coda segmentation rather than the other way around. Therefore, while onset-rime segmentation might be prerequisite to reading, reading might be prerequisite to vowel-coda segmentation. Unfortunately, Stahl and Murray (1994) did not measure the children's knowledge of grapheme-phoneme correspondences for onsets or codas, so it is unclear whether acquisition of grapheme-phoneme correspondences is sufficient for acquisition of onset-rime or vowel-coda segmentation.

The research conducted by Penney et al. (n.d.) supports the theory that the acquisition of grapheme-phoneme correspondences for word onsets precedes onset-rime segmentation. These authors found that while TM had acquired letter names, the ability to match spoken and written words using onset letter-sound associations, suggesting that TM had acquired onset grapheme-phoneme correspondences, TM was still unable to perform onset deletion. This suggests that phoneme identity does not subsume phoneme segmentation, and instead, grapheme-phoneme acquisition might precede onset-rime or vowel-coda segmentation.

The literature reviewed above and in the previous section formed the foundation for the third hypothesis. The first part of Hypothesis Three proposes that children need to acquire onset grapheme-phoneme correspondences before they can delete onsets from spoken words. The second part proposes that children need to acquire coda grapheme-phoneme correspondences before they can delete codas from spoken words.

Onset deletion is similar to onset-rime segmentation in that both tasks require the child to separate onsets from rimes in spoken word contexts. The difference is that onset deletion requires the child to produce the left over rimes only, such as *oat* after removing the /g/ in *goat*, and onset-rime segmentation requires the child to produce both the onsets and rimes separately, such as /s/ and *un* for *sun*. Similar reasoning applies to coda deletion and vowel-coda segmentation.

Evidence was presented earlier in this paper showing how Bradley and Bryant's (1983) conclusion that phoneme awareness or sound awareness facilitated initial reading acquisition was incorrect for two reasons. First, Bradley and Bryant found that the Combination Letter- Sound group achieved significantly higher reading and spelling scores than the Sound-Only group. This suggested that teaching children letters and sounds together generated higher reading achievement rather than teaching only sounds.

However, the authors concluded that the sound teaching was the critical factor in improving literacy.

Second, Bradley and Bryant (1983) did not control for the linguistic status of their oddity-task items. As previously discussed, the children may have learned to sort words by common onsets or rimes rather than by common initial, middle, and final phonemes, suggesting that teaching children letters together with onset and rime sound-categorization facilitated reading achievement. Therefore, it appears that oddity-task success may depend on the linguistic status of the test units, and on whether children develop alphabetic representation for those units, or not.

These speculations formed the foundation for the fourth hypothesis. The first part of Hypothesis Four proposes that in an oddity task, the linguistic status of the common sound being detected is important. Children will recognize rime differences between spoken words before onset and coda differences, and onset differences before coda differences. The second part proposes that children need alphabetic representation for word onsets before they can recognize onset differences between spoken words, and alphabetic representation for word codas before they can recognize coda differences between spoken words.

Goswami and Bryant (1990) believe that reading by analogy facilitates initial reading acquisition. While Ehri and Robbins (1992) demonstrated that some degree of reading or decoding knowledge was necessary before children can read by analogy, Penney et al. (n.d.) found TM could begin to read by analogy once he had acquired grapheme-phoneme correspondences for onsets and codas. Therefore, it seems that reading by analogy develops once children have acquired alphabetic insight.

To read by analogy, a child first needs to identify the clue word, and then be told its pronunciation, as in Goswami's (1986) research. Next, the child needs to recognize the resemblance between the clue word and the target word. In other words, the child needs to know that the clue word *at* has the same pronunciation as *at* in *hat,* the target word to be read, which is easy to do if the two words are shown together. Ehri and Robbins (1992) suggested that letter knowledge and basic phonological skills, such as onset-rime segmentation or blending, were required before children could read by analogy. However, in the study reported here, all clue words for the reading-by-analogy task were rime units of the target words. Therefore, to produce the target word, the child had to know how to delete only the onset of the target word, and blend the target onset onto the clue word shown. Consequently, one should expect to see reading by analogy develop after the child has learned grapheme-phoneme correspondences for onsets and codas, and can possibly segment or blend words into onsets and rimes.

In contrast, coda deletion is not expected to be a prerequisite for the reading-by-analogy task. The child must know only how to segment the onset and rime of the target word. Therefore, in addition to letter names, onset and coda identity, and onset and coda phonetic-cue reading, an important prerequisite for doing the reading-by-analogy task should be onset-rime segmentation, or onset deletion, rather than vowel-coda separation, or coda deletion. For the fifth hypothesis, I propose that letter-name knowledge, onset and coda identity, phonetic-cue reading for onsets and codas, and perhaps onset deletion develop before the ability to read words by analogy. While not expected to be a prerequisite, coda deletion may still develop before reading words by analogy, and so this relationship will be assessed as well.

A widely held belief is that phoneme awareness is a critical prerequisite of reading acquisition (Bradley & Bryant, 1983; Ehri et al., 2001; Lundberg et al., 1988). In Liberman's et al. (1974) investigation of children's early phonological development, a task of phoneme tapping was used to measure children's phoneme awareness. Liberman's et al. (1974) showed that preschool children were able to tap out the syllables in words, but not the individual phonemes. In contrast, children in the first grade were able to tap out the phonemes, suggesting that formal reading instruction may facilitate the recognition of phonemes.

Bradley and Bryant (1983) and Ehri et al. (2001) each found that combined sound and letter instruction resulted in greater reading achievement rather than sound instruction without letters, but each failed to explain the significance of letters adequately. Stahl and Murray (1994) found that the ability to manipulate phonemes in words, such as vowel-coda segmentation, develops only after children learn to read numerous words, not before.

In accordance with the ABC-GPC theory of reading, phoneme awareness is a skill that is neither readily available to preliterate children, nor is it prerequisite to reading acquisition (Adams, 1990; Liberman et al., 1974; Stahl & Murray, 1994). Instead, one should expect to see phoneme awareness develop after children can read words independently. Therefore, for the sixth and final hypothesis, I propose that children acquire true reading ability and accurate spelling skills before they are able to count phonemes in spoken words.

The expected developmental sequence for initial reading acquisition is as follows. Children acquire letter-name knowledge as a first step towards literacy, and phoneme identity for single consonant onsets and then codas as the second step. Next, children with several grapheme-phoneme correspondences for onsets can match spoken and written words first on the basis of the onsets, and then later on the basis of codas. Once children have established alphabetic representation for onsets and codas, they can do onset and coda oddity tasks, respectively, and can read by analogy. Finally, after children can read and spell a number of words, they will be able to count phonemes.

Tasks Used to Test the Hypotheses

Children's knowledge of letter names was assessed using a timed test of naming 54 upper- and lower-case letters of the English alphabet. Children's onset and coda identification skills were measured using a test of Onset and Coda Identities adapted from Murray (1998). This test determined children's ability to identify a target sound in a pair of words based on recognition of the word's onset or coda. Children's ability to recognize a word by identification of the initial or final grapheme-phoneme correspondence in the word was assessed by a Phonetic-cue Reading Task. Children were shown three written words and asked to identify the target word pronounced by the experimenter. Children's ability to separate word onsets and codas was assessed using an Onset- and Coda-Deletion Test, in which children were asked to remove a sound, such as the beginning sound /g/ from *goat* to produce a new word *oat*. The Bradley and Bryant

(1983) Odd-Man-Out task was used to assess children's ability to detect rime, onset, and coda differences within a set of three spoken words. The test items were controlled for the linguistic status of the unit being accessed.

To assess children's spelling ability, a brief spelling test was given in which children were asked to spell words taken from the Onset- and Coda-Deletion Test. Early word-reading ability was assessed using an experimenter-created Word-Decoding Task that measured children's decoding ability for real words. A Reading-By-Analogy (RA) task adapted from Goswami and Bryant (1990) was used to measure children's ability to read new words using rime analogies. This task measures children's ability to blend an onset from a target word, such as the /s/ in *sat*, onto the clue word or rime unit, *at*. All clue words on this reading-by-analogy task were real words with a V-C (vowel-consonant) structure, such as *at* and *it*, therefore, segmentation of target-word onsets, but not clue-word onsets, may be necessary for achieving RA success. Although coda deletion is not expected to be a prerequisite for reading by analogy, this relationship will be assessed as well.

A phoneme-counting task was used to assess children's ability to recognize the individual sounds or phonemes heard in spoken words. Children were taught how to recognize and represent individual phonemes in words using small fish tokens, and then the children were asked to use the tokens themselves to represent and count the phonemes heard in words spoken by the experimenter. This task is similar to Liberman's et al. (1974) phoneme-tapping task, in which children had to tap once with a wooden dowel for each sound heard in a word. The use of tokens to represent the phonemes removes the extra memory component of having to hold the sounds in memory to count them. A child can represent each phoneme with a token at the same time as he or she identifies it, similar to the Liberman et al. task, and then count the tokens afterwards.

Method of Analysis

To test each hypothesis, scatterplots were generated and a logical analysis approach used by Stahl and Murray (1994) was applied. Scatterplots show two variables plotted against each other with each participant represented by a single point in a two-dimensional space. If skill X is a prerequisite for skill Y, one should see a J-shaped scatterplot in which variable Y remains near floor values below a critical level of X. Above the critical level of X, there will be values of Y above the floor. If skill X is necessary for the development of skill Y, the absence of X will necessarily imply the absence of Y, but the presence of X does not ensure the presence of Y (Stahl & Murray, 1994, pp.226). However, while the finding of a J-shaped curve between skill X and Y would be consistent with X being a prerequisite for Y, but it would not necessarily imply causality. It may be that skill X is not a prerequisite for skill Y, but simply that X develops earlier than skill Y.

Scatterplots of each variable were plotted as a function of age, and as a function of other tasks. Stahl and Murray (1994) used a cutoff of 70 % success to indicate mastery of a task. A more stringent cutoff of 80 % success was used here to indicate mastery on the letter naming, onset- and coda-identity, onset- and coda-phonetic-cue reading, and odd-man-out tasks. For the reading, spelling, and phoneme-awareness tasks there was no 80 % mastery criterion. The acquisition of expert reading and spelling ability is a life-long process that takes years, and neither reading nor spelling can be considered as 'mastered' when a child can read or spell 35 words. Instead, there were three categories of reading and spelling success. There were the Non-Readers (NR) or Spellers (NS), who read or spelled fewer than 10 words accurately, the Emergent Readers (ER) or Spellers (ES) who read or spelled between 10 and 34 words accurately, and the Real Readers (RR) or Spellers (RS) who read or spelled 35 or more words accurately. For the phoneme-awareness test, because only three children achieved the pre-set 80 % mastery criterion, two categories of phoneme awareness success were created. There were the children without phoneme awareness who received a zero score (failure) in the phoneme-counting test, and the children with phoneme awareness who received a score of eight or higher (success) in the same test.

METHOD

Participants

Upon receipt of ethical approval from the Interdisciplinary Committee on Ethics in Human Research (ICEHR) at Memorial University, the principle researcher distributed and obtained letters of informed consent from the participant's parents or guardians. All the children enlisted said they wanted to participate when asked, and throughout the course of the study, none of the children indicated in any way that they wanted to stop participating. The children were recruited from a local daycare, an after-school enrichment centre, and an elementary school in the St. John's area. A total of 60 children were initially recruited, but there were five children that did not complete all the tests because two moved out of the province, and three went on vacation. Therefore, the data used in the final analyses is based on a sample size of 55 children. There were 20 pre-school children aged 3:10 to 5:5 years of age, 17 kindergarten children aged 5:0 to 6:5 years of age, and 18 first-grade children aged 6:6 to 7:3 years of age.

The children's literacy experiences before their participation in the current study were not ascertained. While the preschool children's literacy experiences are unknown, the kindergarten and first-grade children obviously had some formal reading and spelling instruction before participating in the current study. In all Newfoundland and Labrador schools, the areas of reading, spelling and writing, as well as listening, speaking, viewing, and other ways of representing language are classified as General Curriculum Outcomes. These outcomes areas are the foundation for the English Language Arts Curriculum Guides (Government of Newfoundland and Labrador, Education, n.d.). While these outcomes guides emphasize that children should know letter names and letter sounds, and have phoneme awareness by the completion of the third grade, there are no instructional programs described. Mainly, the type of reading and spelling instruction that the students receive is left to the discretion of the particular school or individual teacher, and teachers are encouraged to use a whole language approach for teaching reading and spelling and other subject areas. Although the kindergarten and first-grade children in the present study did receive formal reading instruction before participating in the study, they may or may not have received explicit letter, letter-sound, or phoneme-awareness instruction.

The sample did not include children with cognitive impairments (i.e., cognitive delay, Down's syndrome, autism, or brain damage), hearing or speech impairments, or behavioural problems (i.e., attention deficit disorder or hyperactivity) as reported by parents or school officials. None of the children scored more than two standard deviations below the mean on the Peabody Picture Vocabulary Test-Revised (Dunn & Dunn, 1981). The Raven's Colored Progressive Matrices (Raven, Court, & Raven, 1986), a test of children's non-verbal reasoning ability was administered as well; none of the children scored more than one and a half standard deviations below the mean.

Testing Procedures

Children were tested individually in five sessions of 30-minutes within a five-week period. The children were tested in a small quiet room at their preschool, school, or after-school activity centre. The testing rooms were free of distractions and had no alphabetic material displayed. For the two standardized tests the children sat to the right of the experimenter at a small square table. For the remaining tests, the child and the experimenter sat on the floor opposite each other, sitting on a large pillow each. The experimenter wore a large purple and yellow striped hat during each session and spoke with the children in a playful manner before each session to help make them feel comfortable. As a break from the testing, the experimenter played a brief hide-n-seek card game between the second and third tests in each session. The experimenter hid ten 4 x 6 inch picture cards in the testing room while the child covered his or her eyes and counted to 20. At the end of each session the children were praised for their efforts and given stickers. At the end of the final session, each child chose a small toy as a reward.

All children received the two standardized tests in the first session. In each group, half of the children received the PPVT-Revised first, followed by the CPM, while the other half received the CPM first followed by the PPVT-Revised. The phoneme-counting test was always administered in session five because any alphabetic or phonological learning occurring in the first four testing sessions should assist the children during the phoneme-counting test, and failure on the phoneme-counting test after receiving training on various phonological tasks would indicate that the phoneme-counting test was very difficult and not easily acquired by young children.

The remaining nine tests were categorized according to their estimated difficulty. Category A, the easy tests, included rapid letter naming, phoneme identity, and phonetic-cue reading. Category B, the moderately difficult tests, included the onset- and coda-deletion test, odd-man-out test, and the pretest for reading by analogy. Category C, the difficult tests, included reading, spelling, and reading by analogy. For sessions two, three, and four, a test was chosen randomly from category A, B, and C and then administered to the child. This arrangement was chosen so that a child would receive one easy test, one moderately difficult test, and a difficult test rather than three difficult tests in each session. Excluding the two standardized tests, no partial marks were given in any of the nine tests administered. Each correct response was scored as a one, and each incorrect response was scored as a zero.

Tests Administered

Peabody Picture Vocabulary Test-Revised edition (PPVT-Revised)

The PPVT-Revised is a test of receptive vocabulary for current Standard English. The experimenter followed the standard procedures for administering the PPVT-Revised (Dunn & Dunn, 1981) using test form M. On each trial, the experimenter showed each child four pictures of common objects or actions and said a word. The children indicated the picture that best matched the stimulus word. The time to administer the PPVT-Revised was approximately 15 minutes.

Raven's Colored Progressive Matrices (CPM)

The CPM is a test of general non-verbal reasoning for individuals between six and 89 years of age, and measures their ability to complete both whole or uniform visual patterns and ordered or sequential visual patterns (Raven, et al., 1986). There are two series of test items, A and B, and the items in both tests are colored matrices or patterns that increase in their degree of difficulty within sets and between sets. Children cannot move to the B set series without completing the A set first. There are 24 test items in test series A, which has two subsets, set A with 12 items and set A_b with 12 items, and there are 12 items in test series B.

In set A, the children were shown a pattern with a piece missing and were asked to indicate the correct missing piece from six pieces that would complete the pattern. In the A test series (A_b items), the children were shown three patterns with a fourth pattern missing and again had to select the missing pattern from six patterns. To solve for the fourth pattern the children needed to make an analogy based on the three original patterns shown in the sequence. In set B, the children were shown items with patterns like the patterns in sets A and A_b but they were more difficult, and again the children had to select the missing pieces. The time to administer the CPM was approximately 20 minutes.

Rapid Letter-Naming (RLN) test

Participants received two separate letter-naming trials, one with 26 upper-case letters and one with 26 lower-case letters in random order. Half of the children in each group received the upper-case letters first, while the other half received the lower-case letters first. Both sets were printed in 40-point Arial font in black ink in landscape format on 8.5 x 11 inch standard white paper. The letters were arranged in four rows of five letters each, and one row of six letters.

Participants were instructed to name the letters on each sheet of paper as quickly as possible working from left to right in each row. Using a blank sheet of paper, the experimenter demonstrated the left to right direction by moving a finger across the top of the page. The experimenter asked if the child understood the direction indicated and if necessary repeated this movement and instruction until the child understood. The children were told that it was more important to get the name of the letters right than to go fast. The experimenter timed each test trial and recorded any errors the children made.

Onset and Coda Identities (OID and CID) test

The identity test is a verbal test that assesses children's ability to recognize a target word from a pair of spoken words that begins with or ends in a given target sound. For the OID test, the experimenter first told the child that he/she was going to play a repeating game, and then asked the child to repeat a funny phrase, such as "*we will see the moon soon*". The experimenter then said the target onset sound, such as /s/, and asked the child to repeat it. The child was then asked which of two words had the target onset sound /s/. For example, the experimenter said, "Do you hear /s/ in the word *moon* or *soon*?" If the child did not respond, the experimenter repeated the word pairs once only. If there was still no response, the experimenter asked the child to choose the word that would best answer the question. The same procedures were used for the CID test, but the target sounds were in the coda position. For example, for the target sound /p/, the test sentence was "Have you seen a *cat* wearing a *cap*?" and the word pair was *cat* and *cap*. All test items were single consonant onsets or codas, all target sounds to be detected were *n, p, k, b, g, t, z, s, m, d,* and each test set contained 10 sentences. Half of the children received the OID test first and half received the CID test first.

This test was modeled after the Phoneme Identities Test created by Murray *et al.* (2000). In Murray's test, children indicate the target word from a word pair with the target sound, either an onset, coda, or middle sound, and these target sounds are arranged randomly. For the current study, only one test item was taken directly from Murray et al.'s test, that being *'we will see the moon soon'*, and the principal experimenter created the remaining 19 test items.

Murray's test items were not used because the principal experimenter wanted to control for linguistic factors that were not controlled in Murray's Phoneme Identity Test. First, Murray et al.'s (2000) test does not distinguish items according to their linguistic complexity. In the present study, children were tested separately for onset identity and coda identity skills. Second, the Murray et al. test words within a pair did not have the same or similar vowels, so the vowel similarity of each word pair was not controlled. In the OID and CID test used here, the items have the same or highly similar sounding vowels in every word pair. Third, in Murray et al.'s test some of the target consonant sounds were embedded in consonant clusters or had digraph spellings. The target words used here have single-consonant onsets and codas and contained no digraphs.

Onset and Coda Phonetic-cue Reading (OPCR and CPCR) test

Test procedures were adapted from Penney, Drover and Dyck (2003). This test assesses children's ability to identify one of three written words that match a spoken word. There were 14 test items for the OPCR and CPCR test sets. For each test-trial, three written words were printed in upper-case letters in 70-point Times New Roman font in black ink. Each set of three words was arranged in landscape format on an 8.5 X 11 sheet of white paper. For the OPCR test, the three written words had different beginning letters but the same middle and ending letters, such as *MOB, SOB, JOB.* For the CPCR test, the three written words had the same beginning and middle letters but different ending letters, such as *HAT, HAM, HAD.* Two target words on the CPCR test are words with a final silent *e* (*MAKE* and *GAVE).* For this reason, the written non-target words were words also spelled with a silent *e* at the end. Half of the children received the OPCR test first and half received the CPCR test first.

For both the OPCR and CPCR, the examiner let the children know that they were going to play a "word-finding game". First, the experimenter showed the child the three written words and then said, "Can you tell me which word says _____", giving the spoken word. The child was allowed to make a first choice, and the experimenter asked the child if that was his or her final response. If the child said 'no', the child was asked to make a second choice. If there was no response, the child was asked to make the best choice, and the child's final response was recorded. The children responded to each item in all the trials. The same procedure was used for the parallel CPCR test. For each test, the target letter-sounds were *m, p, s, n, f, l, r, t, d, b, z, v,* hard c, and hard g.

Odd Man Out (OMO) test

The OMO test assesses children's ability to indicate which word out of three words has a different rime, onset, or coda. The material and procedures for this test were modeled after Bradley and Bryant's (1983) oddity test. Whereas Bradley and Bryant did not control for the linguistic complexity of the target sounds, the goal here was to examine the effect of linguistic complexity by comparing children's ability to recognize words with different rimes. Accordingly, the Odd-Man-Out test had three parts, the Rime Oddity Test (R-OMO), the Onset Oddity Test (O-OMO), and the Coda Oddity Test (C-OMO). Each separate test had 10 target items. To control for potential practice effect the children received one of the following three testing orders: R-OMO, O-OMO, C-OMO; O-OMO, C-OMO, R-OMO; C-OMO, R-OMO, O-OMO. There were 18 children who received the first test order, 19 had the second order, and 18 had the third order.

Before the children were tested on the oddity test, they were trained on a picture task that taught the concept of the OMO. For the picture task, the experimenter told the child they were going to play a picture game, and that he or she had to identify the picture that did not belong or was different. For each trial, the child was shown a set of three picture cards with different objects or animals on each of them. Two of the cards were related in some way, making the third card the odd man out. For example, the first set of picture cards was a pink pig, a yellow sun, and a yellow moon. The child was asked if the three pictures were the same, and if the response was "no" the child was then asked to point to the odd man out. If the child chose the wrong card, the experimenter asked if the child was sure that it was the different one. If the response was "yes", the experimenter explained why the response was incorrect, and asked the child to choose again. If the child chose the wrong card again, the experimenter indicated the correct card and explained that it was the odd man out because it was the only card that was pink and an animal, in the case of the first set of picture cards. The experimenter then continued with the remaining picture sets. The procedures for the second and third set of picture cards were the same as the first, and the position of the odd card was always chosen randomly. None of the children had difficulty learning the concept of the OMO test.

Following the picture task, the children received each of the three experimental test sets. For each OMO test set, the child was first told that he or she was going to play a listening game that was like the picture game. Before administering each of the tests, the experimenter taught the children the concept of rimes, onsets and codas by asking the child a number of structured questions with corrective feedback. For example, before the onset-OMO test set, the experimenter asked the child, "What is the first sound you hear in the word *duck*?" If the child said /d/, the experimenter continued by asking the child to produce another word beginning with the same sound as *duck*. If the child did not respond, the experimenter asked whether the words *van* and *duck* had the same beginning sound. If the child said 'yes' the experimenter provided the correct response, but if the child said 'no', the experimenter said, "Good, you are right", and again asked the child to produce another word with the same beginning sound as *duck*. If the child produced a correct response, the experimenter began the onset experimental test. If the child was again unsuccessful in producing a word beginning with /d/, the experimenter asked the child whether *duck* or *van* had the same beginning sound as *doll*, and then whether *lump* or *doll* had the same beginning sound as *desk*. If the child responded correctly in each of the latter trials, the experimenter continued onto the experimental test, but if the child gave incorrect responses, testing stopped. The experimenter noted whether the child could recognize or generate words containing the target training-sounds, or not. The child had to at least recognize whether words had the same target sound to proceed to the experimental test. Although not all the children could produce a word that rhymed, began with or ended in the same sound as a target training-word, they were all able to recognize which word in a pair of words shared the same rime, beginning or ending sounds as the target training-word. The training procedures were the same for the rime and coda test sets, except the target sounds for the training words were rimes and codas, for the R-OMO and C-OMO tests respectively.

