KNOWLEDGE AND USE OF VOWEL LETTER-SOUND RELATIONS BY BEGINNERS TO READ AND SPELL WORDS

by

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Abstract

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The objective of this study was to explore beginners' knowledge of short vowel letter-sounds and its relationship to children's word reading and spelling abilities. Twenty-four five and six-year-old children completed several tasks assessing knowledge of vowel letter-sound and sound-letter associations, word and pseudoword reading, and spelling. Performance on the vowel tasks was used to separate children into high and low vowel knowledge groups. All children learned to read two sets of simplified spelling words to criterion: one set with vowels, and the other set without. It was expected that children with high vowel knowledge would learn words containing vowels faster and with more ease than words without vowels, whereas children with less vowel knowledge would learn words without vowel letters with more ease.

Findings suggested that order of acquisition of short vowels reflects not only teaching, but also the distinctiveness of articulatory features among the vowels. Children's mistakes in short vowel sound production showed usage of a letter name strategy. Short vowel knowledge was significantly correlated with reading and spelling performance. Children with high short vowel letter-sound knowledge learned significantly more words and in fewer trials than children possessing low short vowel letter-sound knowledge. Contrary to our expectations, however, vowel letters in the target words did not affect learning. Individual analysis of children's performance revealed that children who reached criterion in the learning task in fewer than ten trials had achieved mastery or near mastery to at least three vowel letter-sounds.

Findings are discussed in terms of the role of automatization of letter-sound knowledge in word recognition theories, and the role of decoding in helping children acquire more vowel knowledge. Acquisition of the idea of a vowel system to represent letters and sounds may be particularly helpful in enhancing word learning and spelling.

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Knowledge and Use of Vowel Letter-Sound Relations by Beginners to Read and Spell Words

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Chapter 1

Introduction

Does knowing the vowel spelling system help children learn to read and spell words better? Does learning to read and spell words teach children about how vowels are written? Regardless of the answer, both questions imply that knowing the vowel writing system is important for learning to read and spell words in English. All words in English contain vowel sounds in their pronunciations, and most of those vowel sounds are represented in spelling. However, it turns out that representation of vowel sounds is variable and not very consistent in English. Variability and lack of consistency make mastering the rules and contexts that govern the vowel spelling system a difficult but important task in learning to read and spell English.

Some researchers postulate that vowels are less significant than consonants for the process of reading words (Hillerich, 1967; Adams, 1990; New, Araújo & Nazzi, 2008). Others propose that vowels and consonants not only are processed differently in the brain (Caramazza, Chialant, Capasso & Miceli, 2000; Carreiras, Gillon-Dowens, Vergara & Perea, 2008, Carreiras, Duñabeitia & Molinaro, 2009), but at the onset of word recognition in the brain, delays in the speed of arrival of consonant information are more disruptive to reading than delays in the speed of arrival of vowel information (Lee, Rayner & Pollatsek, 2001). According to Berent and Perfetti (1995), there are two cycles of assembly of information that differ in their speed and automaticity: consonants are automatically assembled first, whereas vowels are added by a slower and more controlled process, although both sources of information may be integrated before the eye fixates the target word to be read (Ashby, Treiman, Kessler & Rayner, 2006).

Because there are only 6 letters (A, E, I, O, U, Y) that singly or in combination are used to represent vowels, and because there are constraints limiting how vowel spellings are pronounced in specific consonant contexts, readers can reasonably guess how to read any word without paying attention to vowels if they have additional contextual constraints to aid their guess. For example, if you are reading about the importance of vowels and consonants, and you see the sentence:

"Vwls r mr dffclt t lrn thn cnsnnts…",

You could make an educated guess that the "vwls" represents vowels, and that "dffclt" would represent difficult, even if you were not able to guess the whole sentence, or had no idea where the vowel letters should be inserted. Miller and Friedman (1957, cit. in Adams, 1990) found that when all vowels were removed from English texts, adults could read and understand them almost perfectly. It might be even easier if the slots for vowels were marked, as in

"v*w*ls *r* m*r* d*ff*c*lt t* l**rn th*n c*ns*n*nts".