For each of the experimental tests, the child was asked to say which word was the odd man out because it had either a different rime, beginning or ending sound. The experimenter said, "Listen carefully, I will say three words and you tell me which word is the odd man out." Once the child chose a word, he or she was asked if the word chosen was correct. If the child replied "no", the experimenter asked the child to say the correct word. The three words were repeated twice only, if necessary. No corrective feedback was provided, and testing stopped if a child made five consecutive errors. Because the OMO test was a long and difficult task, the experimenter frequently gave encouragement to each child throughout the training and experimental tests.

Onset and Coda Deletion (OD and CD) test

A deletion test was used to assess the children's ability to remove onsets and codas within spoken words. The onsets and codas to be deleted were single consonants, and the word remaining after the onset or coda was deleted was a real word familiar to young children. The child was taught the concept of beginning sounds before the onset deletion test and ending sounds before the coda deletion test using the onset and coda odd-man-out training materials, procedures, and criteria respectively. There were 12 target items for each test set (OD and CD), and the words each had a simple consonant-vowel-consonant structure with regular spelling patterns. Half of the children received the onset deletion test first, and half received the coda deletion test first.

For both tests, the experimenter told the children that they were going to play a "sound-chopping game" for which they had to chop beginning or ending sounds out of words and say the sound left over. The onset deletion test required the children to say the word remaining after the initial sound was removed. For example, the experimenter asked "What is *pit* without the /p/?" the correct response was "it". The coda deletion test required the children to say the word remaining after the final sound was removed. For example, the experimenter asked "What is *mole* without the /l/?" the correct response was "mow". No corrective feedback was provided during the experimental trials, and testing stopped if a child made five consecutive errors.

Reading by Analogy (RA) test

The reading by analogy test used here assessed the children's ability to read a target word when given a clue word that rhymed or had the same orthographic sequence as the end of the target word, its rime unit. The children were told that they were going to be word detectives, and like all detectives they were going to be given a word clue that would help them solve a mystery. The experimenter showed the child the first clue word and read it aloud, such as *at*, and then spelled the word aloud. The children were then asked to read the clue word aloud also. Then, with the clue word visible, the children were asked to read the mystery words.

For the RA test, there were eight clue words, *at*, *in*, *it*, *ink*, *and*, *ark*, *ice*, and *ear*, one for each of the eight sets of mystery words. The first six sets of mystery words had five words per trial, and the final two sets had six words per trial, for a total of 42 mystery (target) words. In each trial, there were four mystery words with single-consonant onsets, such as *bat*, *mat*, *sat*, and *rat* for the *at* clue word, or *sand*, *land*, *hand*, and *band* for the *and* clue word, and one or two mystery words with digraphs, such as *ch* in *chat* for the *at* clue word, or cluster onsets, such as *gr* in *grand* and the *st* in *stand* for the *and* clue word. Testing stopped at the end of a set after five consecutive errors had been made.

Real-word reading test

The children were shown eight lists of words, one list at a time, and asked to read each word aloud. There was a total of 66 words, of which 43 were words taken from items in the phonetic-cue reading test, deletion test, reading by analogy test, and phoneme counting test, and 23 were words chosen by the experimenter. The words were printed on eight sheets of 8.5 x 11 white paper in Twentieth Century MT font using black ink. For each list, the words were presented in a column in the center of the page. Because the words increased in difficulty, the first two lists each had five words on it, and the third list had six words on it, and each list was printed in the same 45-point font. The remaining five lists, containing the most difficult words, each had 10 words on them in the same 25-point font. To build the children's confidence, the first two words on the test were *A* and *I*, which were counted in the total score. Testing stopped at the end of a list after five consecutive errors had been made.

Real-word spelling test

The children were told they were going to play a spelling game. The experimenter said, "Listen carefully as I say a word and a sentence." The experimenter said the word to be spelled, and a sentence containing the word to give the word's meaning. After each target word and sentence was given, the experimenter then asked the child, "Please spell out loud the word ______ ". If a child did not understand what spelling was, the experimenter used the first word, *I*, as an example. Three out of 55 children did not understand the concept of spelling; they were tested on the first list of words anyway, and given a score of zero. The test words were the same words used in the Real-Word Reading Test. Testing stopped after five consecutive errors had been made.

Phoneme counting (PC) test

There were three parts in the phoneme-counting test. In the training trials, the children were taught the concept of counting phonemes in words. In the pretest trials, children were given a pretest to determine whether they had learned the concept of phoneme counting. In the experimental trials, the children were tested on 22 new words in order to determine the children's phoneme-counting ability.

The first set of training words was *I*, *hi*, and *kite* presented in that order. The second set of training words was *A*, *may*, and *cake*, and the third set was *owe*, *go*, and *goat*. It was thought that by beginning training with a one-phoneme word, such as *I*, and then progressing to a two-phoneme word, such as *hi*, and then a three-phoneme word, such as *kite*, would facilitate the children's understanding that words are made-up of individual sounds or phonemes that are strung together and can be counted. The pretest words were words with two or three phonemes each, *site*, *tie*, *bye*, *rain*, *ape*, *ray*, *toe*, *low*, and *boat*. The pretest words contained similar sounding vowels (*o*, *i* and *a)* as the training words. It was thought that controlling the sounds of the vowels in the training and pretest words would make the pretest easier to do than if the sounds of the vowels were all different. The 22 experimental words had between one and four phonemes each and were randomly selected from words in the Real-Word Reading test. The pretest and experimental words were presented to the children in a random order.

The experimenter explained that the child was going to play a game called 'catching fish'. Five small fish-shaped tokens were lined up and the experimenter put on a pelican hand puppet. The child was told that pelicans like to catch and eat fish, but that this pelican was allowed to catch a limited number of fish only. To decide how many fish the pelican could catch, the child had to determine or count the number of phonemes in a word. The experimenter then demonstrated how to represent phonemes with fish tokens for the first set of training words.

In the first training trial, the experimenter said, "There is one sound in the word *I* ", and then repeated the word *I* while using the pelican to pick up one fish token. The experimenter explained that the pelican was allowed to pick up or catch one fish because there was only one sound in the word *I*. The same dialogue was used to demonstrate the two sounds in *hi*, and then the three sounds in *kite*. The experimenter then gave the puppet to the child and asked, "How many sounds do you hear in the word *I*," and provided feedback. The same procedure was followed for *hi* and *kite*. This same training procedure was repeated, for each set of training words, until either the child could count the correct number of phonemes in each set of training words, or up to a maximum of five times. This means that the first set was given up to five times, the second set up to five times, and the third set up to five times, if necessary. If after the fifth repetition of the third set of training words the child could not produce the correct number of phonemes, further testing stopped. There was only one child who did not complete the training trials successfully, thus she did not do the pretest or experimental test.

If the child completed the training trials successfully, a pretest was given on nine new words. The child was told that he or she had to win a 'semi-final' game in order to play the 'championship' game. For each of the pretest words, the experimenter asked the child, "Can you show me how many sounds you hear in the word _____ by catching the right number of fish?" The child then responded by collecting the fish. Although they were not required to do so, most of the children attempted to say each of the sounds aloud. The criterion for success on the pretest was 8 out of 9, but if a child scored below 6 out of 9, he or she did not proceed to the experimental test.

At the start of the experimental test, the child was told that there were many more words and that they might hear more than three sounds in a word. For each experimental trail, the experimenter asked the child, "Can you show me how many sounds you hear in the word _____ by catching the right number of fish?" The child then responded by collecting the fish. The experimenter repeated the word once, if necessary, but no feedback was provided. Testing stopped after five consecutive errors.

RESULTS

Descriptive Statistics

Tables 1, 2, and 3 show the means and standard deviations for age and all tests administered for each group. Table 4 shows the average age and test means, standard deviations, and minimum and maximum scores obtained on each test for the whole sample. In each table, the descriptive statistics for the phoneme identity, phonetic-cue reading, and deletion tests are presented for each of the phonological levels assessed.

Table 1.

Age and test means and standard deviations (Std. Dev.) for the Preschool group. Group size or $n = 20$

	Mean	Std. Dev.
Age (months)	56.45	5.66
<u>Tests</u>		
Letter Naming		
Upper-case (26)	17.20	8.89
Lower-case (26)	13.50	7.44
Phoneme Identity		
Onset (10)	7.35	1.81
Coda (10)	5.90	1.92
Phonetic-cue Reading		
Onset (14)	7.60	3.14
Coda (14)	6.40	3.52
Phoneme Deletion		
Onset (12)	1.00	3.15
Coda (12)	4.40	4.77
Odd Man Out		
Rime (10)	4.95	2.44
Onset (10)	2.65	2.18
Coda (10)	1.10	1.41
Analogy Pretest (22)	.45	1.28
Analogy Reading (42)	4.10	9.07
Word Reading (66)	2.60	3.62
Word Spelling (66)	2.25	2.07
Phoneme Counting (22)	1.25	3.85

Table 2.

Age and test means and standard deviations (Std. Dev.) for the Kindergarten group. Group size or $n = 17$

	Mean	Std. Dev.
Age (months)	69.00	3.06
Tests		
Letter Naming		
Upper-case (26)	25.23	1.30
Lower-case (26)	23.59	2.53
Phoneme Identity		
Onset (10)	9.41	0.62
Coda (10)	7.94	2.22
Phonetic-cue Reading		
Onset (14)	13.59	0.80
Coda (14)	11.65	3.08
Phoneme Deletion		
Onset (12)	6.59	5.28
Coda (12)	7.24	4.37
Odd Man Out		
Rime (10)	7.18	1.81
Onset (10)	7.00	2.47
Coda (10)	5.35	2.91
Analogy Pretest (22)	5.71	5.63
Analogy Reading (42)	24.41	12.83
Word Reading (66)	17.53	15.66
Word Spelling (66)	10.76	9.00
Phoneme Counting (22)	4.47	5.76

Table 3.

Age and test means and standard deviations (Std. Dev.) for the first grade group. Group size or n =18.

	Mean	Std. Dev.
Age (months)	81.44	3.63
Tests		
Letter Naming		
Upper-case (26)	25.67	0.59
Lower-case (26)	25.11	1.32
Phoneme Identity		
Onset (10)	10.00	0.00
Coda (10)	9.72	0.75
Phonetic-cue Reading		
Onset (14)	13.78	0.43
Coda (14)	13.61	0.78
Phoneme Deletion		
Onset (12)	11.17	1.86
Coda (12)	10.72	2.97
Odd Man Out		
Rime (10)	7.67	1.94
Onset (10)	8.50	1.79
Coda (10)	6.83	2.57
Analogy Pretest (22)	13.94	5.97
Analogy Reading (42)	38.78	3.52
Word Reading (66)	40.94	16.20
Word Spelling (66)	30.33	14.72
Phoneme Counting (22)	12.72	6.59

Table 4.

Means, standard deviations (Std. Dev.), minimum (Min.) and maximum (Max.) scores on each test across groups. Sample size or $N = 55$.

	Mean	Std. Dev.	Min. Score	Max. Score
Age (months)	68.51	11.31	46.00	87.00
Tests				
Letter Naming				
Upper-case (26)	22.45	6.67	1.00	26.00
Lower-case (26)	20.42	7.08	0.00	26.00
Phoneme Identity				
Onset (10)	8.86	1.63	5.00	10.00
Coda (10)	7.78	2.35	3.00	10.00
Phonetic-cue reading				
Onset (14)	11.47	3.53	4.00	14.00
Coda (14)	10.38	4.15	2.00	14.00
Phoneme Deletion				
Onset (12)	6.05	5.58	0.00	12.00
Coda (12)	7.35	4.84	0.00	12.00
Odd Man Out				
Rime (10)	6.53	2.39	0.00	10.00
Onset (10)	5.91	3.32	0.00	10.00
Coda (10)	4.29	3.40	0.00	10.00
Analogy Pretest (22)	6.49	7.31	0.00	22.00
Analogy Reading (42)	21.73	17.20	0.00	42.00
Word Reading (66)	19.76	20.50	0.00	62.00
Word Spelling (66)	14.07	15.40	0.00	56.00
Phoneme Counting (22)	6.00	7.27	0.00	22.00

The data were analyzed using scatterplots and a logical analysis approach adopted from Stahl and Murray (1994). The scatterplots have two reference lines representing the mastery criterion for test X and test Y, unless stated otherwise. The number of children who had mastered both tests X and Y, neither test X or test Y, test Y only, and test X only is shown. The logical analysis approach was then used to determine whether children could do test X without success on test Y or vice versa. If the numbers show that children could perform test X only if they had achieved mastery of test Y, test Y is a possible prerequisite for test X. Success on test Y before test X is a type of correlational evidence, indicating that one can speculate, but not confirm that test Y is a prerequisite for test X.

Two reference lines are shown for each task variable plotted as a function of another task variable, unless otherwise stated in the caption. The horizontal and vertical lines in these graphs represent the mastery criteria for each of the task variables given. The use of these reference lines divides each graph into four quadrants. Each quadrant represents those children who either had reached the mastery criteria for each variable, one variable or the other, or neither variable. The numbers shown in each quadrant (in bold) represent the total number of children in each of the latter categories. On all the graphs there are circles that represent the children's scores. A single circle represents one child, and a circle with radiating lines or petals represents more than one child. For example, a circle with two petals represents two children who obtained the same score.

Two reference lines are shown for each task variable plotted as a function of age, unless otherwise stated. The horizontal lines represent the mastery criterion for the variable given. The numbers given (in bold) above and below this line represent the total number of children who had reached the mastery criterion or not, respectively. The vertical lines represent the age when 50 % of the children reached the mastery criterion for the variable given. When less than 50 % of the children had reached the mastery criterion, the vertical line represents the age when 20 % achieved mastery. In some cases, zero scores were obtained in a test, and in order to show the scores clearly, some scatterplots were plotted with negative numbers.

Hypothesis One

The first hypothesis states letter-name knowledge and onset identity are prerequisites for onset phonetic-cue reading (OPCR), and that letter-name knowledge and coda identity are prerequisites for coda phonetic-cue reading (CPCR). If the hypotheses are correct, one should see J-shaped scatterplots for OPCR plotted as a function of letter-name knowledge and onset identity, and for CPCR plotted as a function of letter-name knowledge and coda identity as well. All of the analyses for letter-name knowledge were conducted using upper-case letter naming scores because the test words for the phonetic-cue reading test were presented in upper-case letters.

Figure 1 shows letter-name knowledge scores plotted as a function of age. Here, 82 % of the sample had reached the letter-name mastery criterion of 21 letters. By 74 months (6:2 years), 50 % of the children had mastered letter-name knowledge. Figure 2 shows onset identity scores plotted as a function of age. Overall, 76 % of the sample reached the mastery criterion for onset identity, with 50 % achieving mastery by the age of 78 months (6:6 years). Figure 3 shows OPCR scores plotted as a function of age, with

50 % of the children achieved OPCR mastery by the age of 78 months. Overall, 73 % of the sample reached the mastery criterion, and this percentage includes one child who missed the OPCR cutoff by 0.2 of a mark. This one child was counted as having OPCR mastery for all subsequent analyses using the OPCR data (indicated by asterisks or crosses on the relevant scatterplots). Figures 1, 2, and 3 clearly show that knowledge of letter names for 50% of the children was acquired several months before either onset identity or onset phonetic-cue reading. Phoneme identity and phonetic-cue reading for onsets were mastered by the same age, again, several months after letter-name knowledge.

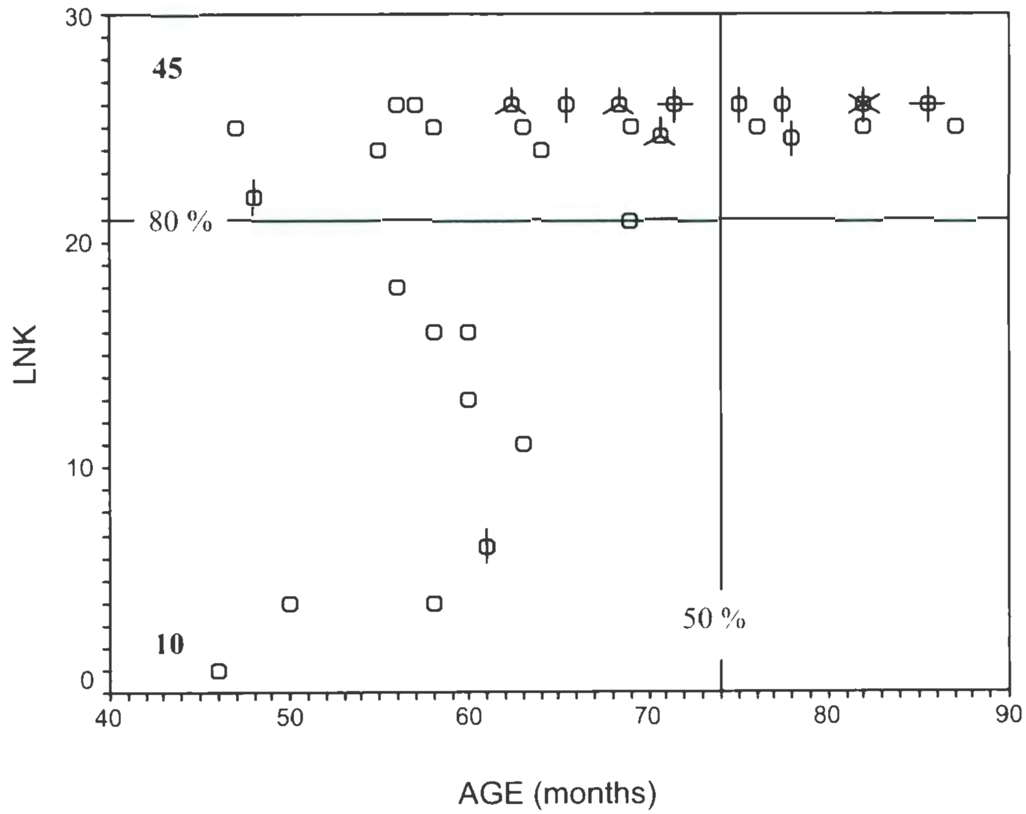

Figure 1. Scatterplot of Letter-Name Knowledge (LNK) scores plotted as a function of Age in months

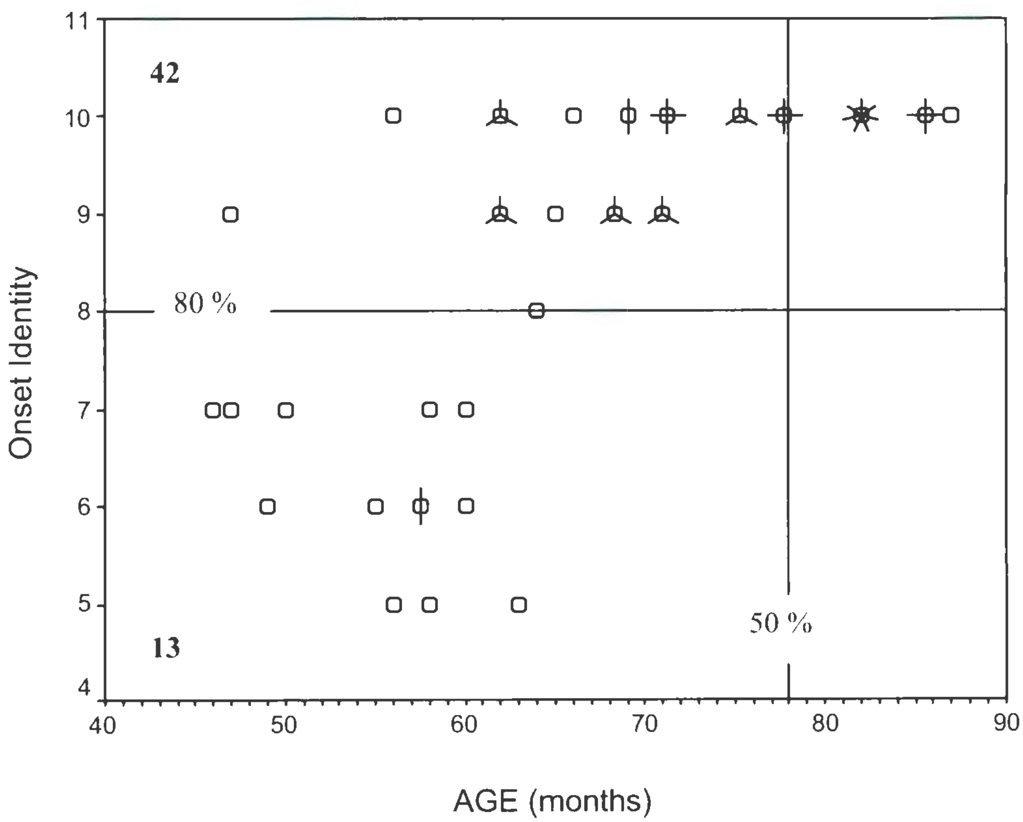

Figure 2. Onset Identity scores plotted as a function of Age in months

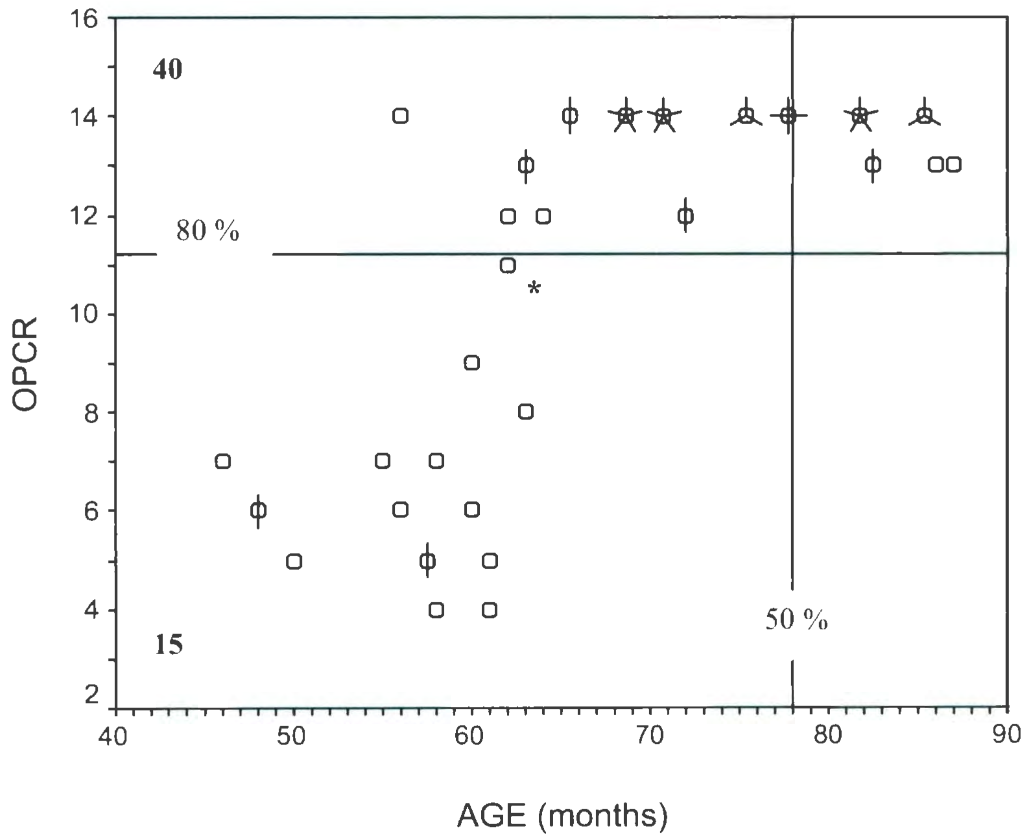

Figure 3. Onset Phonetic-Cue Reading (OPCR) scores plotted as a function of Age in months. The asterisk or * represents the one child counted as having OPCR mastery

Figure 4 shows the relationship between letter-name knowledge and onset identity. Seventy-three percent had established both letter names and onset identity, while 15 % had established neither skill. Four percent (two children) had established onset identity without letter names, while nine percent (five children) had mastered letter names but not onset identity. The two children with mastery of onset identity but not letter-name knowledge were preschoolers 61 months of age, but with exceptional phonological skills for their age. The five children with mastery of letter names before onset identity were preschoolers between 47 and 58 months with phonological skills that were expected given their age.