The necessity of vowels in speech, combined with our sight word knowledge of words, and our linguistic expectations about the structure of sentences makes reading without vowel letters a possibility (Adams, 1990). The fact that we are skilled readers is probably responsible for the facilitative effect found when asterisks replace vowel letters in words. Since we know spellings of words, the additional information provided by the asterisks allows our brains to match the words we have stored in our lexicon with the configuration of the consonants seen in print, and to decide which are the most probable spellings for the words that need to be identified. All this, of course, is helped by our linguistic expectations about the structure of the sentence. Beginning readers who know few spellings of words and therefore have very small sight word lexicons to help guide their mental search will not experience such a facilitative effect. Depending upon whether their consonant knowledge is sufficient to help them sound out approximations of the words being read, they might be able to guess correctly the identities of the words using their partial cues, although such a process would be laborious and time consuming, but not impossible.

In spelling words, however, accurate vowel representation is essential. The written identity of any word consists of a prescribed sequence of letters. Even in reading words, you need to observe all the information displayed in its spelling to distinguish among similarly spelled words for precise identification. Look quickly at the following word pair: *fat* - *fate*. You know immediately that the first word means a component present in food, whereas the other means some sort of predestination. Therefore, to an experienced reader, small differences in vowel spellings do make a difference, and are quickly recognized. You know instantaneously that the presence of the final silent E in one of the words demands that the first vowel sound be pronounced in one way, whereas the absence of this marker shows you that the vowel should be pronounced in a different way.

But to somebody who is just learning how letters represent speech, mastering rules such as these is a huge step to be surmounted in mastering the English system. Even before beginning readers start to observe the enormous variability in the representation of vowel sounds in spellings, it is important that they perceive that words are written to represent the sounds of speech, and that no words exist without vowels. So, besides learning about the sounds, and all the possible letters that can represent them as well as other sounds, they have to learn that those letters combine in some pre-specified ways.

Learning to read and spell vowels is a source of difficulty for English learners. The complexity of English letter-sound correspondence rules has been shown to affect reading acquisition. (Guthrie & Seifert, 1977). The high level of variability in vowel sound-spelling correspondences may prolong their acquisition and the level of accuracy reached. Statistical analysis conducted on spelling consistencies in English monosyllabic words showed vowels to be the least consistent part of the word to spell (Kessler & Treiman, 2001). Vowel spellings are more difficult for beginning readers to learn than consonant spellings, in both recognition and recall. (Shankweiler & Liberman, 1972; Williams & Knafle, 1977).

Theorists studying reading and spelling development in different languages have proposed that learning to read and spell occurs in stages or phases. Because the vowel writing system in English is so hard to master, acquiring the ability to read and spell vowels correctly has been seen as a landmark for development. Theories of spelling development assign special significance to moments when children start to represent vowels consistently and conventionally in words (Beers & Henderson, 1977; Gentry, 1982; Henderson, 1985; Ehri, 1986, 1992, 2005) and when long vowel markers are represented in words (Beers & Henderson, 1977; Gentry, 1982; Ehri, 1986, 1992, 2005). Strategies used to represent vowel sounds have also been studied, both in children, (Treiman, 1993; Varnhagen, 1995) and in adults (Treiman, Kessler & Bick, 2002). Children utilize their vowel letter-name knowledge, as well as their knowledge about the frequencies of certain phoneme-grapheme correspondences, their phonological and their orthographic knowledge to produce spellings (Treiman, 1993; Varnhagen, Boechler & Steffler, 1999; Hayes, Treiman & Kessler, 2006; Treiman, Kessler, Zevin, Bick & Davies, 2006). The learning of spellings, however, has been shown to refine children's perception and categorization of vowel sounds (Ehri, Wilce & Taylor, 1987). Better readers and children who have been taught spellings are better able to match vowels they hear in words to categories of vowel sounds. It seems that learning the spelling system helps children crystallize categories in perceiving vowels.