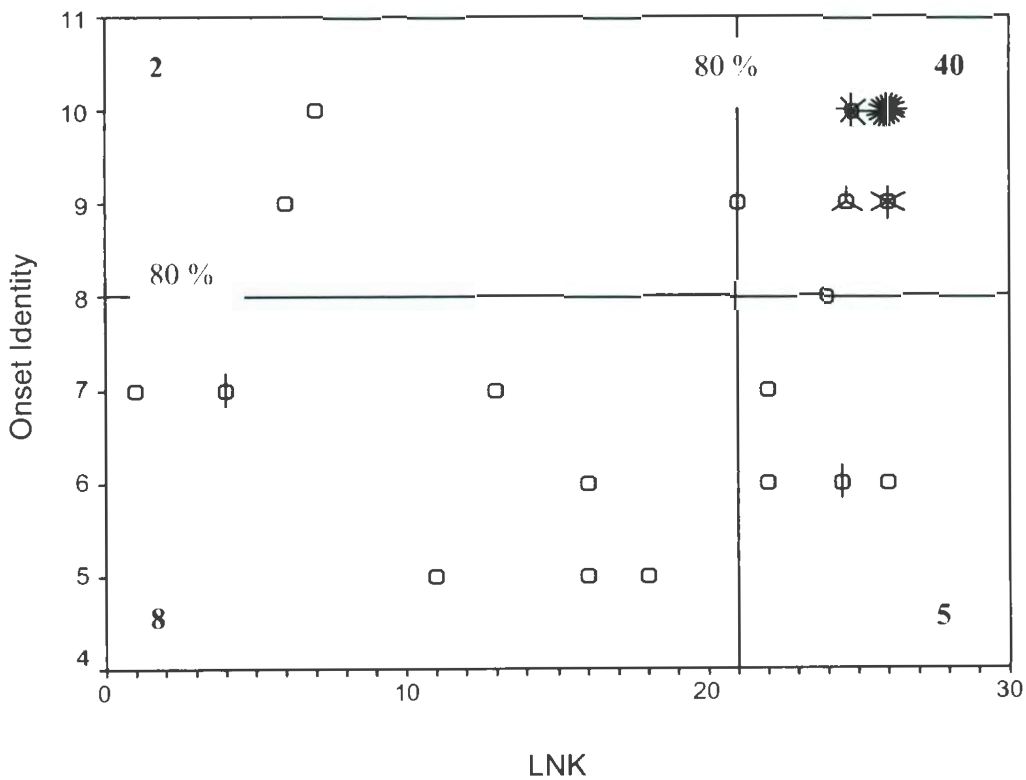

Figure 4. Scatterplot of Onset Identity scores plotted as a function of letter-Name Knowledge (LNK) scores

Letter-name knowledge and onset identity were entered in a *Chi-square* analysis, and the relationship was found to be significant, χ^2 (1, N = 55) = 21.56, $p < 0.001$, indicating that both variables were related. The conditional probability of achieving onset identity mastery given knowledge of 21 letter names was 0.89; the probability of onset identity mastery given the lack of letter knowledge was 0.20. There is a high probability of onset identity success if a child has learned at least 21 letter names.

Knowledge of letter names for 50% of the children was acquired several months before either onset identity or onset phonetic-cue reading, Figure 1 and 2. Onset identity and onset phonetic-cue reading were mastered by the same age, again, several months after letter-name knowledge, Figure 3. Figure 4 together with the strong conditional probability shows that children learn 21 out of 26 letter names before acquiring onset identity. Letter-name knowledge as a prerequisite for onset identity cannot be ruled out, consistent with Hypothesis One.

Figure 5 shows the relationship between letter-name knowledge and onset phonetic-cue reading (OPCR). Here, 73 % of the total sample reached mastery on both letter-name knowledge and OPCR, while 18 % had mastered neither skill. No child had mastered OPCR without also mastering letter names, but nine percent had mastered knowledge of letter names before OPCR. A *Chi-square* test was calculated on the numbers shown in Figure 5 and was found to be significant, χ^2 (1, N = 55) = 32.56, $p <$ 0.001, indicating that the variables were related. The conditional probability of achieving OPCR mastery given mastery of letter names is 0.89, but there was no chance of OPCR mastery without mastery of letter-name knowledge first.

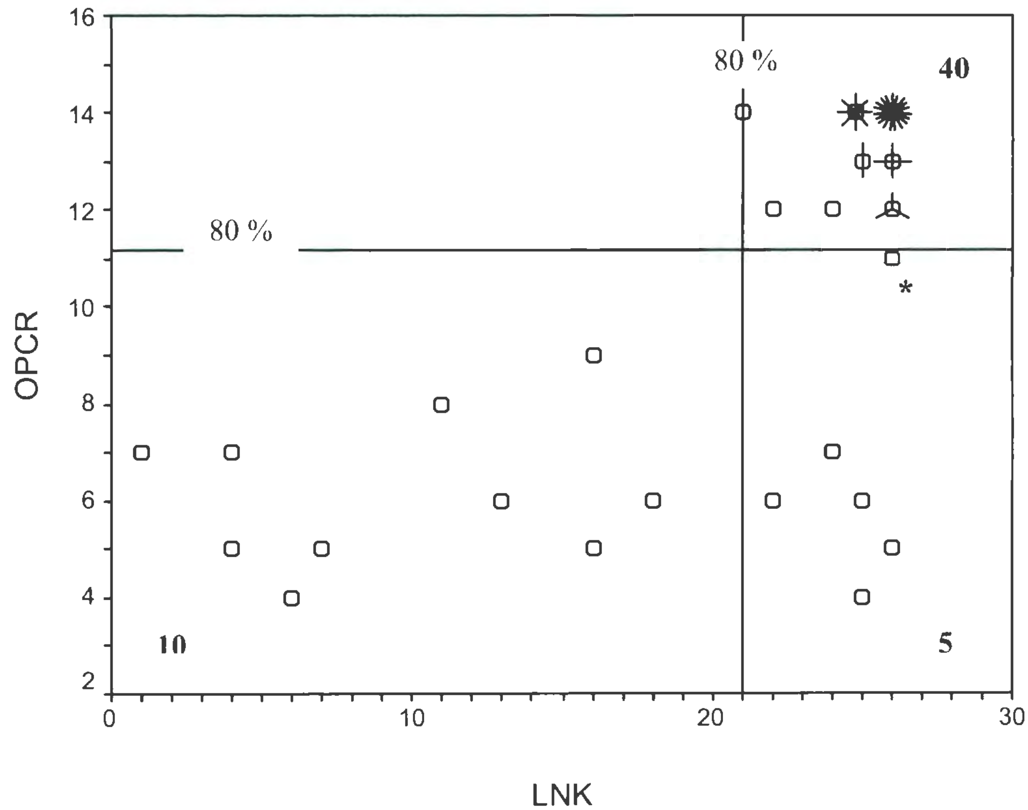

Figure 5. Onset Phonetic-Cue Reading (OPCR) scores plotted as a function of Letter-Name Knowledge (LNK) scores. The asterisk or * represents the one child counted as having OPCR mastery

Figure 6 shows the relationship between onset identity and onset phonetic-cue reading (OPCR). Here, 71 % of the children had established both onset identity and OPCR, and 22 % had established neither skill. Only one child had reached mastery on OPCR before onset identity, but only by a score of one on the identity task. Five percent (three children) had mastered onset identity but not OPCR, but it was expected that some children would have onset identity without OPCR skills.

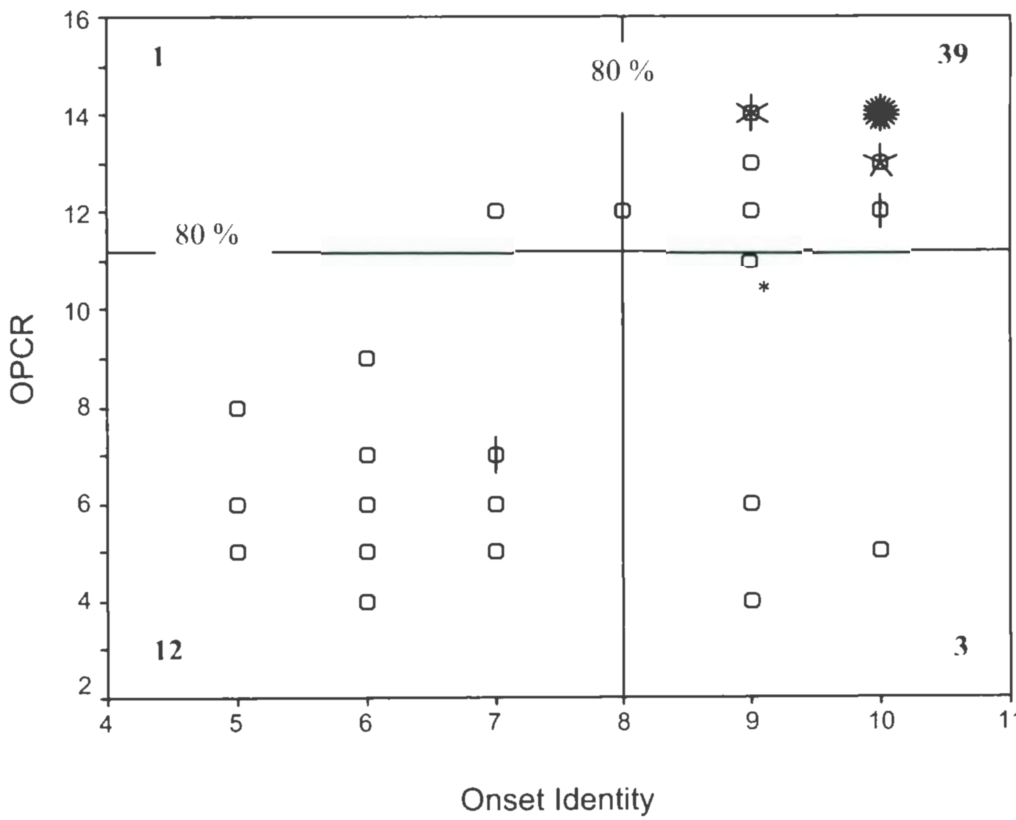

Figure 6. Onset Phonetic-Cue Reading (OPCR) scores plotted as a function of Onset Identity scores. The asterisk or * represents the one child counted as having OPCR mastery

A *Chi-square* test was calculated on the numbers shown in Figure 6 and was found to be significant, χ^2 (1, N = 55) = 36.25, p < 0.001, indicating that the onset identity and onset phonetic-cue reading were related. The conditional probability of mastery for onset phonetic-cue reading given mastery of onset identity was 0.93, while the probability of onset phonetic-cue reading given no onset identity was 0.077.

The first part of Hypothesis One proposed that letter-name knowledge and onset identity precede onset phonetic-cue reading. The age data (Figures 1, 2, and 3) show that 50 % of the children mastered letter knowledge by 74 months (6:2 years), while the corresponding age for both onset identity and onset phonetic-cue reading mastery was 78 months (6:6 years). Figures 4 and 5 show that the children acquired knowledge of letter names before both onset identity and onset phonetic-cue reading. Figure 6 shows that with one exception onset identity developed before onset phonetic-cue reading. The scatterplots of letter-name knowledge, onset identity, and onset phonetic-cue reading plotted as a function of age show that letter names are acquired before both onset identity and onset phonetic-cue reading. Therefore, both letter names and onset identity are possible prerequisites for onset phonetic-cue reading ability, consistent with the first part of Hypothesis One.

The second part of Hypothesis One states that both letter-name knowledge and coda identity are prerequisites for coda phonetic-cue reading (CPCR), and therefore should be mastered earlier than CPCR. The scatterplots relating letter-name knowledge and coda identity to CPCR should therefore show a J-shaped function. Figure 1 shows that letter-name knowledge was established at 74 months of age (6:2 years) for 50 % of the. Figure 7 shows coda identity as a function of age. Only 58 % of the children reached mastery, with 50 % reaching mastery by 84 months of age (7:0 years). Figure 8 shows CPCR as a function of age, with 62 % of the sample reaching mastery. This percentage includes two children who missed the CPCR cutoff by 0.2 of a mark. These children were counted as having CPCR mastery for all subsequent analyses using the CPCR data (indicated by asterisks or crosses on relevant scatterplots). Figure 8 shows 50 % of the children reached the CPCR criterion by 83 months (6:11 years). Therefore, 50 % of the children had mastered letter-name knowledge nine or ten months before achieving mastery on either coda identity or coda phonetic-cue reading.

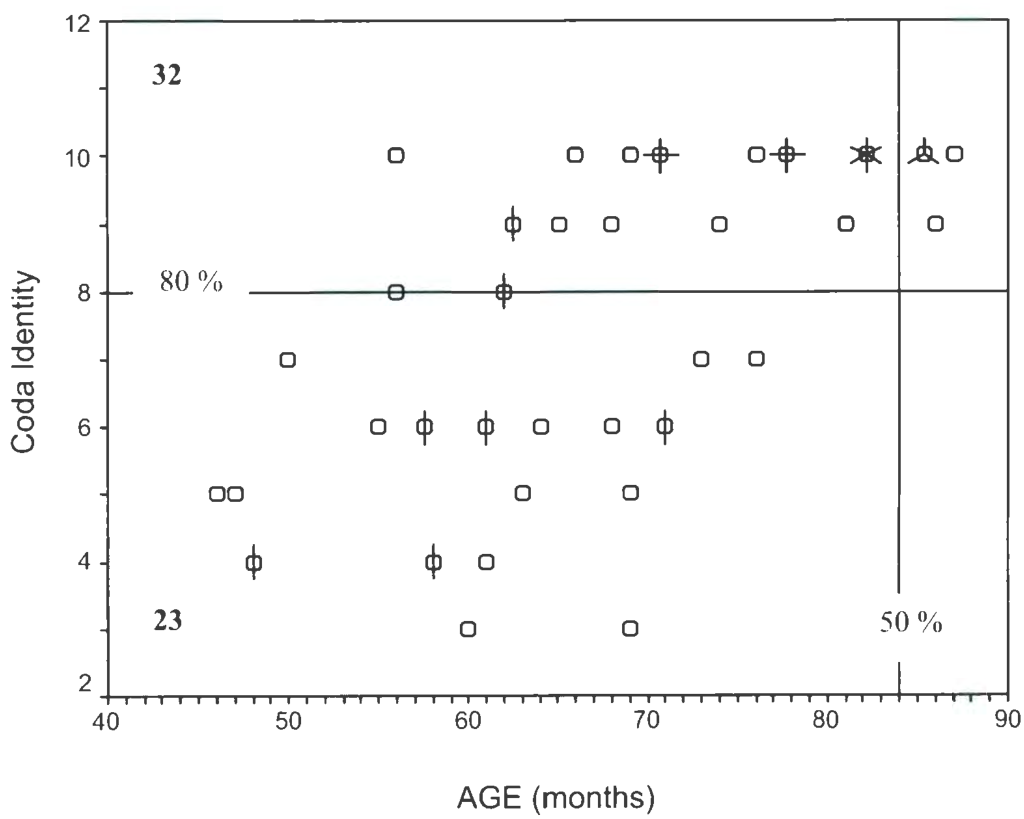

Figure 7. Coda Identity scores plotted as a function of Age in months

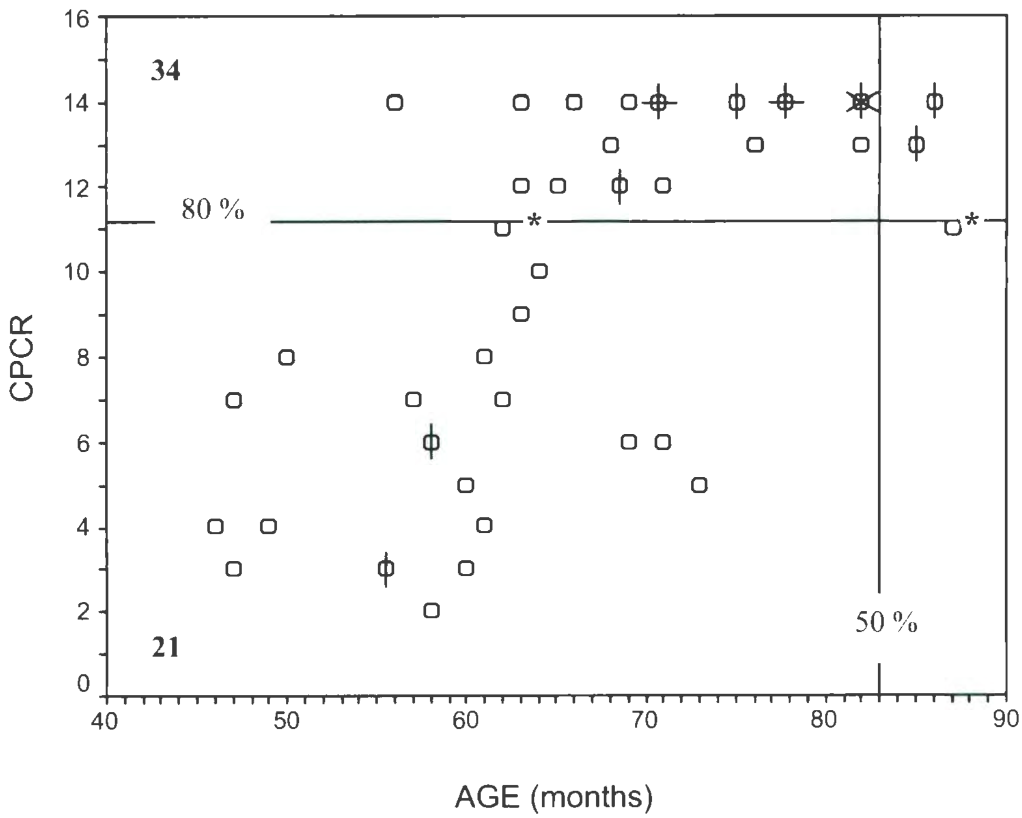

Figure 8. Coda Phonetic-Cue Reading (CPCR) scores plotted as a function of Age in months. The asterisks or * represents the two children counted as having CPCR mastery

The relationships between letter-name knowledge and coda identity with coda phonetic-cue reading are shown in Figures 9 and 10. Figure 9 shows 55 % (30 children) of the children achieved mastery for both letter-name knowledge and coda identity, while 15 % had mastered neither skill. Two children mastered coda identity before letter knowledge, while 27 % had mastered letters without coda identity.

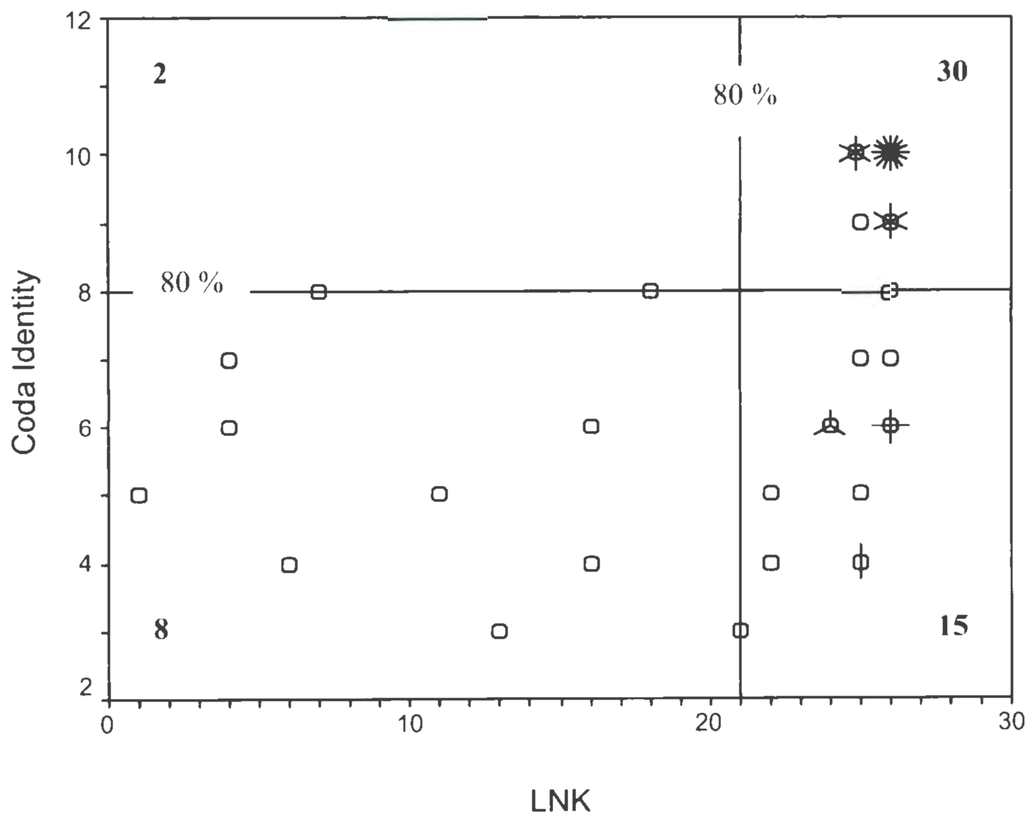

Figure 9. Coda Identity scores plotted as a function of Letter-Name Knowledge (LNK) scores

The *Chi-square* for letter-name knowledge and coda identity was significant, χ^2 $(1, N = 55) = 7.33$, $p < 0.01$, indicating the two variables were related. The conditional probability of achieving coda-identity mastery given knowledge of 21 letter names was 0.67, while the probability of mastering coda identity without 21 letter names was 0.20.

Figure 10 shows that 62 % of the children had mastered both letter-name knowledge and coda phonetic-cue reading (CPCR), and 18 % had mastered neither skill.

No child mastered CPCR without also having mastered letter names, but 20 % of the children mastered letter-name knowledge before CPCR. The *Chi-square* for letter-name knowledge and CPCR was significant, χ^2 (1, N – 55) – 19.79, $p < 0.001$, indicating that the two variables were related. The conditional probability of CPCR mastery given knowledge of 21 letter names was 0.76, while the probability of achieving CPCR mastery without letter knowledge was zero.

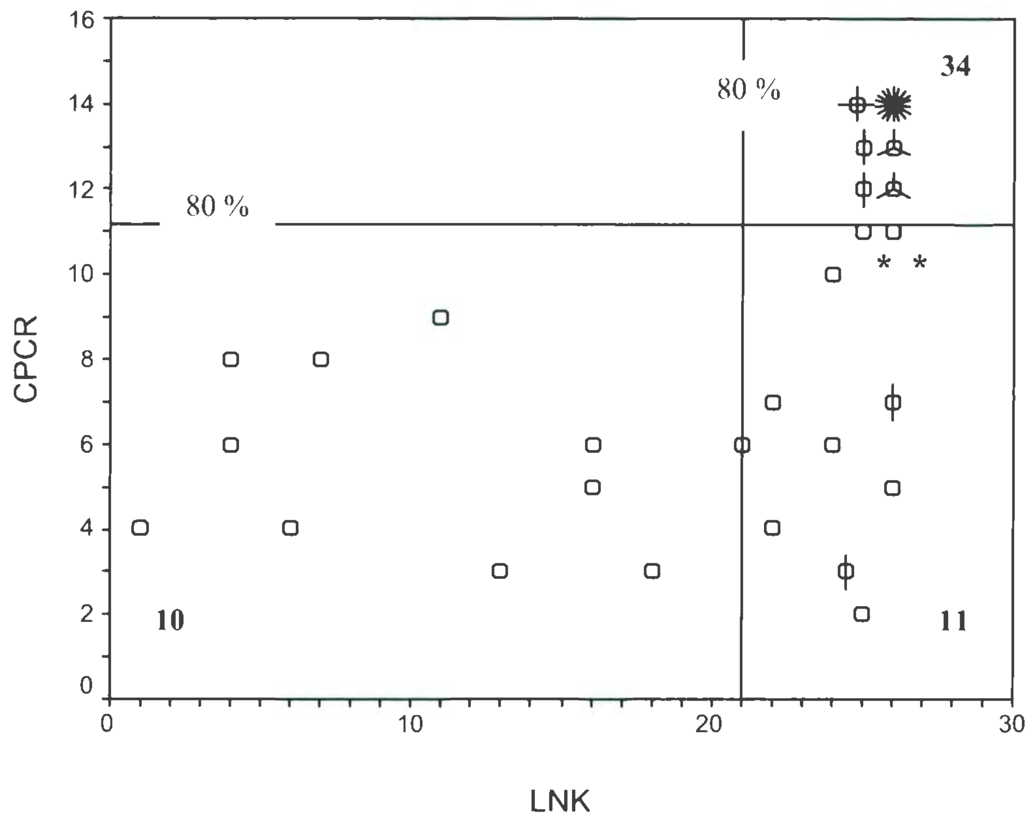

Figure 10. Coda Phonetic-Cue Reading (CPCR) scores plotted as a function of Letter-Name Knowledge (LNK) scores. The asterisks or * represents the two children counted as having CPCR mastery

Figure 11 shows the relationship between coda identity and coda phonetic-cue reading (CPCR). Fifty-five percent of the children had mastered both coda identity and CPCR tests, while 35 % had mastered neither. Four percent (two children) of the children mastered coda identity before CPCR, and seven percent (four children) mastered

CPCR without coda identity. The *Pearson* correlation coefficient was calculated and was significant, $r = 0.838$, $p < 0.001$, as was the *Chi-square*, χ^2 (1, $N = 55$) – 33.06, $p < 0.001$, indicating the two variables are related. Figure 11 suggests that coda identity and CPCR develop simultaneously, and there is no evidence to support the view that coda identity develops prior to CPCR.

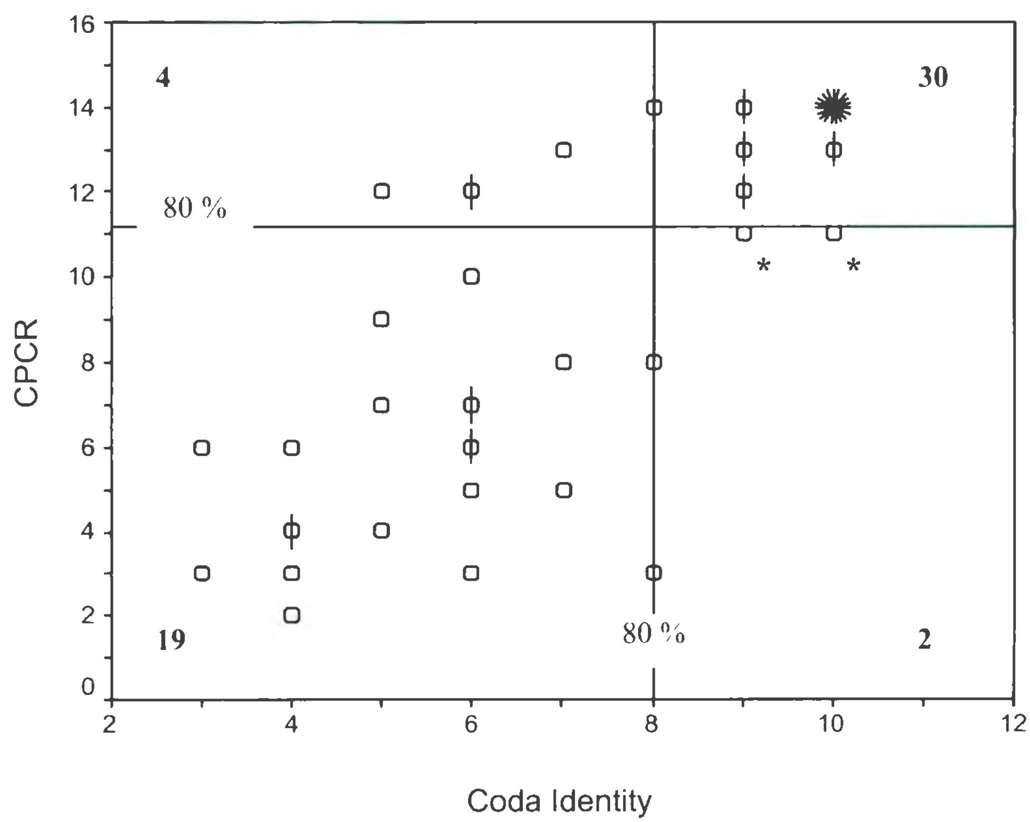

Figure 11. Coda Phonetic-Cue Reading (CPCR) scores plotted as a function of Coda Identity scores. The asterisks or * represents the two children counted as having CPCR mastery

An examination of the two participants who mastered coda identity but not coda phonetic-cue reading (CPCR) showed that both were under 62 months of age and had not mastered letter-name knowledge. Given weak letter-name knowledge, mastery of CPCR is not expected. The four children who mastered CPCR without coda identity had expert knowledge of letter names, onset identity, and onset phonetic-cue reading, indicating good letter-sound knowledge for onsets, but not for codas.

By 74 months of age, 50 % of the children had acquired letter-name knowledge, and then by 84 and 83 months 50 % of the children acquired coda identity and coda phonetic-cue reading, Figures 1, 7, and 8, respectively. Knowledge of letter names developed 10 months before coda identity and nine months before coda phonetic-cue reading. Clearly, children acquire letter-name knowledge first, consistent with the second part of Hypothesis One. With only two exceptions, the analyses of the relationship between letter-name knowledge and coda identity and coda phonetic-cue reading support the findings that letter-name knowledge was attained before coda identity and coda phonetic-cue reading, Figure 9 and 10 data together with the conditional probabilities. However, there was no evidence that coda identity developed prior to coda phonetic-cue reading, and four children developed the skills in the reverse order of the predicted relationship, Figure 11.

In summary, knowledge of letter names develops prior to onset and coda identity, and onset and coda phonetic-cue reading, indicating that letter-name knowledge is a possible prerequisite for each of the latter skills. However, the relationship between onset identity and onset phonetic-cue reading and between coda identity and coda phonetic-cue reading are not as clear. In the absence of strong opposing evidence, it is reasonable to conclude that onset identity and onset phonetic-cue reading develop concurrently, as do coda identity and coda phonetic-cue reading.

Hypothesis Two

Hypothesis Two proposed that children acquire onset identity before coda identity and onset phonetic-cue reading before coda phonetic-cue reading. Figures 2 and 7 show onset and coda identity each plotted as a function of age, respectively. Fifty percent of the children achieved mastery of onset identity by 78 months, and coda identity by 84 months. Figure 12 shows the relationship between onset identity and coda identity. Fifty-six percent of the children had mastered both onset and coda identity, while 22 % mastered neither task. Only one child achieved mastery for coda identity but not onset identity, while 20 % mastered onset identity before coda identity. Onset identity was mastered before coda identity, Figures 2, 7 and 12, consistent with the first part of Hypothesis Two.

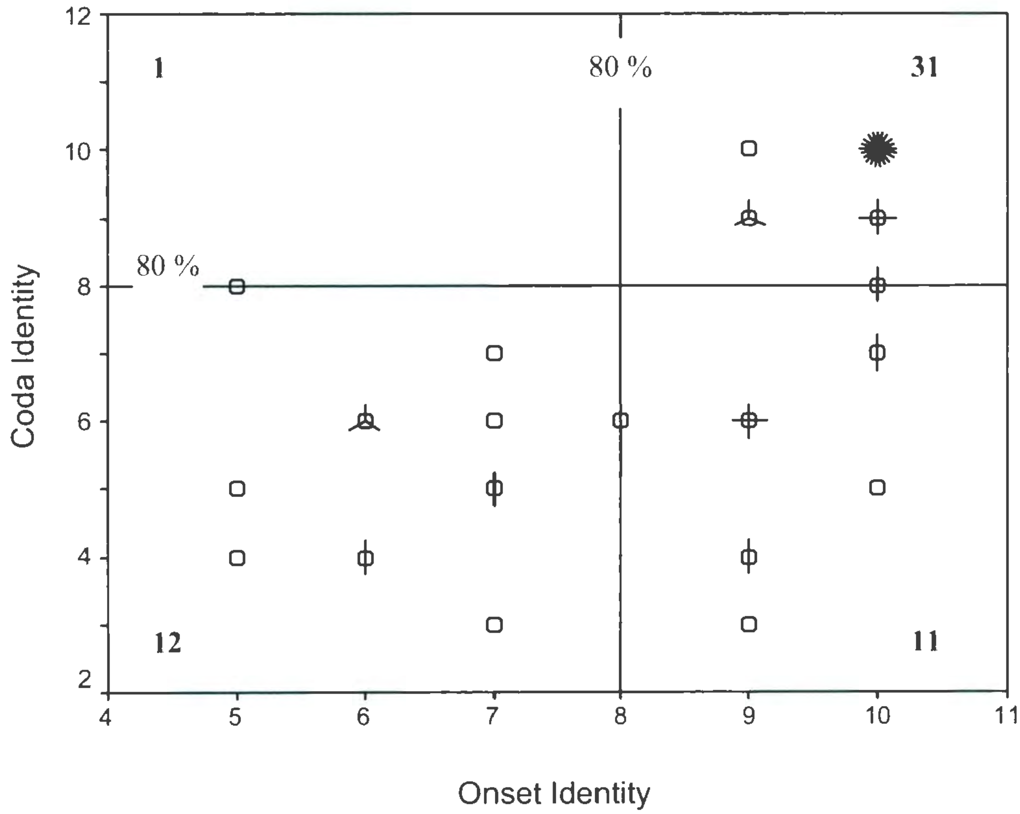

Figure 12. Coda Identity scores plotted as a function of Onset Identity scores

An ANOVA analysis was conducted to determine the relative difficulty of the phoneme identity test at the level of onsets and codas, with grade level (preschool, kindergarten, and the first grade) as the independent variable. There was a significant main effect for linguistic level of the identity test, F (1, 52) = 22.35, $p < 0.001$, and for grade, F (2, 52) = 34.43, $p < 0.001$, but no significant interaction effect. Table 5 shows the means and standard deviations for onset identity and coda identity for each grade level, and as predicted for Hypothesis Two, onset identity means were significantly higher than coda identity means for every grade level.

Table 5.

Onset Identity (OID) and Coda Identity (CID) test means and standard deviations (Std. Dev.) at each grade level (PS = preschool, K= kindergarten, FG = first grade), *n* = total number of children in each grade

Test	GRADE	*n*	Mean	Std. Dev.
OID	PS	20	7.35	1.81
	K	17	9.41	0.62
	FG	18	10.00	0.00
CID	PS	20	5.90	1.92
	K	17	7.94	2.22
	FG	18	9.72	0.75

Figure 3 and 8 show onset and coda phonetic-cue reading respectively plotted as a function of age. Figure 3 shows 72 % of the children had mastered onset phonetic-cue reading, with 50 % of the children achieving mastery for onset phonetic-cue reading (OPCR) by 78 months. Figure 8 shows 62 % of the children had mastered coda phonetic-cue reading, with 50 % achieving coda phonetic-cue reading (CPCR) by 83 months; five months after 50 % of the children attained OPCR.

Figure 13 shows the relationship between onset phonetic-cue reading (OPCR) and coda phonetic-cue reading (CPCR). Sixty-two percent of the children had mastered both OPCR and CPCR, while 27 % mastered neither skill. No child had mastered CPCR before OPCR, but 11 % had achieved OPCR mastery before mastery of CPCR.

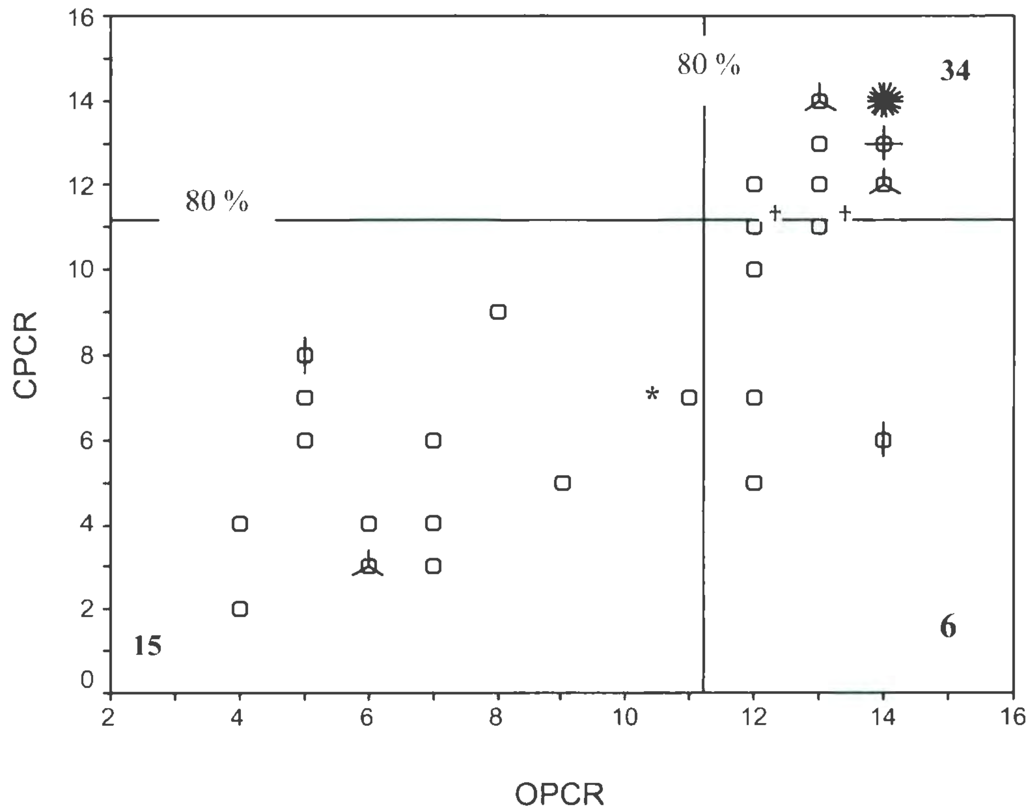

Figure 13. Coda Phonetic-Cue Reading (CPCR) scores plotted as a function of Onset Phonetic-Cue Reading (OPCR) scores. The asterisk or * represents the one child counted as having OPCR mastery, and the crosses or † represent the two children counted as having CPCR mastery

An ANOVA analysis was conducted to determine the relative difficulty of the phonetic-cue reading task at the level of onsets (OPCR) and codas (CPCR), with grade level (preschool, kindergarten, and the first grade) as the independent variable. There was a significant main effect of linguistic complexity, $F\,(1, 52) = 13.59$, $p < 0.001$, and of grade, $F\,(2, 52) = 54.79$, $p < 0.001$, but no significant interaction effect. Table 6 shows the means and standard deviations for onset and coda phonetic-cue reading, and as predicted for Hypothesis Two, the means for OPCR were higher than the means for CPCR at every grade level. In summary, children develop both phoneme identity and grapheme-phoneme correspondences for simple onsets (OID and OPCR) before phoneme identity and grapheme-phoneme correspondences for simple codas (CID and CPCR), consistent with the second hypothesis, Figures 2, 3, 7, 8, 12, and 13, together with Tables 5 and 6, and the ANOVA results.

Table 6.

Onset Phonetic-Cue Reading (OPCR) and Coda Phonetic-Cue Reading (CPCR) test means and standard deviations (Std. Dev.) at each grade level (PS – preschool, K = kindergarten, One – first grade), *n* = total number of children in each grade.

Test	GRADE	*n*	Mean	Std. Dev.
OID	PS	20	7.60	3.14
	K	17	13.59	0.80
	FG	18	13.78	0.43
CID	PS	20	6.40	3.52
	K	17	11.65	3.08
	FG	18	13.61	0.78

Hypothesis Three

Hypothesis Three states that children cannot remove onsets and codas from spoken words before achieving alphabetic representation for onsets and codas, respectively. If Hypothesis Three is correct, one should see J-shaped scatterplots when onset deletion (OD) is plotted as a function of onset phonetic-cue reading, and when coda deletion (CD) is plotted as a function of coda phonetic-cue reading.

Figure 3 shows that 73 % of the children tested had mastered onset phonetic-cue reading, and Figure 14 shows that only 44 % of the children tested had mastered onset deletion. The age of mastery for 50 % of the children cannot be compared between the deletion and phonetic-cue reading tests, but a z-test of proportions was significant, $z = 3.10$, $p < 0.01$. This indicates that the onset deletion test was more difficult than the onset phonetic-cue reading test.

Figure 14 shows that onset deletion as a function of age has a bimodal distribution. There are two different groups, 44 % of the children (24 children) with a zero score in the onset deletion test, referred to as the OD-absent children, and the remaining children (31 children) with a score of five or greater in the onset deletion test, referred to as the OD-present children. The OD-absent children were mostly younger preschool children, while OD-present children were mostly older first-grade children.

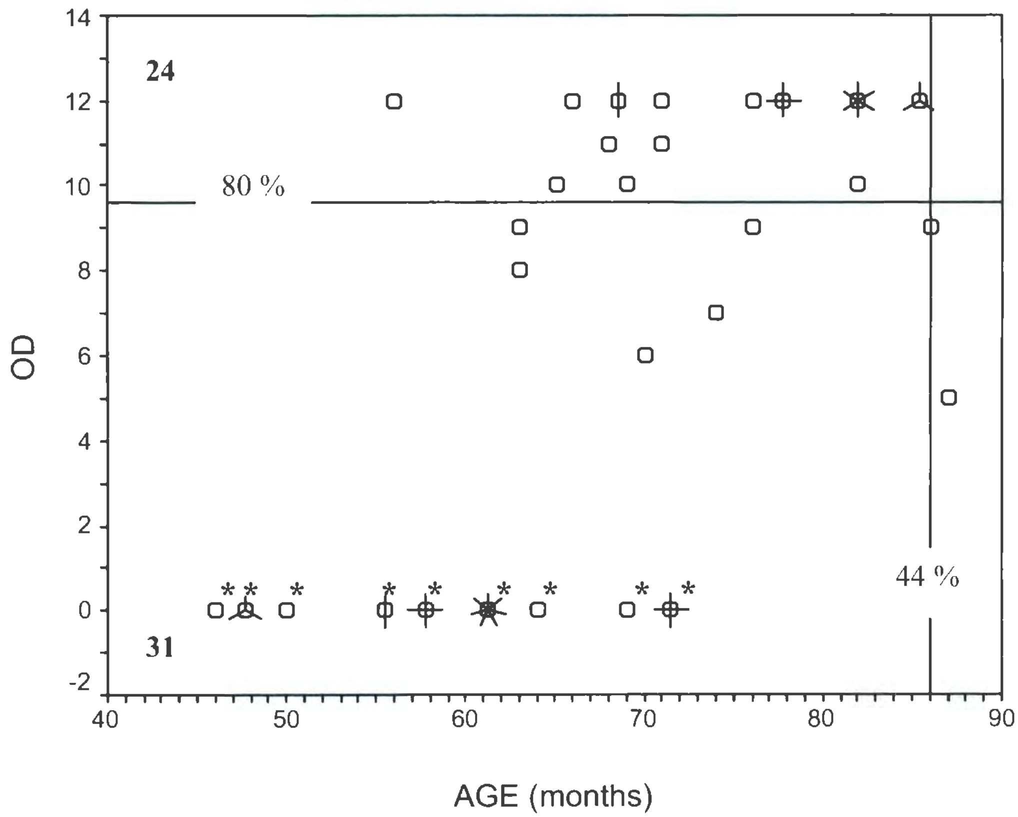

Figure 14. Onset Deletion (OD) scores plotted as a function of Age in months. The scores marked with asterisks or * represents the OD-absent children

Table 7 compares the performance of OD-absent and OD-present children on letter-name knowledge, onset identity, coda identity, onset phonetic-cue reading (OPCR), coda phonetic-cue reading (CPCR), onset odd-man-out (O-OMO), and coda odd-man-out (C-OMO) in percentages, means and standard deviations. The majority of the OD-absent children had not mastered onset identity, coda identity, OPCR, or CPCR; just over half had mastered knowledge of letter names; only one child had mastered O-OMO; and none had mastered C-OMO. In contrast, all of the OD-present children had mastered letter names, onset identity, OPCR, and CPCR, and a large majority had mastered coda identity, O-OMO and C-OMO. The OD-absent children are clearly different than the OD-present children in that they had less developed alphabetic and phonological-processing skills.

Table 7.

Percentages (%), means, and standard deviations (Std. Dev.) for the number of OD-absent and OD-present children with mastery of Letter-Name Knowledge (LNK), Onset Identity (OID), Coda Identity (CID), Onset Phonetic-Cue Reading (OPCR), Coda Phonetic-Cue Reading (CPCR), Onset Odd-Man-Out (O-OMO), and Coda Odd-Man-Out (C-OMO), n = the number of children in each group.

	OD-absent (n = 24)			OD-present (n = 31)		
Tests	%	mean	Std. Dev.	%	mean	Std. Dev.
LNK	58	18.3	8.45	100	25.7	0.53
OID	46	7.6	1.74	100	9.8	0.37
CID	17	5.8	1.80	90	9.3	1.25
OPCR	42	8.5	3.50	100	13.8	0.40
CPCR	13	6.4	3.12	100	13.5	0.85
O-OMO	4	3.1	2.36	84	8.1	2.07
C-OMO	0	1.6	1.86	68	6.4	2.85

Figure 15 shows the relationship between onset phonetic-cue reading and onset deletion. Forty-four percent of the children had mastered both tasks, and 29 % had mastered neither task. No child scored above zero on the onset-deletion task before mastering onset phonetic-cue reading, but 27 % had mastered onset phonetic-cue reading before onset deletion.

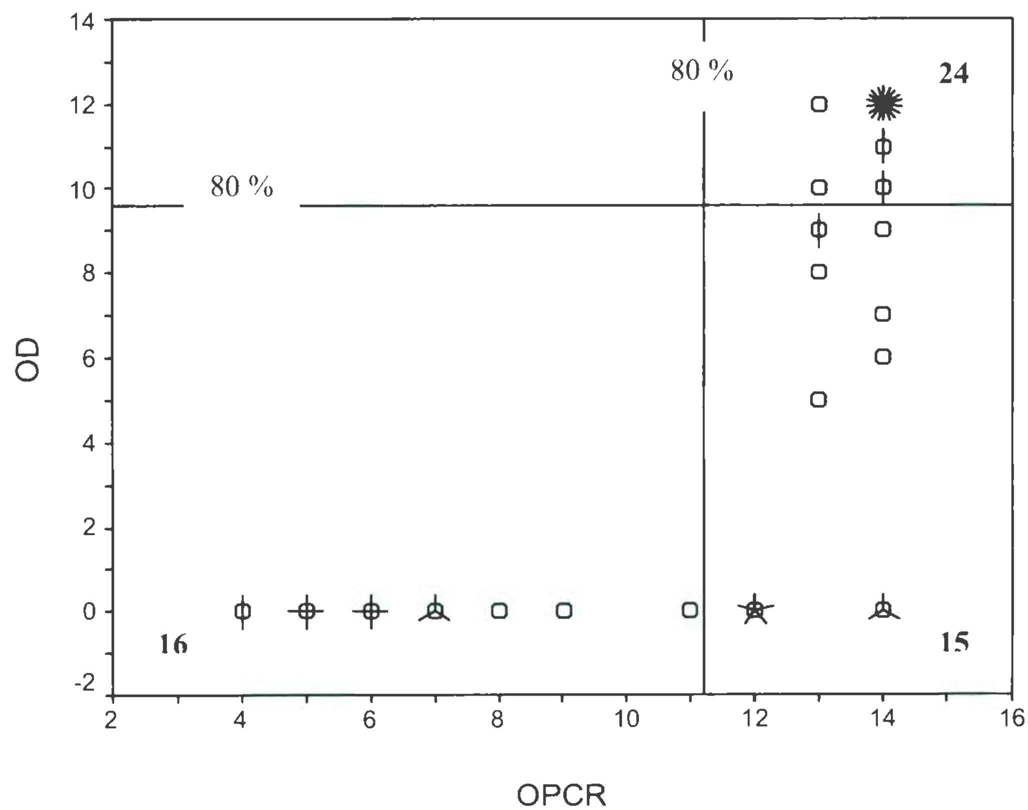

Figure 15. Onset Deletion (OD) scores plotted as a function of Onset Phonetic-Cue Reading (OPCR) scores

A *Chi-square* analysis of the onset phonetic-cue reading and onset deletion variables was significant, $\chi^2\,(1, N = 55) = 17.47, p = 0.001$, indicating that the variables are related. The conditional probability of onset-deletion mastery given mastery of onset phonetic-cue reading was 0.62, while the probability of achieving onset deletion without onset phonetic-cue reading was zero.

The proportion of children who reached the mastery criterion on onset phonetic-cue reading was significantly higher than the proportion of children reaching the mastery criterion on onset deletion, Figure 3 and 14 together with the z-test results. In addition, children mastered onset phonetic-cue reading before onset deletion, Figure 15. The findings reported here indicate that onset phonetic-cue reading develops before onset deletion, consistent with Hypothesis Three.