Vowel letter-sound relations have also been shown to be one of the most difficult achievements for children with a reading disability (Shankweiler & Liberman, 1972). They are less likely than typically developing readers to apply orthographic patterns in reading words, and they tend to misread vowel letters in words producing vowel sounds that are not allowed by the spelling. (DiBenedetto, Richardson & Kochnower, 1983). Children with reading disabilities tend to perceive and produce less well defined vowel categories than age matched controls, probably due to a difficulty processing vowel sounds with similar phonetic characteristics (Post, Foorman & Hiscock, 1997; Post, Swank, Hiscock & Fowler, 1999; Bertucci, Hook, Macaruso & Bickley, 2003; Bernstein, 2009) .

Although readers' vowel knowledge has been studied (with both quantitative and qualitative methodology), there is not much research regarding the relationship of children's vowel knowledge across various tasks. Does their performance show differences depending on which tasks are used to assess their knowledge? For children who perform poorly in production tasks, would recognition tasks be able to detect any emergent vowel knowledge?

Additionally, there is relatively little research addressing how children use their short vowel knowledge to learn words. Do vowels, at any point of their mastery or use, facilitate either reading or spelling performance? If children can correctly distinguish between words that differ only in their vowel sounds and spellings when they read them, what else can they do that is more advanced than children who cannot yet distinguish between written vowels in words? Is there a difference achieved in terms of word recognition? If a child knows how vowels are spelled, would she/he use such knowledge to discriminate faster among confusing words, or would the speed of recognition be similar to that of children who do not know vowels well?

According to Ehri's theory of sight word learning (1992), children learn to read words by associating letters in spellings to sounds in pronunciations, and storing the connections in memory in a form that amalgamates the spellings, pronunciations and meanings of the words. The connections are formed based on the child's knowledge of letter-sound correspondences. Novice readers, in contrast to more advanced readers, are able to form only partial grapheme-phoneme connections to store words in their lexicons because they lack full knowledge of letter-sound relations, particularly vowels (Ehri, 1986, 1992, 1999). These incomplete representations make the process of reading words from memory more difficult. One reason is that similarly spelled words are mixed up when they are read because the partial connections used to read them are not distinct (Ehri, 1986, 1992, 1999). Theoretically, by increasing the number of letter-sound connections for each word, children should improve their spelling skill as well as their accuracy in accessing learned words in their lexicons to read them. Evidence with beginning readers supports this (Ehri & Wilce, 1987a, 1987b).

In being able to compute more complete mappings of letters and sounds in words by knowing vowels as well as consonant letter-sound relations, children should acquire full representations of new words that are learned. Because vowels appear in every word in the orthography, their mastery should enhance greatly the number of reliable word encodings/decodings a child is able to perform. Therefore, improvement in knowledge of English vowels should increase the number of words a child is able to learn by sight, as well as increase the speed of the word reading process. Also it is likely that a child who possesses vowel as well as consonant knowledge will exhibit stronger skills in spelling than a child who possesses mainly consonantal knowledge.

One way to study the contribution of vowels in learning to read and spell is to assess children's consonant and vowel knowledge, separate them into groups that differ in vowel knowledge, and examine how their knowledge correlates with their ability to learn new words. If Ehri's (1992) theory is correct, children with more complete vowel knowledge should encode words more completely and with less ambiguity, and they should retrieve them from memory faster than children with a less complete vowel knowledge.

Some may argue that such a study would be merely academic. If in a natural situation children learn both types of letters (vowels and consonants) concomitantly, why go to the trouble of studying the consequences of each for word learning? One reason is that for most children, learning to read is not a natural act that occurs spontaneously. For the majority, some form of instruction is needed. We want to be able to provide evidence about which are the best ways of helping children learn to read and spell better, and faster. To do that, we have to know how each of the components of the process works, and the effects each component has on the others.

Venezky (1974) highlighted the importance of isolating and evaluating "critical components" of methods that teach children to read, as opposed to comparing whole methods consisting of many components. According to him, the gains in learning the specific contribution that each component makes to a method is more worthwhile and economical than investing large funds into comparing dissonant methods. Knowledge derived from this type of research could then be used to improve practice, by making instruction more flexible and adaptive for individual students.

Use of a design that investigates knowledge already possessed and used by children in their normal school life has more ecological validity than a controlled experiment. The former design allows us to investigate the impact of knowledge acquired in normal circumstances. Although such a design falls short in providing evidence that the targeted variable plays a causal role in learning, it offers a more realistic picture of how beginners use their consonant and vowel knowledge to spell and learn new words.