Figure 9 showed that sixty-two percent of the children tested had mastered coda phonetic-cue reading, with 50 % achieving mastery by 83 months (6:11 years) of age. Figure 16 shows that 51 % of the children tested had mastered coda deletion, with 50 % achieving mastery by 87 months of age. Children mastered coda phonetic-cue reading four months earlier than coda deletion. Although most of the children who reached the mastery criterion for coda deletion were older than 65 months (5.5 years), Figure 16 shows that there were children between 46 and 55 months old (4:2 to 4:7 years) who could do some of the coda deletion items.

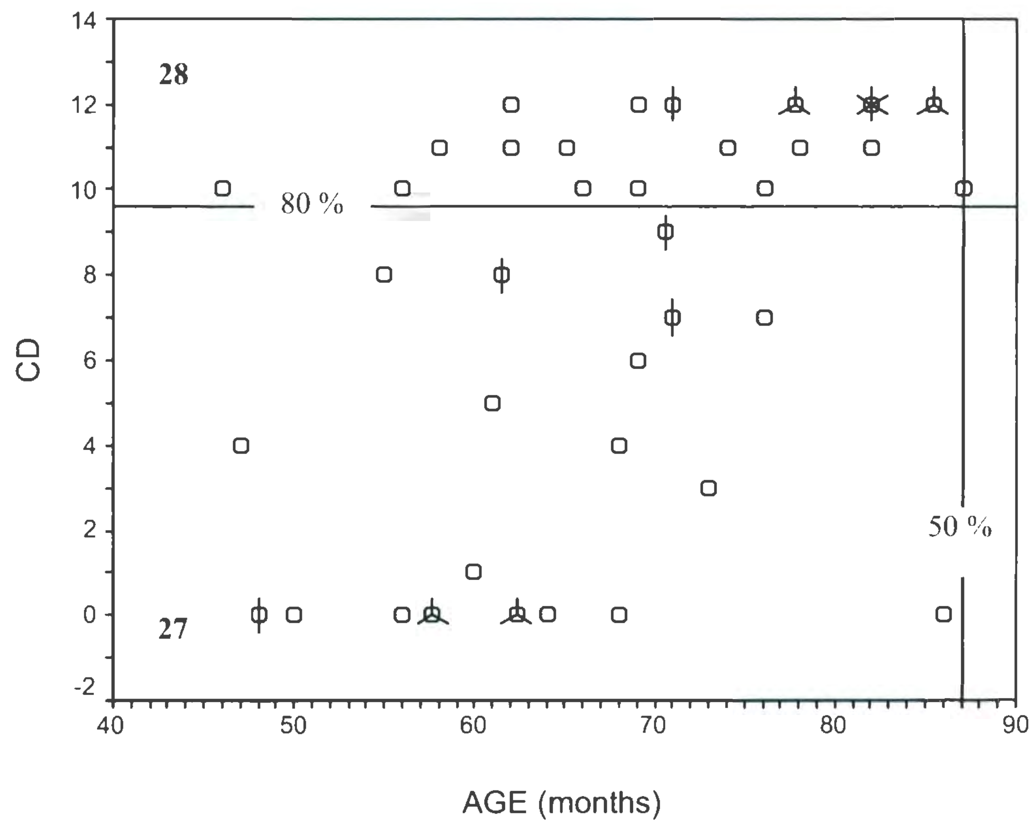

Figure 16. Coda Deletion (CD) scores plotted as a function of Age in months

Figure 17 shows coda deletion plotted as a function of coda phonetic-cue reading. Forty-four percent of the children had mastered both tests, and 31 % had mastered neither test. Seven percent (four children) had mastered coda deletion but not coda phonetic-cue reading, and 18 % had mastered coda phonetic-cue reading but not coda deletion.

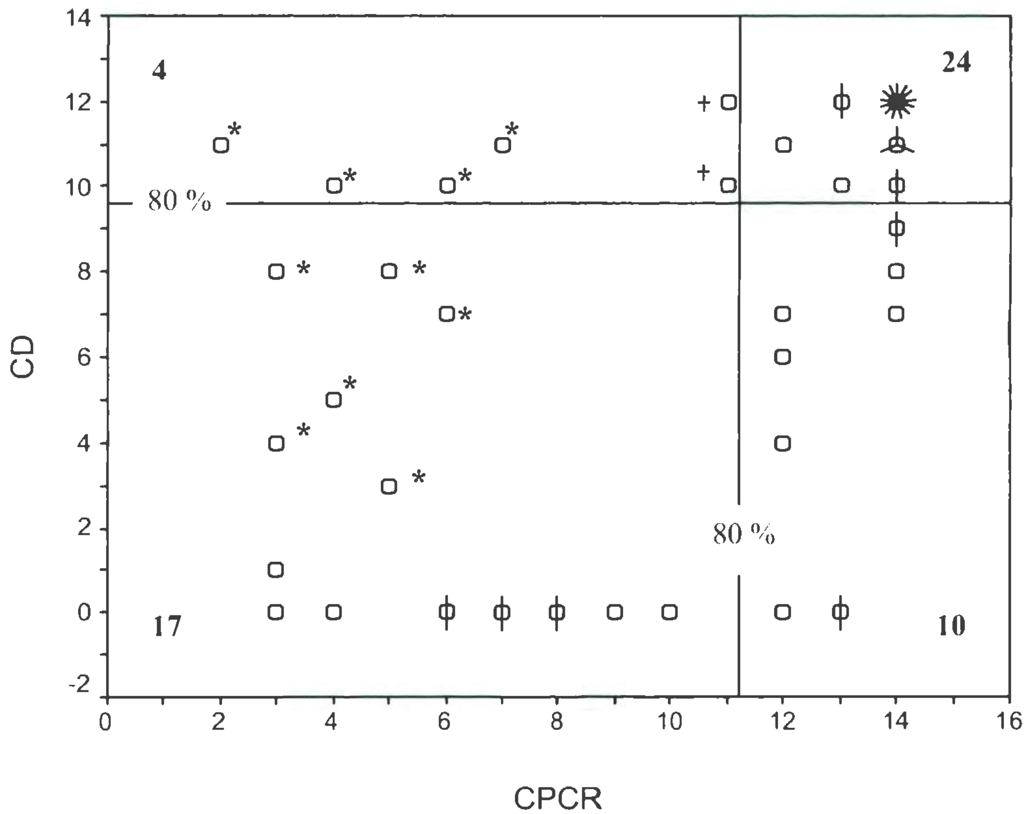

Figure 17. Coda Deletion (CD) scores plotted as a function of Coda Phonetic-Cue Reading (CPCR) scores. The asterisks or * represents each CD-discrepant child, and the crosses or † represents the two children counted as having CPCR mastery

According to Figure 17, there were 10 children (marked with asterisks in Figure 17) who could do coda deletion, a score of three or higher, without mastery of coda phonetic-cue reading. These children are called the CD-discrepant children because their ability to do coda deletion without alphabetic representation for codas was considered unusual. The remaining 45 children showed the predicted sequence of development between coda phonetic-cue reading and coda deletion, and are called the CD-normal children. A comparison of the alphabetic and phonological processing skills between the CD-discrepant children and the CD-normal children was therefore conducted.

Table 8 shows that none of the CD-discrepant children had mastered coda identity, coda phonetic-cue reading, onset deletion, or coda odd-man-out, and only one or two CD-discrepant children had mastered onset phonetic-cue reading and onset odd-man-out. In contrast, most of the CD-normal children had mastered letter-name knowledge, onset and coda identity, and onset and coda phonetic-cue reading. Just over half had mastered onset deletion (three more children missed the onset deletion criterion by 0.6 of a mark), and several children had mastered onset and coda odd-man-out. Therefore, the CD-normal children had both better alphabetic and phonological processing skills than the CD-discrepant children, Table 8. The coda-deletion performance for the CD-normal children was consistent with their coda phonetic-cue-reading performance, and with the other onset and coda tests. However, the CD-discrepant children's coda-deletion performance was discrepant not only with their coda phonetic-cue-reading performance, but with their performance on the other alphabetic and phonological tests, particularly on the coda tasks. Except for letter-name knowledge and onset identity, the CD-discrepant and CD-normal children were clearly different. Their ability to do coda deletion was unexpected and unusual given their poor coda phonetic-cue reading and phonological-processing skills overall.

Table 8.

A comparison between the percentages (%), means, and standard deviations (Std. Dev.) for the number of CD-discrepant and CD-normal children with mastery of Letter-Name Knowledge (LNK), Onset Identity (OID), Coda Identity (CID), Onset Phonetic-Cue Reading (OPCR), Coda Phonetic-Cue Reading (CPCR), Onset Odd-Man-Out (O-OMO), Coda Odd-Man-Out (C-OMO), and Onset Deletion (OD), with *t-tests* (n – sample size).

	CD-discrepant group (n = 10)			CD-normal group (n = 45)			*t-tests*	
Tests	%	mean	Std. Dev	%	mean	Std. Dev	*df*	*t*
LNK	70	19.4	8.97	84	23.1	5.96	53	1.63^{ns}
OID	60	8.00	1.56	80	9.04	1.59	53	-0.88^{ns}
CID	0	5.10	1.29	71	8.38	2.10	53	4.72**
OPCR	3	8.80	3.79	80	12.07	3.22	53	2.81**
CPCR	0	4.50	1.58	76	11.69	3.32	53	6.65***
O-OMO	2	2.60	2.17	47	6.64	3.09	53	3.92***
C-OMO	0	1.30	1.83	29	4.96	3.32	53	3.35**
OD	0	0.00	0.00	53	8.50	3.44	53	4.39***

During the administration of the coda-deletion test the CD-discrepant children were observed to behave unusually. First, during the practice trials, with the exception of one child, none of the CD-discrepant children knew what ending sounds were when asked. None of them were able to produce words containing the target codas, and they all had considerable difficulty understanding what was meant by ending sounds. Although all of the 10 CD-discrepant children did learn to identify words with the same codas, six children barely qualified in the training. Second, during both the practice and experimental trials, five of the CD-discrepant children had to be reminded to identify or remove the ending sound rather than the beginning sound or rime for several items. Five children had to have practice or experimental items repeated twice before responding correctly. Third, during the experimental trials, five of the children were observed to hold their breath at the end of the target word, and two silently mouthed the coda to be removed. The children who showed this unusual behavior seemed to be inhibiting the enunciation of the coda, and often produced an odd sounding or shortened vowel sound. For example, *loss* without the /s/ sounded more like an L sound plus a schwa sound, making it difficult to discern whether the child had actually produced the precise target sound, *law*. These responses were counted as being correct.

The observation that the CD-children were holding their breath and mouthing the coda silently raised the question of whether they were using a phonologically based strategy to do the coda-deletion test. Seven out of the 10 CD-discrepant children showed this unusual behavior, while only two out of the 45 CD-normal children showed this behavior. A *z-test* comparing the proportion of CD-discrepant and CD-normal children showing this unusual behavior was significant, $z = 6.26$, $p < 0.01$. The proportion of children who seemed to be inhibiting the coda sound was higher for CD-discrepant children than the CD-normal children. The two CD-normal children who showed this unusual behavior had mastered coda phonetic-cue reading, while just missing mastery for coda deletion.

Coda phonetic-cue reading was mastered four months earlier than coda deletion, Figure 9 and 16. However, it seemed that some children, the CD-discrepant children, had some coda-deletion ability before coda phonetic-cue reading, Figure 17. The coda deletion performance of these CD-discrepant children was not consistent with their performance on the coda phonetic-cue reading task, but this was not the case for the CD-normal children. The CD-normal children had both better alphabetic skills (letter naming, onset and coda phonetic-cue reading) and phonological processing (onset and coda identity, onset and coda odd-man-out, and onset deletion) than the CD-discrepant children, Table 8. These latter findings together with the age findings, the behavioral observations, and the *z-test* results suggest that the CD-discrepant children did not actually know how to delete codas. The CD-discrepant children only appeared to have coda-deletion ability before alphabetic representation for codas because they were inhibiting the pronunciation of ending sounds by holding their breath or mouthing the coda silently.

If the scores of the CD-discrepant children are eliminated, Figure 17 shows the predicted J-shaped curve. Only children who reached the mastery criterion for coda phonetic-cue reading, with scores of 11 or higher were able to achieve a score of six or higher on the coda-deletion task. A *Chi-square* analysis of the coda phonetic-cue reading and coda-deletion variables was significant, χ^2 (1, N = 55) = 16.66, $p < 0.001$, indicating that the variables were related. The conditional probability of achieving coda-deletion success given mastery of coda phonetic-cue reading was 0.69, while the conditional probability of coda deletion without mastery of coda phonetic-cue reading was zero. With the elimination of the coda-deletion scores for the CD-discrepant children, the age findings, Figure 9 and 16, and Figure 17 together with the *Chi-square* results and the conditional probabilities indicate that coda phonetic-cue reading or alphabetic representation for codas precedes coda deletion, consistent with the third hypothesis.

Hypothesis Four

Part one of the fourth hypothesis proposes that children will be able to detect rime differences between spoken words before onset differences, and onset differences before coda differences. Part two of Hypothesis Four proposes that onset phonetic-cue reading precedes the ability to do the onset odd-man-out test. When onset odd-man-out scores are plotted on a scatterplot as a function of onset phonetic-cue reading, Hypothesis Four predicts a J-shaped relationship with onset odd-man-out scores increasing above some chance level only for children with well-developed onset phonetic-cue reading skills. Similar reasoning applies for the parallel coda tasks: only those children with coda phonetic-cue-reading ability will be able to do the coda odd-man-out test.

Figure 18, 19, and 20 shows that less than 50 % of the children tested achieved the 80 % mastery criterion on the rime odd-man-out, onset odd-man-out, and coda odd-man-out tests, respectively. Therefore, the age for when 20 % (11 out of 55 children) of the children achieved mastery of the rime (R-OMO), onset (O-OMO) or coda odd-man-out (C-OMO) tests were calculated. Figure 18 shows 40 % of the children had mastered R-OMO, with 20 % achieving mastery by 71 months of age (5:11 years). Figure 19 shows 38 % had mastered O-OMO, with 20 % achieving mastery by 78 months of age (6:6 years). Figure 20 shows 24 % had mastered C-OMO, with 20 % achieving mastery by 83 months of age (6:11 years). Figures 18, 19, and 20 show 20 % of children mastered R-OMO seven months earlier than O-OMO, which was mastered five months earlier than C-OMO.

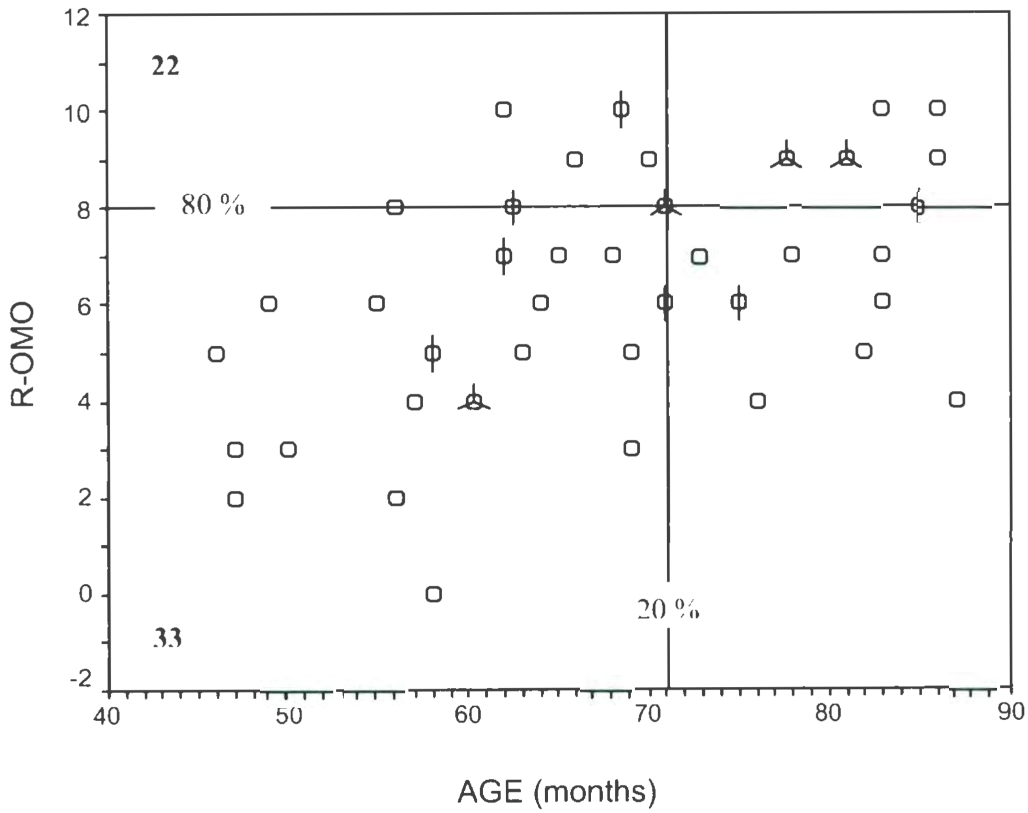

Figure 18. Rime Odd-Man-Out (R-OMO) scores plotted as a function of Age in months

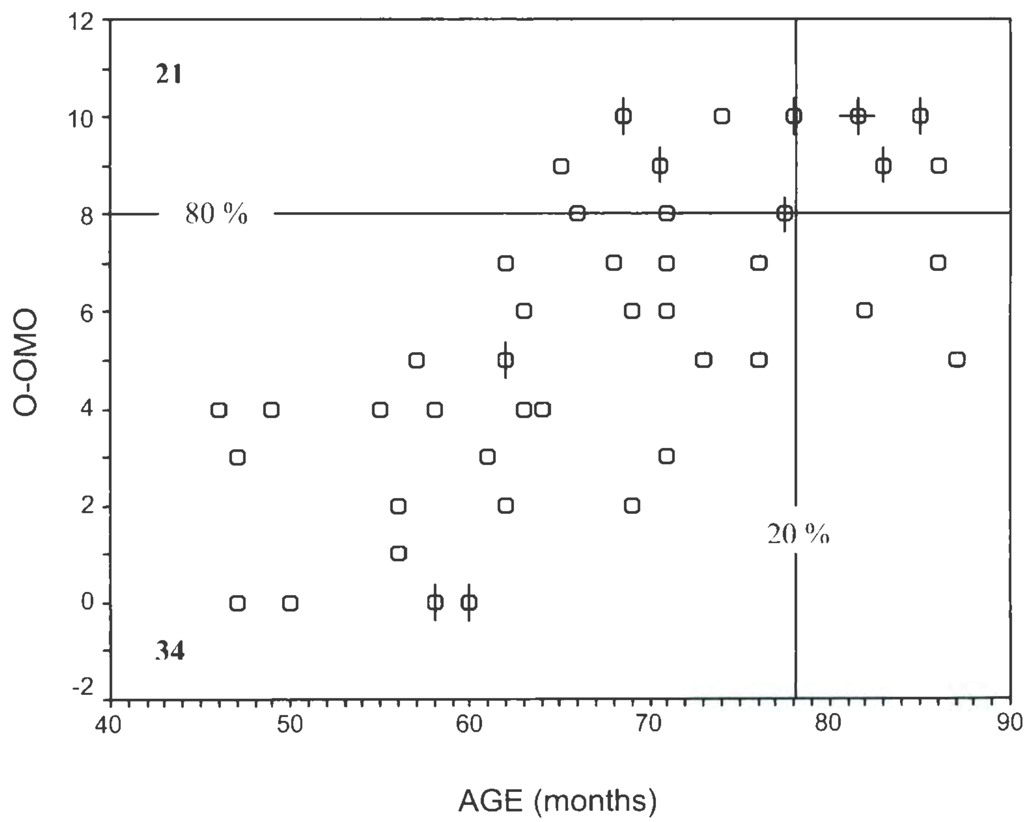

Figure 19. Onset Odd-Man-Out (O-OMO) scores plotted as a function of Age in months

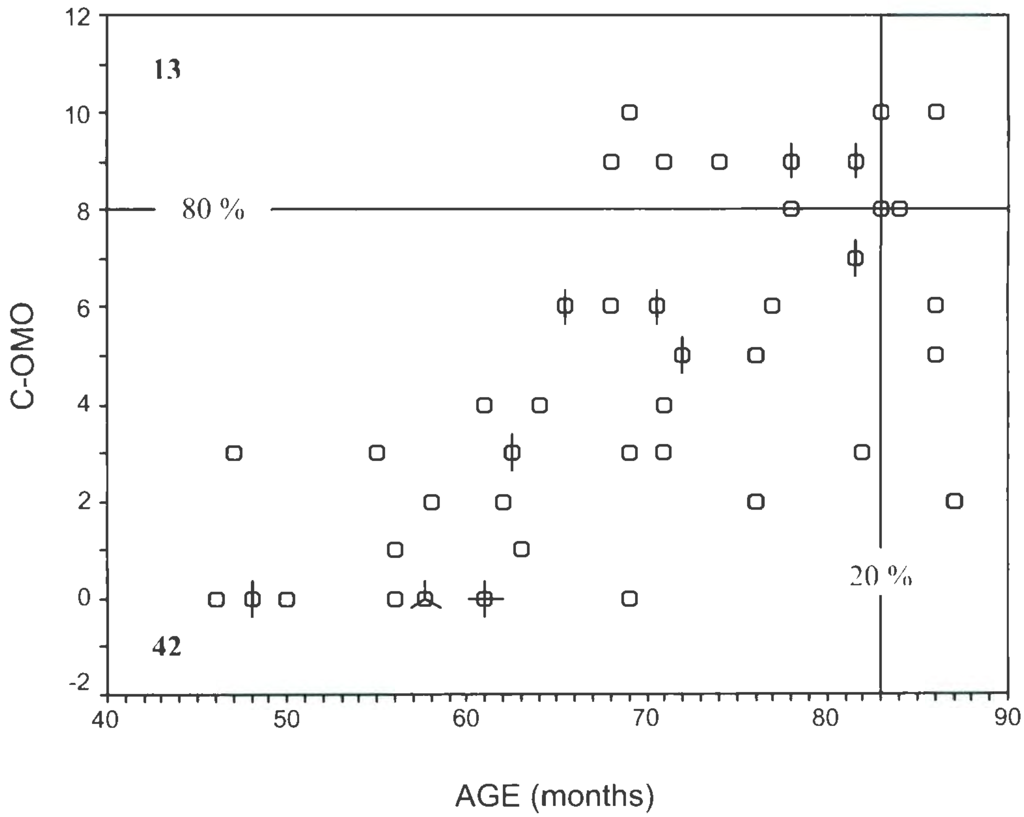

Figure 20. Coda Odd-Man-Out (C-OMO) scores plotted as a function of Age in months

A repeated-measures ANOVA was conducted to examine the relative difficulty of the rime, onset, and coda odd-man-out tests. The independent variable was grade (preschool, kindergarten, and first grade), and the dependent variable was linguistic complexity (rimes, onsets, and codas). Table 10 shows the means for each of the odd-man-out subtests at each grade. There was a significant main effect of linguistic level, F $(2, 104) = 36.99$, $p < 0.001$, a significant main effect of grade level, $F\,(2, 52) = 32.81$, $p < 0.001$, and a significant interaction, $F\,(4, 104) = 8.34$, $p < 0.001$. The rime-oddity test was easier than the onset- and coda-oddity tests, and onset oddity was easier than coda oddity.

Table 10.

Means and standard deviations (Std. Dev.) for Rime Oddity (R-OMO), Onset Oddity (O-OMO), and Coda Oddity (C-OMO) tests at the Preschool (PS), Kindergarten (K), and First Grade (FG) levels, *n* = total number of children in each grade

Tests	Grade	Mean	Std. Dev.	*n*
R-OMO	PS	4.95	2.44	20
	K	7.18	1.81	17
	FG	7.67	1.94	18
O-OMO	PS	2.65	2.18	20
	K	7.00	2.47	17
	FG	8.50	1.79	18
C-OMO	PS	1.10	1.41	20
	K	5.35	2.91	17
	FG	6.83	2.57	18

Because there was a significant interaction effect, three one-way repeated-measures ANOVAs were conducted, one at each grade level, along with *a priori Bonferroni* pair-wise comparisons between the means for each subtest. For the preschool group, there was a significant linguistic level effect, $F(2, 38) = 31.49$, $p < 0.001$. The three pair-wise comparisons were significant: rime oddity (R-OMO) was easier than onset oddity (O-OMO), $p < 0.005$, R-OMO was easier than coda oddity (C-OMO), $p < 0.001$, and O-OMO was easier than C-OMO, $p < 0.005$.

For the kindergarten group, there was a significant linguistic level effect, $F = (2, 32) = 8.39$, $p < 0.005$, and two pair-wise comparisons were significant; O-OMO and C-OMO, $p < .01$, and R-OMO and C-OMO, $p < .025$. The R-OMO and O-OMO tests did not differ, but both were easier than the C-OMO test. For the first-grade children, there was a significant linguistic level effect, $F(2, 34) = 10.74$, $p < 0.001$, and one of the three pair-wise comparisons was significant: O-OMO and C-OMO, $p < 0.001$. The only significant finding was that O-OMO was easier than C-OMO.

Twenty percent of the children mastered the rime-oddity test at 71 months, the onset oddity at 78 months, and the coda oddity five months later at 83 months, Figures 18, 19, and 20 respectively. The age data together with the results from the repeated-measures ANOVAs indicate that rime and onset differences are normally easier to detect than coda differences, with rime differences being easier than onset differences for very young children.

Part two of Hypothesis Four states that children need to have alphabetic representation for onsets before they can do the onset odd-man-out test. Figure 21 shows onset odd-man-out plotted as a function of onset phonetic-cue reading. Thirty-eight percent of the children had mastered both onset oddity and onset phonetic-cue reading (OPCR), while 27 % had mastered neither test. There were no children who met the mastery criterion for onset odd-man-out without OPCR mastery, but 35 % had reached the OPCR mastery criterion before the onset-odd-man-out mastery criterion. Mastery of onset phonetic-cue reading was achieved before mastery of onset odd-man-out, consistent with part two of Hypothesis Four.

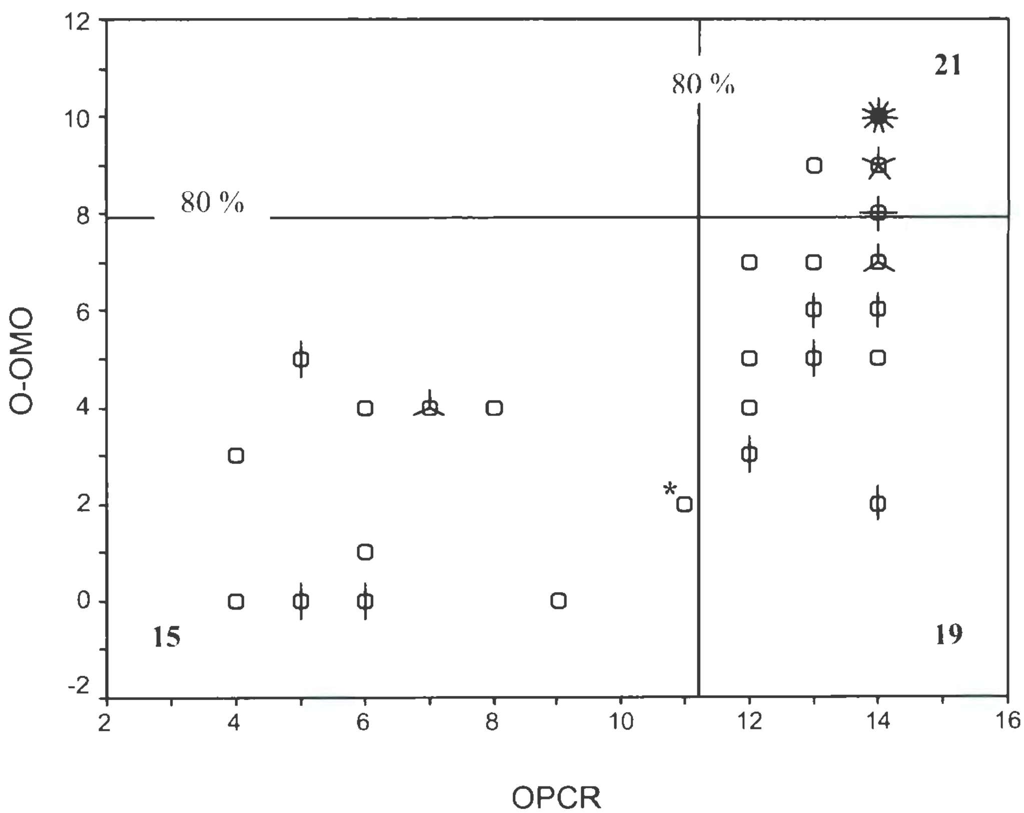

Figure 21. Onset Odd-Man-Out (O-OMO) scores plotted as a function of Onset Phonetic-Cue Reading (OPCR) scores. The asterisk or * represents the one child counted as having OPCR mastery

Figure 22 shows coda odd-man-out plotted as a function of coda phonetic-cue reading (CPCR). Twenty-four percent of the children had mastered both coda odd-man-out and CPCR, while 38 % had mastered neither test. There were no children who met the coda odd-man-out mastery criterion without CPCR mastery, but 38 % had reached the

CPCR mastery criterion without mastery of coda odd-man-out. Mastery of coda phonetic-cue reading was achieved before mastery of coda odd-man-out, consistent with part two of Hypothesis Four.

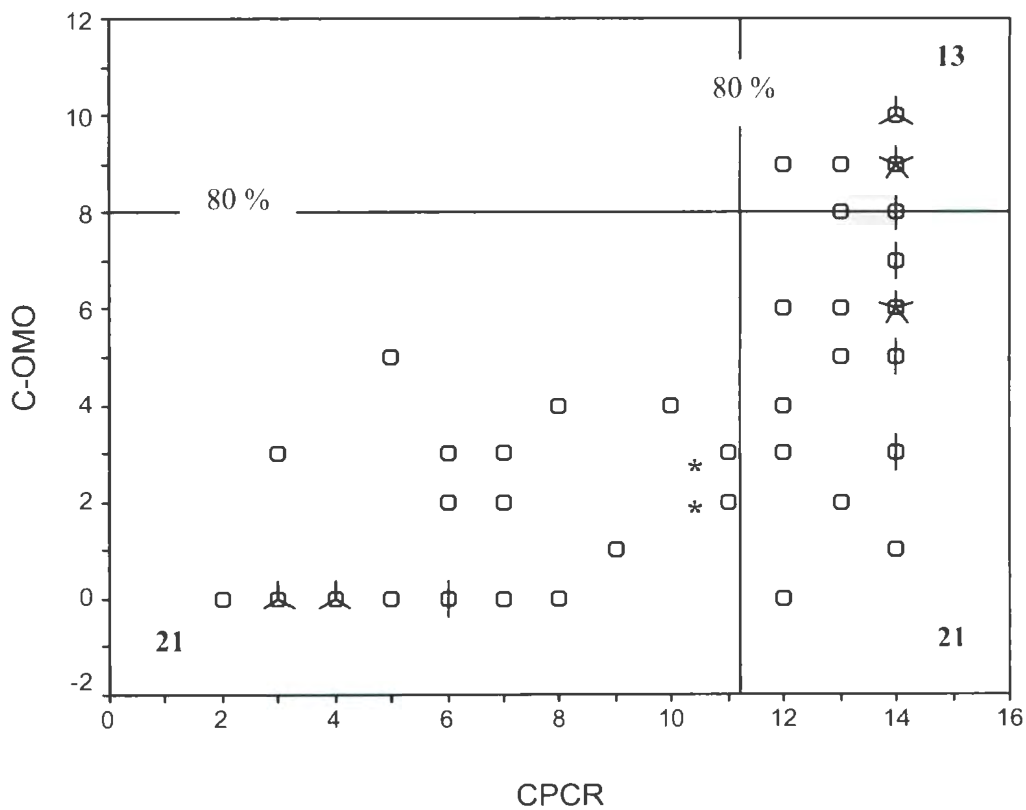

Figure 22. Coda Odd-Man-Out (C-OMO) scores plotted as a function of Coda Phonetic-Cue Reading (CPCR) scores. The asterisks or * represent the two children counted as having CPCR mastery

Forty percent, 38 %, and 24 % of the children achieved the mastery criterion on the rime-, onset-, and coda-oddity tests, Figures 18, 19, and 20 respectively. Also, 20 %

of the children mastered the rime-oddity test at 71 months, the onset oddity at 78 months, and the coda oddity five months later at 83 months, Figures 18, 19, and 20 respectively. These findings together with the results from the repeated-measures ANOVAs indicate that rime and onset differences are easier to detect than coda differences, with rime differences being easier to detect than onset differences for the youngest children, consistent with the first part of Hypothesis Four. Furthermore, children achieve mastery of onset phonetic-cue reading before mastery of onset odd-man-out, Figure 21, and mastery of coda phonetic-cue reading before mastery of coda odd-man-out, Figure 22. These findings suggest that alphabetic representation for onsets and codas may be prerequisites for onset and coda odd-man-out, respectively, and therefore supports the second part of Hypothesis Four.

Hypothesis Five

The fifth hypothesis proposed that letter-name knowledge, onset and coda identity, onset and coda phonetic-cue reading, and onset deletion are prerequisites for reading by analogy (RA). Although it is not expected to be a prerequisite, coda deletion may develop before reading by analogy as well.

The analyses conducted in Hypothesis One clearly show that the children acquired letter names before onset and coda identity and onset and coda phonetic-cue reading. Therefore, only the scatterplots or data between reading by analogy and onset and coda identity and onset and coda phonetic-cue reading are reported.

Figure 23 shows the number of RA target words a child read correctly, in the presence of analogy clue words, plotted as a function of age. Thirty-six percent of the children reached the 80 % mastery criterion for reading by analogy, with 20 % of the children achieving RA mastery by 81 months (6:9 years).

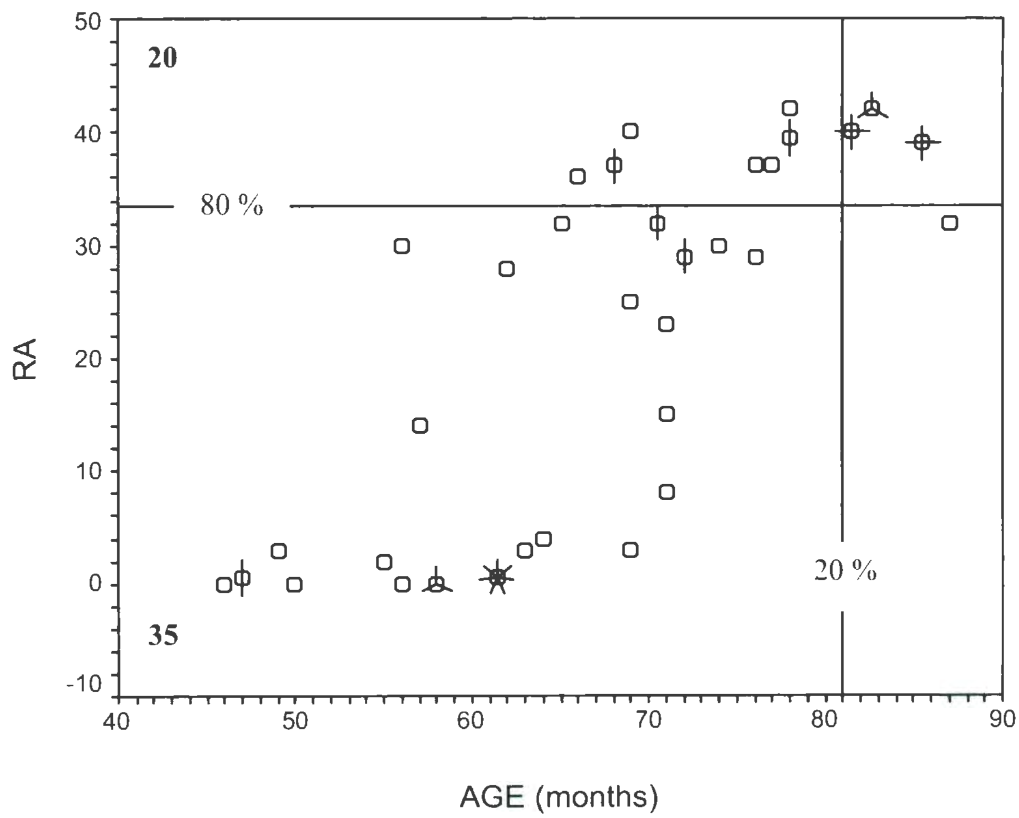

Figure 23. Reading by Analogy (RA) scores plotted as a function of Age in months

The scatterplot of reading-by-analogy scores as a function of onset identity scores is not shown, but the results were clear. Thirty-four percent of the children reached the 80 % mastery criterion for both onset identity and analogy, and 24 % mastered neither task. There were no children who mastered reading by analogy without onset identity, but 42 % mastered onset identity without reading by analogy. With one exception, analogy scores rose above zero or one only for children with onset identity scores of eight or higher. The data show that children mastered onset identity before they could read words by analogy.

The scatterplot of reading-by-analogy scores plotted as a function of coda identity (not shown) showed that 33 % of the children mastered both coda identity and reading by analogy, while 38 % mastered neither task. Two children (four percent) mastered reading by analogy before coda identity, but 14 children (25 %) mastered coda identity before reading by analogy. The data show that, with a couple of exceptions, children normally mastered coda identity before they could read words by analogy.

Figure 24 shows reading by analogy plotted as a function of onset phonetic-cue reading. Seventy-three percent of the children mastered onset phonetic-cue reading, and only 36 % mastered reading by analogy. A *z-test* comparing the proportions of children reaching the 80 % mastery criterion on both tests was found to be significant, $z = 4.21$, $p < 0.01$. Onset phonetic-cue reading was therefore easier to do than reading by analogy.

Figure 24 shows that 36 % of the children mastered both onset phonetic-cue reading and reading by analogy, and 27 % mastered neither task. None of the children mastered reading by analogy without onset phonetic-cue reading, but 36 % had mastered onset phonetic-cue reading without analogy. With one exception, reading-by-analogy scores rose above zero or one only for children with an onset phonetic-cue reading score of 12 (86 % success) or greater. Onset phonetic-cue reading preceded the ability to read words by analogy.

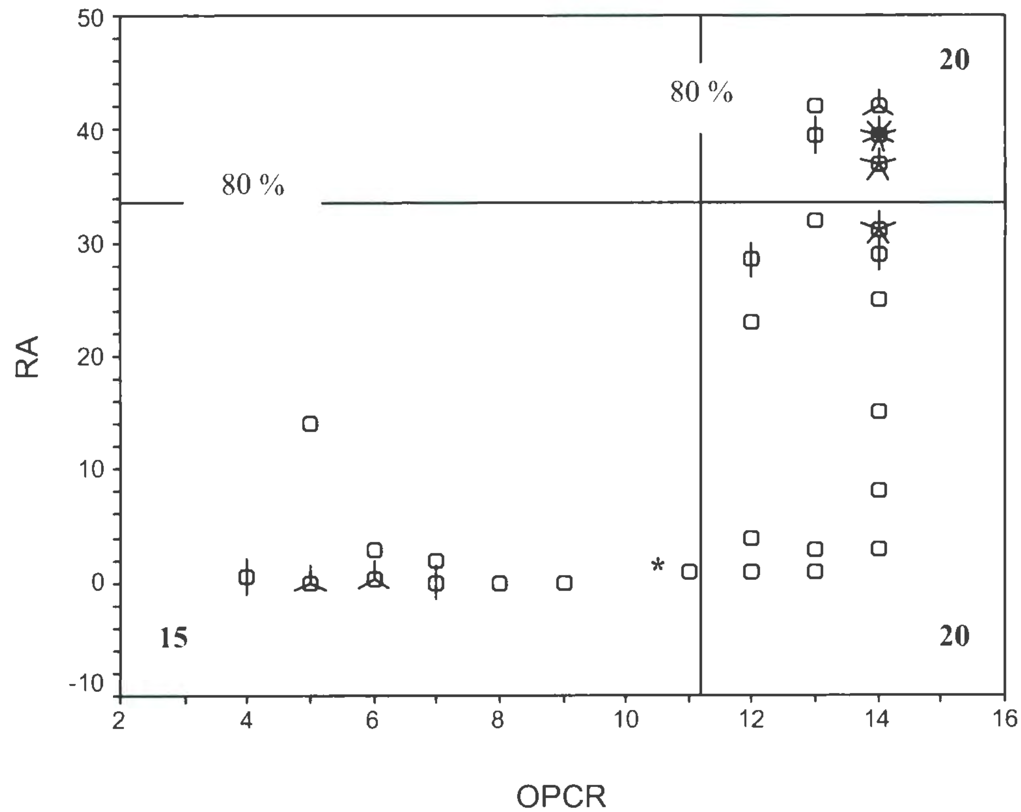

Figure 24. Reading by Analogy (RA) scores plotted as a function of Onset Phonetic-Cue Reading (OPCR) scores. The asterisk or * represents the one child counted as having OPCR mastery.

Figure 25 shows the relationship between reading by analogy and coda phonetic-cue reading (CPCR). Sixty-two percent of the children mastered coda phonetic-cue reading, and only 36 % mastered reading by analogy. A *z-test* comparing the proportions of children reaching the 80 % mastery criterion for reading by analogy and coda phonetic-cue reading was significant, $z = 2.83$, $p < 0.01$. The coda phonetic-cue reading test was therefore easier to do than the analogy test.

Figure 25 shows that 36 % of the children mastered coda phonetic-cue reading and reading by analogy, while 38 % mastered neither task. No child mastered reading by analogy without coda phonetic-cue reading, but 25 % mastered coda phonetic-cue reading without reading by analogy. Figure 25 shows that there was only one child with a CPCR score less than six and an analogy score above 20. Coda phonetic-cue reading preceded the ability to read words by analogy.

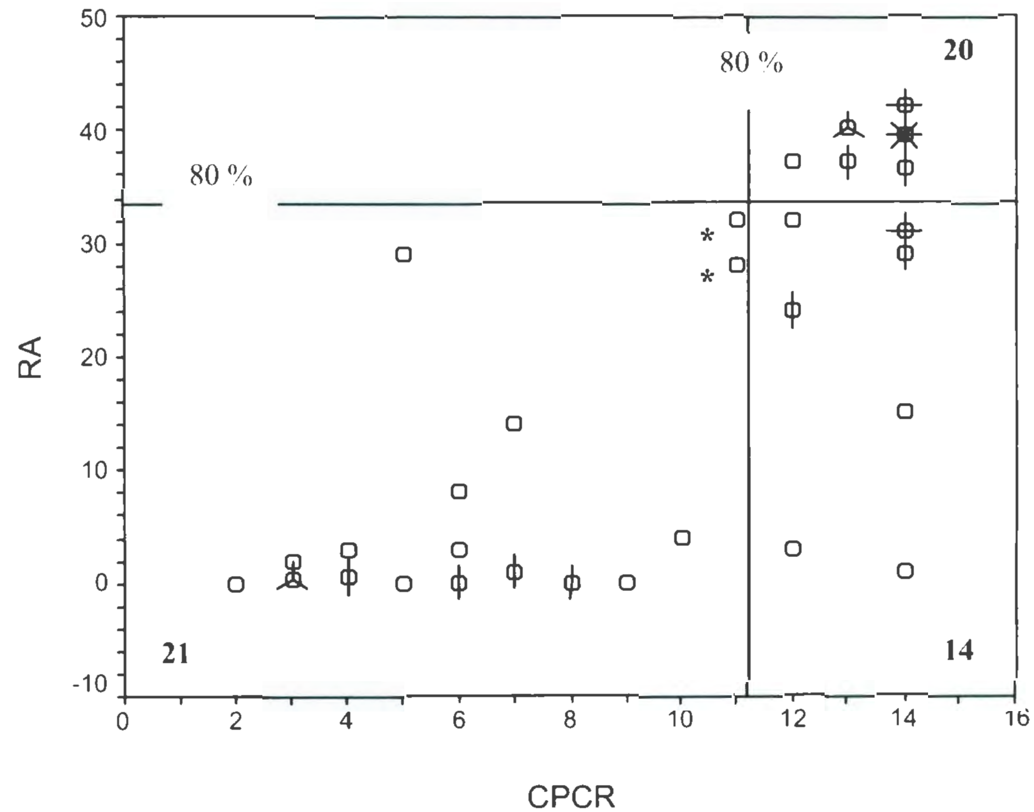

Figure 25. Reading by Analogy (RA) scores plotted as a function of Coda Phonetic-Cue Reading (CPCR) scores. The asterisks or * represents the two children counted as having CPCR mastery.

Forty-four percent of the children mastered onset deletion, Figure 14, and only 36 % mastered reading by analogy, Figure 23. A *z-test* comparing the proportions of children reaching the 80 % mastery criterion for analogy and the proportion of children reaching the 80 % criterion for onset deletion was not significant. This suggests the neither test was significantly easier than the other.

Figure 26 shows the relationship between reading by analogy and onset deletion. Thirty-five percent of the children mastered both reading by analogy and onset deletion, and 55 % mastered neither task. One child reached the 80 % mastery criterion for reading by analogy before reaching mastery of onset deletion, and five children (nine percent) mastered onset deletion without mastery of analogy. The *Pearson* correlation coefficient was calculated and was significant, $r = 0.862$, $p = 0.01$. Figure 26 together with the *z-test* and correlation results suggest that onset deletion and reading by analogy develop simultaneously, and there is no evidence to support the view that one develops before the other at the 80 % mastery criterion.

In contrast, Figure 26 shows that none of the children reached the 80 % mastery criterion in onset deletion without the ability to read at least 50 % of the target words (The 50 % horizontal line shown in Figure 26) in the reading-by-analogy test. However, 15 % (eight children) read 50 % or more of the target words in the reading-by-analogy test, but did not reach the 80 % criterion in onset deletion. Thus, some skill below the 80 % mastery criterion in reading by analogy develops before children achieve the 80 % mastery criterion in onset deletion.

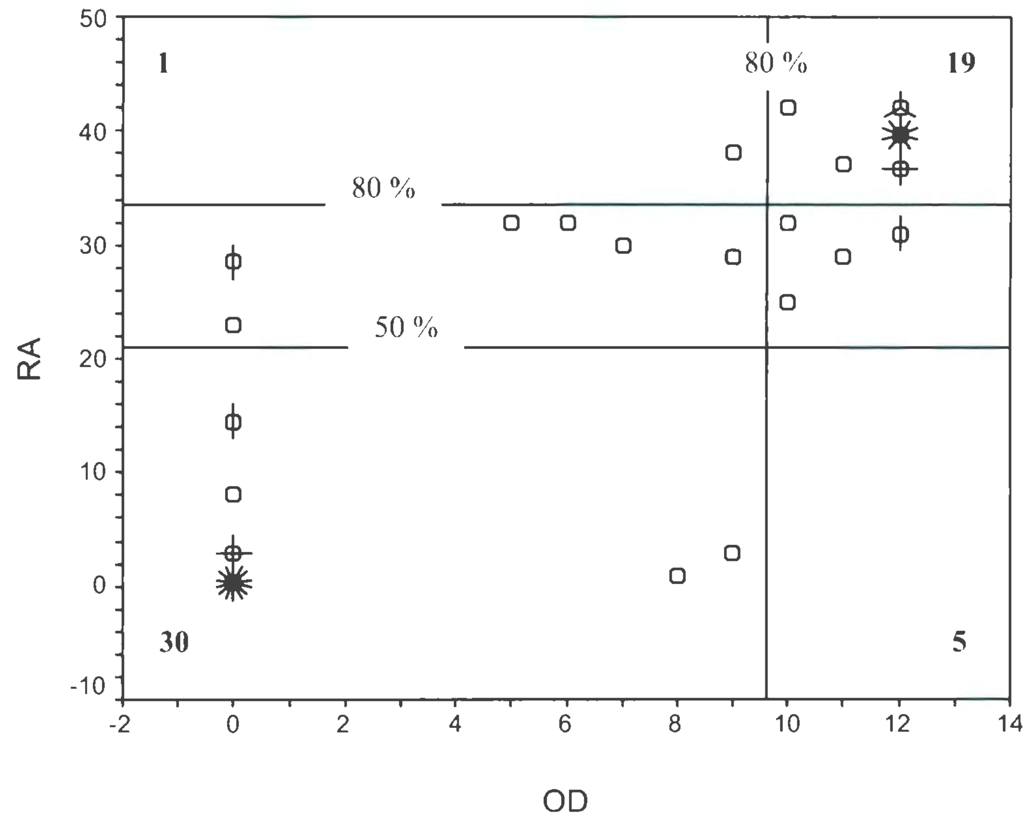

Figure 26. Reading by Analogy (RA) scores plotted as a function of Onset Deletion (OD) scores

Fifty-one percent of the children tested mastered coda deletion, Figure 16, while only 36 % mastered reading by analogy, Figure 23. A *z-test* comparing the proportions of children achieving the 80 % mastery criterion on both tests was not significant, indicating that reading by analogy and coda deletion were equally difficult.