The proposed study builds on Venezky's (1974) idea of evaluating critical components, specifically the contribution of short vowel grapheme-phoneme knowledge to children's ability to learn to read and spell words. This study has two components: (a) a cross-sectional analysis of the development of short vowel knowledge across various tasks, and (b) the contribution of short vowel knowledge in learning to read words and remembering their spellings.

Twenty-four beginning readers from kindergarten and first grade participated in this research. They were screened for their grapheme-phoneme knowledge as well as for their sight word reading level. Various tasks aiming at identifying their short vowel knowledge were given to them, both in recognition and production of short vowel letters and sounds. Although all tasks measured short vowel knowledge, some tasks were expected to be more demanding than others, both in the number of items and in the difficulty level. The objective of this was to be able to collect substantial information about children's abilities in recognizing and producing short vowels. The number of correct instances of each vowel in each task was observed, and general vowel knowledge trends across all children were investigated. Additionally, correlations between children's vowel knowledge and their sight word reading level were examined. Various hypotheses were investigated regarding performance in those tasks. It was expected that performance would vary depending on the level of difficulty of the task (e.g., production tasks being more difficult than recognition tasks). It was also hypothesized that children would follow similar patterns in learning vowels, with some vowels better known than others for most children.

Since the role of short vowels in reading and spelling words was also one of the main interests in the study, children were grouped according to their short vowel knowledge into a high knowledge group, and a low knowledge group, based on their performance in the several short vowel reading and spelling tasks. The two groups of children were taught to read two sets of words to criterion, one set spelled with vowels and one set written without vowels. The order of presentation of the sets, and the presence or absence of vowel letters were counterbalanced. We compared the number of vowelized words learned to the number of no-vowel words learned by children. Therefore, our independent variables were vowel presence in the words being learned (vowel letters present vs. absent), learning trials (t1, t2, t3, etc.), and students' vowel letter-sound knowledge (high vowel knowledge vs. low vowel knowledge). Our dependent variable was the number of words that children learn to read correctly.

Several hypotheses were tested. Children with high short-vowel grapheme-phoneme knowledge were expected to read words spelled with vowels more easily than words spelled without vowels. According to Ehri's theory (1992, 2005), this is because more complete representations that fully specify the pronunciations of words are retained in memory when vowels are spelled. In contrast, children with low short vowel knowledge were expected to learn to read words spelled without vowels more easily, because words are shorter when vowel letters are not included, and it is easier to form connections to remember three-letter words than four-letter words and to distinguish among them.

In the next chapters, we will review the literature bearing on the difficulties of learning the English vowel system, as well as what is known about children's knowledge of vowels, and what is involved in learning to read words by sight.

Chapter 2

Literature Review

Vowel knowledge in learning to read and spell.

Although several studies have been conducted to understand sight word reading, and many others have studied in detail the acquisition of vowels by children, very few studies have examined the development of short vowel knowledge in children and the relationship between vowel knowledge and sight word learning, especially regarding the complex nature of vowel representation in English.

The vowel writing system in English.

The complexity of the English vowel system.

There are many vowel regularities to be learned in English, at different levels of complexity. (Venezky, 1970, 1999). Thus, it is no surprise that mastering the vowel spelling system is one of the most difficult achievements for literacy beginners.

In order to be able to represent information regarding vowel sounds more reliably, the English phonetician Daniel Jones (Catford, 1988) proposed a system of Cardinal Vowels (CV) to describe vowel sounds based on their place of articulation, in such a way that any phonetician, upon receiving the information, could repeat or at least approximate the sound of an unfamiliar vowel. The CV system is an artificial creation of pure vowels, distributed in two continuous dimensions: position of the tongue (front/center/back), and lip rounding (rounded, unrounded). The vowels of any language are then described and drawn inside a trapezoid graphic that plots each vowel in its place, predicting relative distances between each vowel and the next one represented. The system is based upon the idea of vowel limits, meaning that each vowel sound is produced within a certain area, and when the limits of this area are exceeded, the vowel is no longer recognized as that sound but as another adjacent vowel sound. The Cardinal Vowels System is more of an artifact than a perfect representation of the vowels of a language, since the production of vowels is not fixed within any language and the sounds of the vowels produced in a word can be affected by the neighboring sounds. However, the existence of such a system helps to create a common vocabulary with which the vocalic systems of different languages can be properly described, replicated and studied. Figure 1 represents the Cardinal Vowel trapeze for all languages.