Figure 27 shows the relationship between reading by analogy and coda deletion (Data from the 10 CD-discrepant children were not included in the scatterplot). Thirty-eight percent (17 out of 45 children) of the children reached the 80 % mastery criterion for both analogy and coda deletion, and 40 % (18 out of 45 children) mastered neither task. Three children (seven percent) mastered reading by analogy before coda deletion, and seven children (16 %) mastered coda deletion before reading by analogy.

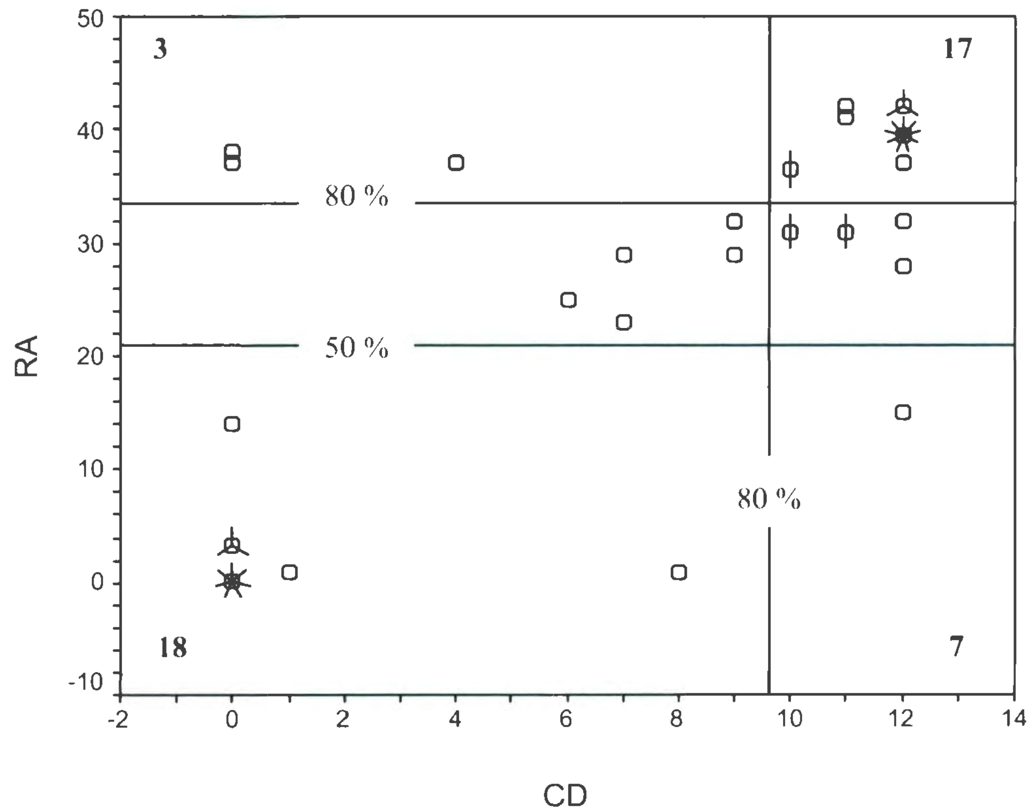

Figure 27. Reading by Analogy (RA) scores plotted as a function of Coda Deletion (CD) scores (10 CD-discrepant children not included), $N = 45$

The *Pearson* correlation coefficient was calculated and was significant, $r = 0.789$, $p = 0.01$. Figure 27 together with the *z-test* and correlation results suggest that coda deletion and reading by analogy develop simultaneously, and there is no evidence to support the view that one develops before the other at the 80 % mastery criterion.

In contrast, Figure 27 show that with the exception of one child, none of the children mastered coda deletion without the ability to read at least 50 % of the target words (50 % horizontal line shown in Figure 27) in the reading-by-analogy test. However, 15 % (eight children) read half or more of the target items on the reading-by-analogy test without mastery of coda deletion. Thus, some skill below the 80 % mastery criterion in reading by analogy develops before children achieve the 80 % mastery criterion in coda deletion.

In summary, letter-name knowledge, onset and coda identity, and onset and coda phonetic-cue reading preceded the ability to read words by analogy (with the clue word present) and therefore cannot be ruled out as prerequisites. These findings are consistent with Hypothesis Five. Also, Hypothesis Five proposed that onset and perhaps coda deletion might develop before reading by analogy. This proposal was not supported; it was found that some skill in the reading-by-analogy test used here developed before children achieved the ability to delete onsets or coda of words, Figure 26 and 27, respectively.

Hypothesis Six

The final hypothesis states that children require substantial reading and spelling ability before they can do the phoneme-counting test. Figure 28 shows word reading scores plotted as a function of the children's age. The horizontal lines distinguish between the three reading groups: Non-Readers (0 – 10 words read), Emergent Readers (10 - 35 words read), and Real Readers (greater than 35 words read). Forty-five percent (25 children) of the children were Non-Readers (NR), 29 % (16 children) were Emergent Readers (ER), and 25 % (14 children) were Real Readers (RR).

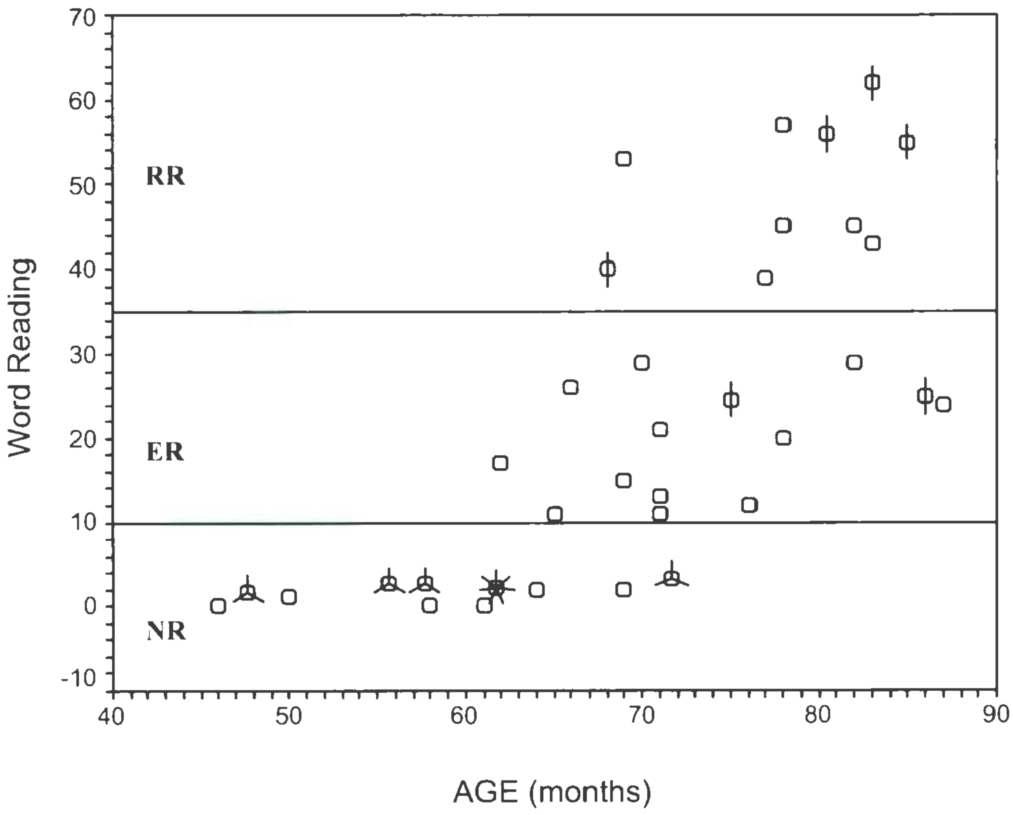

Figure 28. Word Reading scores for Non-Readers (NR), Emergent Readers (ER), and Real Readers (RR) plotted as a function of their Age in months.

Figure 28 shows that no child under the age of 60 months (5:0 years) was able to read any isolated words, but by 74 months of age (6:3 years), all children were able to read 10 or more isolated words. Children five years of age or older were able to read isolated words.

Figure 29 shows spelling scores plotted as a function of the children's age. The horizontal lines distinguish the three spelling groups: Non-Spellers (0 – 10 words), Emergent Spellers (10 - 35 words), and Real Spellers (greater than 35 words). Fifty-one percent (28 children) of the children were Non-Spellers (NS), 40 % (22 children) were Emergent Spellers (ES), and nine percent (five children) were Real Spellers (RS). Figure 29 shows that no child under the age of 62 months (5:2 years) was able to spell any words correctly, but by 73 months of age (6:2 years) all the children were able to spell 10 or more words correctly.

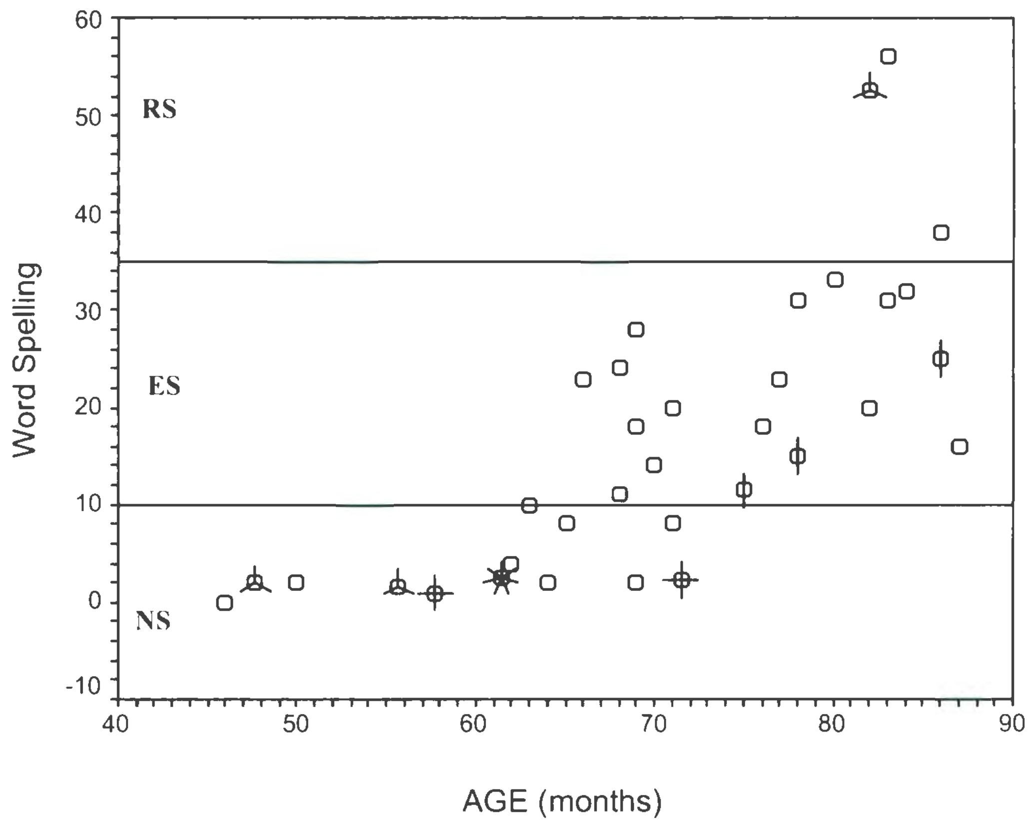

Figure 29. Word Spelling scores for Non-Spellers (NS), Emergent Spellers (ES), and Real Spellers (RS) plotted as a function of their Age in months.

Figure 30 shows phoneme-counting performance plotted as a function of age. Phoneme-counting scores had a bimodal distribution. The scores below the horizontal line shown on Figure 30 represent 56 % (31 children) of the children who either did not pass the phoneme-counting pretest or were given a zero score on the phoneme-counting experimental test. These children are called the Zero-Phoneme-Counting (Z-PC) group. The scores above the horizontal line represent 44 % (24 children) of the children who scored eight or higher in the phoneme-counting experimental test. These children are called the Non-Zero Phoneme-Counting (NZ-PC) group. Figure 30 shows that the performance of the Z-PC and NZ-PC children in the phoneme-counting test overlapped across all ages.

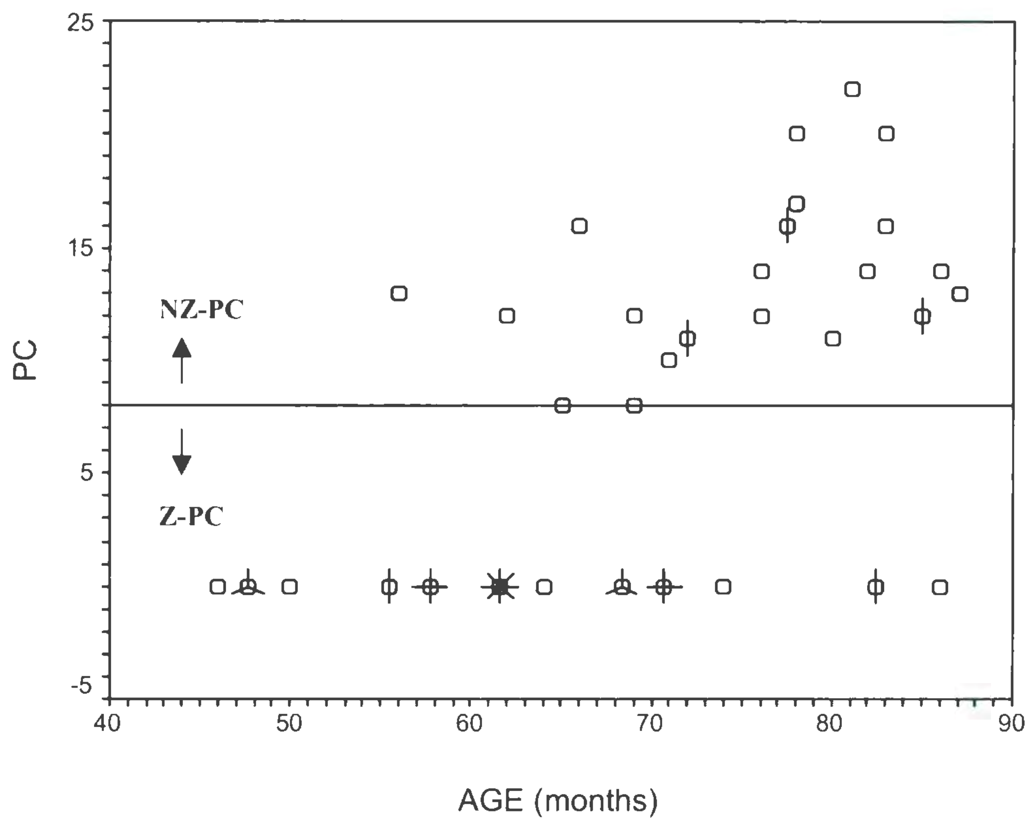

Figure 30. Phoneme-Counting (PC) scores for the 31 Zero Phoneme-Counting children (Z-PC) and the 24 Non-Zero Phoneme-Counting children (NZ-PC) plotted as a function of their Age in months.

Figure 31 shows phoneme-counting scores plotted as a function of the number of words read on the Real-Word Reading Test. The reading performance of the Z-PC and NZ-PC groups overlapped across all ages. Three non-readers were in the NZ-PC group, and five real-readers were in the Z-PC group.

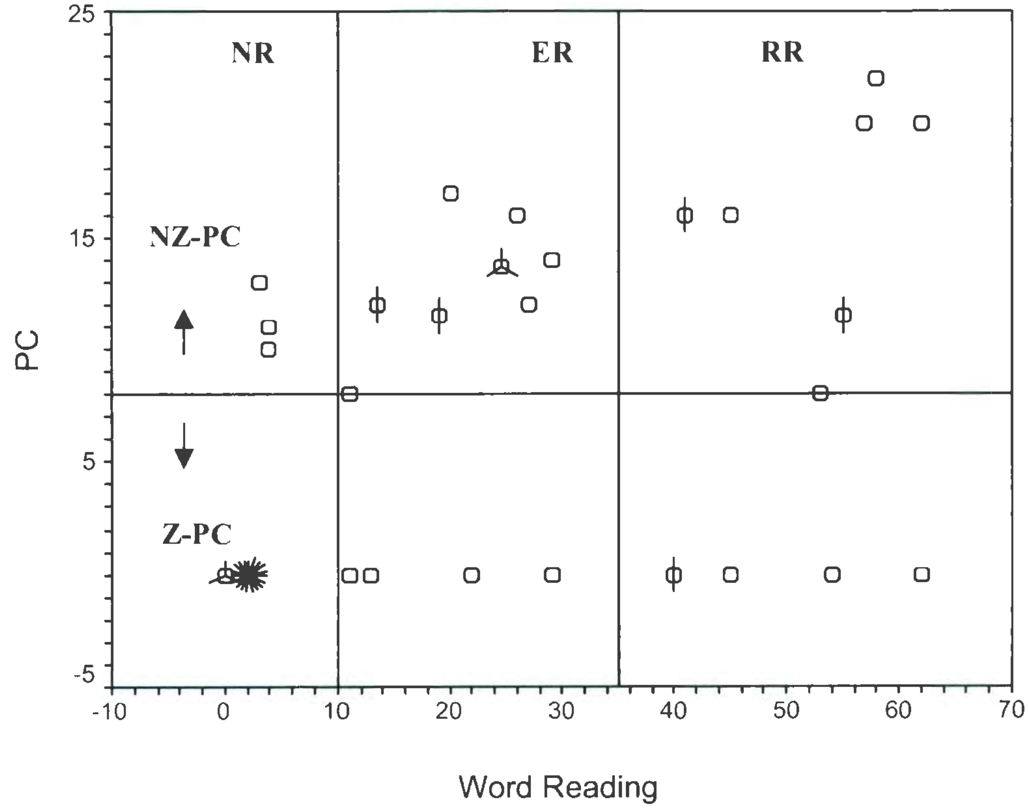

Figure 31. Phoneme counting (PC) scores for the 31 Zero Phoneme-Counting children (Z-PC) and the 24 Non-Zero Phoneme-Counting children (NZ-PC) plotted as a function of Word-Reading scores. The vertical lines distinguish between the three reading groups: Non-Readers (NR), Emergent Readers (ER), and Real Readers (RS)

The *Pearson* correlation between reading scores and phoneme-counting scores was significant, $r = 0.537$, $p < 0.01$. The *Pearson* correlations between age and phoneme counting and between age and reading were also significant, $r = 0.592$, $p < 0.01$, and $r = 0.746$, $p < 0.01$, respectively. A partial correlation between phoneme counting and reading, age controlled, was not significant, $pr = 0.179$. When the effects of age were controlled, the relationship between phoneme counting and reading was no longer significant.

Figure 32 shows phoneme-counting scores plotted as a function of spelling scores. Of the 31 Z-PC children, eight spelled more than 10 words, and three of these children could spell more than 35 words accurately. Of the 24 NZ-PC children, 19 spelled more than 10 words, and two of these children could spell more than 35 words accurately.

The *Pearson* correlation between spelling and phoneme-counting scores was significant, $r = 0.511$, $p < 0.01$. The *Pearson* correlation between age and spelling was also significant, $r = 0.743$, $p < 0.01$. However, the partial correlation between phoneme counting and spelling, age controlled, was not significant, $pr = 0.131$. Similar to the reading results, when the effects of age were controlled, the relationship between phoneme counting and spelling was no longer significant.

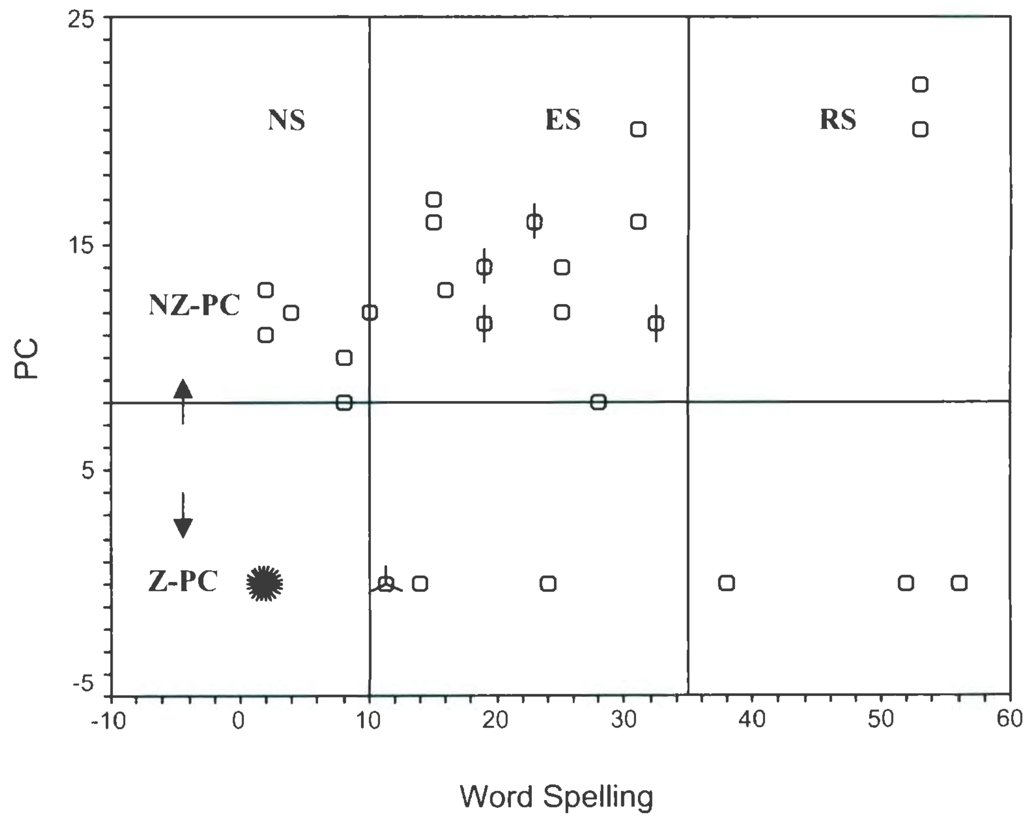

Figure 32. Phoneme counting (PC) scores for the 31 Zero Phoneme-Counting children (Z-PC) and the 24 Non-Zero Phoneme-Counting children (NZ-PC) plotted as a function of Word-Spelling scores. The vertical lines distinguish between the three spelling groups: Non-Spellers (NS), Emergent Spellers (ES), and Real Spellers (RS)

Hypothesis Six proposed that children require substantial reading and spelling ability before they are able to count phonemes in words; however, no evidence was found to support this hypothesis. Figure 28, 29, and 30 show that phoneme counting, reading and spelling all develop at approximately the same age. Figure 31 and 32 show that some children with very low phoneme-counting scores could read and spell well and some children with very high phoneme-counting scores read or spelled very few words. Correlation results show that without age as a factor, phoneme-counting ability is no longer related to reading and spelling. There is no evidence to indicate that reading and spelling are prerequisites for phoneme counting, or the reverse, that phoneme counting is a prerequisite for reading and spelling.

DISCUSSION

Two prominent phonologically based theories of reading were described in the introduction. According to the first theory, phoneme awareness is a critical prerequisite for initial reading development. In order to learn to read, a child must learn to segment words into their individual phonemes and learn associations between graphemes and phonemes (Adams, 1990; Bradley & Bryant, 1983; Ehri et al., 2001). According to the second theory, a child develops some level of literacy before phoneme awareness (Ehri, 1984; Goswami, 1986; Perfetti, et al. 1987). For example, Goswami (1986) proposed that children first learn to read words by analogy. Accordingly, a child can read an unknown word, such as *hat*, by comparing its spelling sequence to a known word, such as *cat*. If this is the case, young children do not need phoneme awareness to learn how to read and write. While this latter theory is believed to be correct, it is incomplete.

A third and more comprehensive theory, the ABC-GPC theory of initial reading was proposed. According to this theory, children first learn names for letters and also learn to recognize the different instances of phonemes in different contexts, a skill called phoneme identity. Once children know letter names and have phoneme identity, they are then able to learn grapheme-phoneme correspondences by attaching letters to the phonemes they represent. When children know grapheme-phoneme correspondences for simple onsets and codas they can begin to recognize words on the basis of this information, a process called phonetic-cue reading. As children begin to read, phoneme awareness, such as phoneme segmentation and blending skills, begins to emerge.

Six individual hypotheses relating to the ABC-GPC theory were tested. Hypothesis One proposed that letter-name knowledge and onset identity is prerequisite to onset phonetic-cue reading (OPCR), and letter-name knowledge and coda identity is prerequisite to coda phonetic-cue reading (CPCR). Hypothesis Two proposed that children acquire onset identity before coda identity, and onset phonetic-cue reading before coda phonetic-cue reading. Hypothesis Three proposed that onset phonetic-cue reading develops before onset deletion, and coda phonetic-cue reading before coda deletion. Part one of the fourth hypothesis proposed that children would detect rime differences between spoken words before onset differences, and onset differences before coda differences. Part two proposed that onset phonetic-cue reading precedes the ability to do onset odd-man-out, and coda phonetic-cue reading to do coda odd-man-out.

Hypothesis Five proposed that letter-name knowledge, onset and coda identity, and onset and coda phonetic-cue reading are prerequisites for the reading-by-analogy task given in the current study, and that onset and coda deletion skills may develop before children can reading by analogy. The final or sixth hypothesis states that children develop substantial reading and spelling ability before they can count the phonemes in spoken words. The following section presents a summary of the major findings relevant to each hypothesis, and on the basis of these findings, a developmental sequence for initial reading and phonological development is proposed. However, the data reported here is correlational, indicating that all conclusions of prerequisite relationships between test variables are speculative rather than confirmed.

Letter Names as the First Step Towards Literacy

By just over six years of age, half of the children had learned most letter names (21 out of 26 letters). This was four months earlier than the age by which 50 % of the children had attained onset identity, and nine months earlier than the age by which 50 % had attained coda identity. Similarly, half of the children had learned letter names four months earlier than the age by which 50 % of the children had acquired phonetic-cue reading for onsets, and nine months earlier than the age by which 50 % had acquired phonetic-cue reading for codas. Second, the scatterplots of onset and coda identity, and onset and coda phonetic-cue reading plotted as a function of letter-name knowledge indicated that letter-name knowledge was usually acquired before phoneme identity for onsets and codas, and before phonetic-cue reading for onsets and codas. These findings support the theory that preliterate children learn the names of letters before they are able to identify a particular phoneme when it occurs as the onset or coda of a word, and that children learn letter names before they begin to recognize words by using beginning or ending letter-sound cues, that is, before they gain alphabetic insight. Therefore, letter-name knowledge is a first step towards literacy.

Evidence that letter-name knowledge is a critical factor for reading achievement comes from the work of Share et al. (1984) who found that letter-name knowledge measured at school entry was the single, best predictor of reading success at the end of kindergarten. The findings from Bradley and Bryant's (1983) phoneme-training study have often been cited as evidence that learning to categorize common sounds in words not only predicts later reading success, but also may be a prerequisite. These researchers taught preliterate children to identify words containing the same onsets and rimes either with or without teaching letters to represent the simple onsets and rimes. Children who had both sound and letter instruction showed greater reading achievement than did the children who had only the sound instruction. While Bradley and Bryant considered the sound training to be the critical factor, retrospection together with the converging evidence obtained in the current study suggests that in fact the combination of sound training and associating letters with sounds was key.

In other phoneme-awareness training studies (Bradley & Bryant, 1983; Byrne & Fielding-Barnsley, 1990; Murray, 1998), children were taught letters at the end of their training to help them complete the post-training reading tasks. For example, in the study by Byrne and Fielding-Barnsley (1990), children were taught the letters that would be seen in the words on a post-training reading task. The authors concluded that the phoneme-identity training produced significant gains in alphabetic insight. However, an alternative interpretation is that the phoneme-awareness training combined with teaching letter-sound associations is the critical factor.

Ehri et al. (2001) analyzed the results from 56 phoneme-awareness training studies conducted over the last three decades. They found that phoneme awareness instruction that included the use of letter names increased young children's reading achievement more than did instruction that used sounds only. Ehri et al. (2001) explained that the concept of sounds or phonemes is an abstract idea that is difficult for many preschool children to grasp. Letters provide concrete, visual symbols that represent the abstract phonemes, thus making the concept of a phoneme easier to grasp. However, letters also provide a way of labeling phonemes and distinguishing them from one another.

One theory proposes that knowledge of letter names promotes sound awareness by drawing attention to the sounds in letter names and the sounds at the beginning or ending of words (Blaiklock, 2004; Treiman & Rodriguez, 1999). Because many letter names also share some of the phonetic features of phonemes, teaching children to identify or sort words by beginning or ending sounds together with letters to represent sounds may serve to actively boost or consolidate phoneme identity, as was proposed by Penney et al. (n.d.). In the current study, phoneme identity for onsets was acquired four months after children attained expert letter knowledge, suggesting that letter names might certainly have a role in boosting or consolidating onset identity rather than the reverse (Byrne & Fielding-Barnsley, 1990; Murray, 1998).

The results reported here support Blaiklock's (2004) findings that children learn to read a number of words before they are able to do phoneme deletion. When Blaiklock controlled for age and letter-name knowledge, many of the concurrent and predictive connections between phonological awareness and later reading became insignificant. Blaiklock (2004) suggested that many concurrent or predictive connections often found between phoneme awareness and reading ability were mediated by letter-name knowledge. Blaiklock concluded that letter-name knowledge is a critical factor for initial reading and phonological development, and knowledge of letter names and letter sounds encourages the development of phonological awareness rather than the reverse.

Carroll (2004) also found evidence that early letter-name knowledge encourages initial reading and is a significant predictor of later phoneme awareness. In her longitudinal study, Carroll found that preliterate children who knew at least one letter name could achieve some success on some phonological tasks eight months later. In her letter-training study, she found that only the children who acquired letter-name knowledge achieved success on the follow-up phoneme-awareness tasks. Carroll (2004) concluded that knowledge of letter-names and letter sounds is essential for learning to read, and facilitates phonological awareness rather than the reverse.

The findings reported here suggest that knowledge of letter names develops first, and may therefore be a prerequisite for the acquisition of phoneme identity for onsets and codas and phonetic-cue reading for onsets and codas. Although a causal relationship between letter-name knowledge and reading development cannot be ascertained, the current findings together with the converging evidence from important causal, correlation, and longitudinal studies (Blaiklock, 2004; Bradley & Bryant, 1983; Byrne & Fielding-Barnsley, 1990; Carroll, 2004; Ehri et al., 2001; Murray, 1998; Penney et al., n.d.; Treiman & Rodriguez, 1999; Share et al., 1984; Stahl & Murray, 1994; Wagner et al., 1997) support the hypothesis that letter-name knowledge is the first step towards literacy.

Onset and Coda Identity and Phonetic-Cue Reading: The Second Step Towards Literacy

By six and a half years of age, an age when children are typically in the first grade and receiving reading instruction, half of the children had developed both onset identity and onset phonetic-cue reading. The scatterplot of onset phonetic-cue reading plotted as a function of onset identity showed that with only one exception, onset identity was acquired just before onset phonetic-cue reading, as expected.

By nearly seven years of age or close to the end of first grade, half of the children had acquired both coda identity and coda phonetic-cue reading. The scatterplot between coda identity and coda phonetic-cue reading showed that the two tasks developed simultaneously. In contrast to the prediction, there was no evidence that coda identity developed before coda phonetic-cue reading. Therefore, a year after the acquisition of letter-name knowledge, and six months after the acquisition of onset identity and onset phonetic-cue reading, children attain coda identity, and coda phonetic-cue reading concurrently.

The findings reported here support Byrne and Fielding-Barnsley (1990) and Murray (1998) who both found evidence that phoneme identity combined with letter-name instruction results in greater gains in alphabetic insight than phoneme segmentation or blending combined with letter instruction. Therefore, phoneme identity and phonetic-cue reading, both for onsets and codas, appear to develop after children gain mastery of letter names.

While phoneme identity and phonetic-cue reading (for both onsets and codas) were acquired simultaneously rather than one before the other, more than 70 % of the children reached the mastery criterion on both onset identity and onset phonetic-cue reading, and less than 62 % had mastered coda identity and coda phonetic-cue reading. The scatterplot of onset and coda identity, and the scatterplot of onset and coda phonetic-cue reading showed, respectively, that children achieved onset-identity skills before coda-identity skills, and onset phonetic-cue-reading ability before coda phonetic-cue-reading ability, as predicted in Hypothesis Two. The children found the onset identity task easier to do than the coda identity task, at each grade level. Similarly, the onset phonetic-cue reading task was easier than the coda phonetic-cue reading task, at each grade level. This suggests that both phoneme identity and phonetic-cue reading for onsets are acquired first, before codas.

The findings reported here support Penney's et al. (n.d.) speculation that phoneme identity and phonetic-cue reading is acquired for the beginning sounds in words before the ending sounds, but they contradict Byrne and Fielding-Barnsley (1990) finding that children could learn phoneme identity in either the onset or coda position equally well. However, Byrne and Fielding-Barnsley's children consistently (but insignificantly) achieved higher scores on the onset identity task than on the coda identity task.

The finding that processing of onsets is superior to that for codas supports Treiman's (1985) hierarchal view of children's phonological development. Treiman (1985) found that preliterate children analyze syllables into onsets and rimes more naturally and easily than into phonemes. Onsets in words are more accessible to young children than are codas, and in terms of phonological development, preliterate children learn to identify onsets of words first. The converging evidence together with the current findings supports the theory that simple onsets of words are easier or more accessible to young children than simple codas. Children first acquire both onset identity and onset grapheme-phoneme correspondences (onset phonetic-cue reading) around six years of age as the second step towards literacy. Some time later, they acquire phoneme identity and grapheme-phoneme correspondences for codas.

The findings reported here also support the theory that young children can recognize words using a phonological decoding strategy in addition to, or after visual-cue reading, as proposed by Ehri and Wilce (1985). Ehri and Wilce speculated that preliterate children transition from visual cue-reading to phonetic-cue reading once they learn letter-sound associations. Recall that visual-cue reading does not involve the use of letter-sound associations, and is therefore not a phonological decoding strategy. Instead, children recall word pronunciations from salient visual-cues associated with printed words, such as STOP on a red octagon traffic signal. Once the associated visual-cues are gone the child can no longer read the words (Gough, 1993). Although phonetic-cue reading ability does not guarantee that a child can produce or read words, it appears to be the first stage towards building an accurate and independent word decoding or true reading ability (Adams, 1990; Tunmer & Hoover, 1993).

In conclusion, as a first step in initial reading acquisition, children learn letter names, and then several months later, as a second step, children acquire phoneme identity and grapheme-phoneme correspondences needed for phonetic-cue reading. Phoneme identity and phonetic-cue reading are acquired for onsets first, and much later for codas.

Phoneme Awareness and Reading Development

Onset and coda deletion

After children have acquired grapheme-phoneme correspondences for onsets, they acquire onset-deletion ability. None of the children could delete onsets before they had mastered onset phonetic-cue reading and onset identity, but many children achieved mastery of onset phonetic-cue reading and onset identity without onset deletion. These findings are inconsistent with Byrne and Fielding-Barnsley's (1990) view that children with phoneme identity will have phoneme segmentation skills. Instead, onset segmentation develops after a child has alphabetic representation for onsets, indicated by onset phonetic-cue reading performance.

The results for coda phonetic-cue reading and coda deletion were somewhat anomalous. There were 10 children, the CD-discrepant children, who did not master coda phonetic-cue reading before coda deletion. However, observations of the children's behaviour during the coda-deletion task and from an examination their orthographic and phonological skills suggested that the CD-discrepant children did not have true coda-deletion ability. The proportion of children showing odd behaviours, such as holding the breath, silently mouthing codas, or producing shortened vowels, was higher in the CD-discrepant group than in the CD-normal group. This suggested, in contrast to the other 45 children (CD-normal group), that the CD-discrepant children were not using a phonologically based strategy to do coda deletion.

Second, the CD-discrepant children had very weak coda awareness and poor onset awareness. None of the CD-discrepant children had attained mastery of coda identity, coda phonetic-cue reading, coda odd-man-out, or onset deletion, and less than four percent had acquired mastery of onset phonetic-cue reading and onset odd-man-out. In contrast, the majority (70 % to 80 %) of CD-normal children showing the predicted sequence of coda deletion development had attained mastery of letter-name knowledge, onset and coda identity, onset and coda phonetic-cue reading, and most (50 % to 30 %) had acquired onset deletion and onset and coda odd-man-out. The CD-discrepant children were clearly lagging behind the CD-normal children in terms of their orthographic and phonological processing abilities, and their coda-deletion ability is inconsistent with their performance on the coda identity, phonetic-cue reading, and odd-man-out tasks. This suggested that the CD-discrepant children were somehow able to inhibit the pronunciation of codas rather than being truly able to delete them.

Stahl and Murray (1994) speculated that some of the children in their study had a Southern dialect such that they tended to drop final consonants. The authors concluded that they were unsure whether the children were deleting the codas deliberately or simply repeating the word as it sounds in their dialect. Stahl and Murray's suspicion regarding the authenticity of the coda deletion test coincides with the uncertainties reported here. It is not clear whether the CD-discrepant children were truly able to produce the target words, or not, or if for other reasons, such as dialect or interrupting the speech stream, they could inhibit coda pronunciation. It is also possible that the children had produced glottal stops for the codas (C. Dyck, personal communication, July 3, 2007). Further research to determine exactly what children do in the coda-deletion test is necessary if coda deletion is to be considered a valid test of phoneme awareness. Researchers who use coda-deletion tasks should interpret them with caution.

When the data of the CD-discrepant children were removed, the expected pattern of development emerged. None of the children could delete codas before they mastered coda phonetic-cue reading, but many children achieved mastery of coda phonetic-cue reading without coda deletion. However, even with the CD-discrepant children included, the weight of evidence supports the prediction that coda phonetic-cue reading develops before coda deletion. Therefore, after children acquire grapheme-phoneme correspondences for codas, as indicated by their coda phonetic-cue reading performance, the next step seems to be coda deletion. These results support Stahl and Murray's (1994) conclusion that children develop vowel-coda segmentation after they learn to read. Generally, coda segmentation develops after a child has alphabetic representation for codas, indicated by coda phonetic-cue reading performance.

Odd-man-out for rimes, onsets and codas

In an oddity test, children detect rime differences in words before onset differences, and onset differences before coda differences. Twenty percent of the children acquired rime oddity by about 6.0 years of age, onset oddity by 6.5 years of age, and coda oddity by approximately 7.0 years of age. The preschool and kindergarten children found the rime task easier to do than the onset task, which in turn was easier than the coda task. For the older, first-grade children, the rime and onset tasks were both easier to do than the coda task. Overall, while 40 percent of the children achieved success on the rime and onset tasks, only 24 percent succeeded on the coda task. The outcome on an oddity task is strongly influenced by the linguistic status of the distinguishing sounds.

The scatterplots of onset and coda odd-man-out as a function of onset and coda phonetic-cue reading, respectively, showed that a child's ability to do the onset and coda odd-man-out tests did not develop above chance level unless he or she had mastered onset and coda phonetic-cue-reading, respectively. However, a large number of children attained the mastery criterion on onset and coda phonetic-cue reading before they could do onset- and coda-odd-man-out, respectively. Therefore, alphabetic representations for onsets developed before the ability to do the onset-oddity task, and alphabetic representations for codas developed before the ability to do the coda-oddity task. This suggests that the grapheme-phoneme correspondences for onsets are prerequisites for onset-odd-man-out success, and grapheme-phoneme correspondences for codas are prerequisites for coda-odd-man-out success.

The findings reported here support Bradley and Bryant (1983) who found that instruction in the oddity task (sound categorization), which included teaching letters to represent sounds, resulted in greater reading achievement than the same sound instruction without letters. In light of the current findings, this is interpreted to mean that only the children in the combined letter-sound group had learned the prerequisite letter-sound associations for onsets and codas and had gained alphabetic insight, which is necessary to achieve success on the oddity task.

Reading by analogy

Reading by analogy for simple words was acquired early in life, between 5.0 and 6.5 years of age, but only for children with firm alphabetic representation for onsets and usually codas. The scatterplot analyses from Hypothesis One show that letter names developed before phoneme identity and phonetic-cue reading for onsets and codas. Then the scatterplot analyses of Hypothesis Five showed that onset and coda identity and onset and coda phonetic-cue reading developed before reading by analogy. The findings reported here suggest that letter names, onset and coda identity and onset and coda phonetic-cue reading are prerequisites for reading by analogy, as predicted in Hypothesis Five.

The current findings support Penney et al. (n.d.) who found that knowledge of letter-sound associations was necessary for knowing how to read by analogy. The findings also partially support Goswami's (1986) and Goswami and Bryant's (1990) early reading theory that preliterate children first learn to read using reading by analogy. However, to be considered a more complete theory, the acquisition of letter names, phoneme identity and letter-sound associations for onsets and codas needs to be incorporated as critical prerequisites for learning to read words by analogy. In conclusion, converging evidence from Penney et al. with the current findings suggests that good orthographic skills or knowledge of letter-sound associations, as demonstrated by the child's ability to do phonetic-cue reading, is prerequisite for reading by analogy.

Hypothesis Five proposed that children might also develop onset-deletion skills before they achieve reading by analogy (RA) skills. The RA task in the current study was designed as a rhyming task, but children may still require onset-deletion skills to remove the onset from the target word. However, it was found that the children could read at least 50 % of the RA test items before they mastered onset deletion, but only the children who mastered onset deletion were able to achieve RA mastery. Some skill in reading by analogy develops before complete mastery (80 %) of onset deletion. This is not consistent with Hypothesis Five.

Coda deletion was not expected to be a prerequisite for reading by analogy. It was thought that to do the reading-by-analogy test, a child must know only how to separate and isolate the onset of the target word and then blend it with the clue word or rime given. Therefore, in addition to letter names, onset and coda identity and onset and coda phonetic-cue reading, an important prerequisite for doing the reading-by-analogy task would be onset-rime segmentation, or onset deletion rather than vowel-coda separation, or coda deletion. However, the results for coda deletion (excluding the data of the 10 CD-discrepant children) and reading by analogy were similar to those for onset deletion and reading by analogy. Although there were a few children with mastery of RA before mastery of coda deletion, in general, children can read some words by analogy without full mastery (80 %) of coda deletion, as expected.

The findings reported here partially support Ehri and Robbins (1992) findings that children need decoding knowledge, the ability to separate words into smaller units, and the ability to blend a part of known words with parts of unknown words to read by analogy. The current findings support the idea that while letter-names, onset and coda identity and letter-sound associations for onsets and codas certainly precede the ability to read words by analogy, it seems children do not need to know how to delete onsets, and usually codas of words before they can do items on the reading-by-analogy test designed here.

The nature of the relationship between phonological processing skills and the reading-by-analogy task used here is therefore clarified. First, children acquire alphabetic insight before they begin to read by analogy. In particular, knowledge of grapheme-phoneme correspondences for onsets and codas is required. However, acquisition of some skill in reading by analogy, at least for the reading-by-analogy test utilized here, does not require onset- or coda-deletion ability.

Phoneme counting and reading and spelling

When a child can read words independently, he or she can learn to count phonemes in words. To do the phoneme-counting test designed here, a child must know that a spoken word is composed of individual sounds that are strung together, and that these sounds can be separated from each other. In the current study, reading and phoneme counting or segmentation developed more or less together. Nine children learned to read 10 or more words without the ability to count phonemes, and three children could not read any words, but they could count phonemes. Although this means that reading and spelling did not develop before phoneme counting, it also means that phoneme counting did not develop before reading and spelling. Additionally, when the age of the children was statistically controlled, the correlation between reading and phoneme counting was no longer significant. While these findings do not show that reading develops first, they do suggest that phoneme counting, a measure of children's phoneme awareness is not a likely prerequisite for reading.

In conclusion, the findings reported here do not support the hypothesis that reading and spelling develop before phoneme counting, but they do show that phoneme counting does not necessarily develop before reading and spelling. Although reading and spelling develop more or less at the same time as phoneme counting, when the effect of age is removed, the relationship between reading and spelling and phoneme counting is no longer significant. This supports the view that an awareness of individual phonemes is not a prerequisite for reading or spelling acquisition.

Perfetti et al. (1987) provided evidence that children's ability to do phoneme-awareness tasks progressed when their reading ability increased. Perfetti et al. concluded that reading and phoneme awareness develop in a reciprocal relationship, rather than one emerging before the other. However, the findings reported here add two critical pieces of information: children can achieve quite high reading and spelling ability without any awareness of individual phonemes in spoken words, and when the effect of age is statistically removed, the relationship between phoneme counting and reading and spelling is not significant. An awareness of phonemes, as measured by the phoneme-counting task designed here, is not a prerequisite for initial reading acquisition; instead, this level of phoneme awareness develops with age, as does reading and spelling ability.

Summary

The primary purpose of the current investigation was to examine the developmental sequence of children's initial reading and phonological processing skills.

Six individual Hypotheses were tested. Letter-name knowledge develops first, followed a few months later by onset identity and onset phonetic-cue reading, which in turn, are followed a few months later by coda identity and coda phonetic-cue reading. Children acquire grapheme-phoneme correspondences for onsets before the ability to delete onsets of words, and they acquire grapheme-phoneme correspondences for codas before the ability to delete codas.

Reading by analogy also develops after both onset phonetic-cue reading and coda phonetic-cue reading are well established. In contrast, the children did not need onset-deletion ability before they could read some words by analogy below the 80 % mastery criterion. Similarly, the children did not master coda deletion before they could read some words by analogy. Although this supports the expectation that coda deletion is not a prerequisite for reading some words by analogy, only the children who mastered coda deletion were able to reach the mastery criterion for reading by analogy. The findings suggest that alphabetic representation for onsets, and possibly for codas are sufficient to begin reading words by analogy.

While reading and spelling ability does not appear to develop before phoneme-counting ability, phoneme counting does not develop before reading and spelling either. Although strong correlations between phoneme counting and reading and spelling were found, once the effects of age were statistically removed the phoneme counting and reading and spelling variables were no longer significantly related. Reading and spelling, and an awareness of phonemes both increase with age, and are significantly correlated. However, either skill could develop without the other. Thus, the findings do not support the theory that there is a causal relationship between phoneme awareness (phoneme counting or segmentation ability) and reading and spelling ability.

IMPLICATIONS

The findings reported here contribute to a comprehensive theory, the ABC-GPC theory of children's initial reading acquisition. The findings show that one skill, such as letter-name knowledge, develops before another skill, such as phonetic-cue reading, with very few exceptions. Because each skill is mastered before the next is acquired, a clear sequence of early reading and phonological development can be generated.

Early reading in the form of phonetic-cue reading, a rudimentary, phonologically-based reading strategy, develops once children learn letter names, followed by phoneme identity and letter-sound associations for onsets and codas. The two latter skills develop first for onsets and then later for codas. Firm alphabetic representation in the form of letter-sound associations appears to be a prerequisite for the acquisition of many phoneme-awareness skills, such as onset and coda deletion, odd man out, and reading-by-analogy, and phoneme-counting ability. A true awareness of phonemes does not precede independent reading or spelling, and is therefore not a likely prerequisite for learning to read, or spell. This sequence of initial reading acquisition can be and should be verified through further experimental research.

A unique contribution of the current study is the finding that phoneme awareness, as measured by the phoneme-counting task designed here, does not emerge before early reading or spelling development. Phoneme awareness is not a skill that is easily taught to preliterate children, and some, but not all young children seem to develop this skill as their reading and spelling ability increase. Consequently, the findings reported here do not support the view that teaching individual sounds or phoneme awareness to beginning readers will facilitate reading acquisition.

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