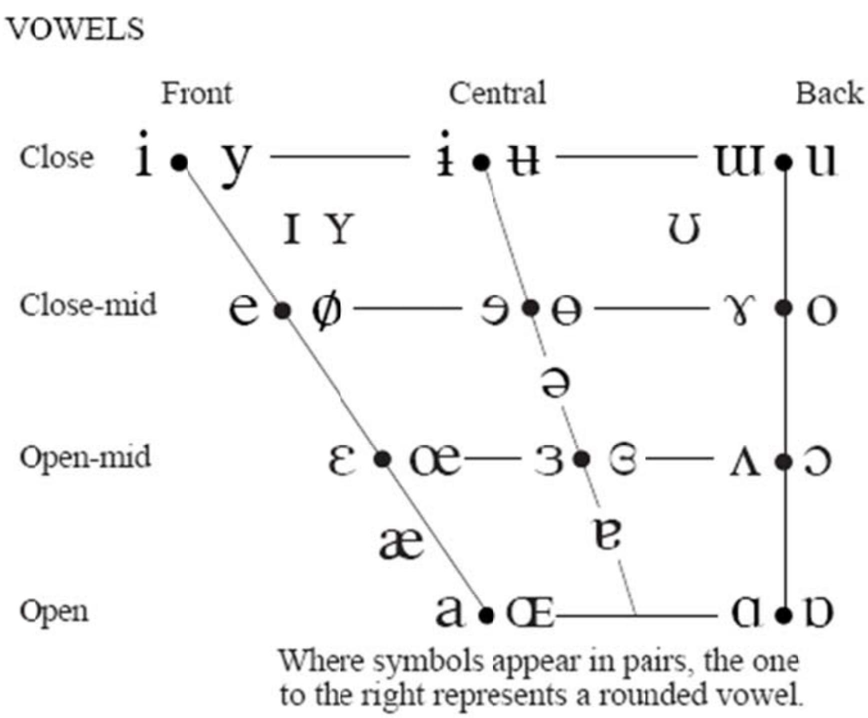
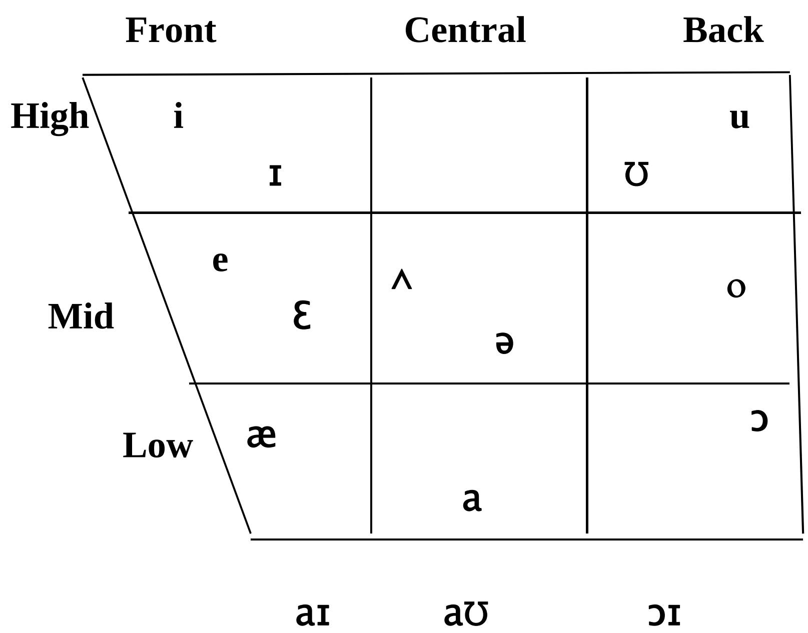


Figure 1. The Cardinal Vowel system. (n.d.). (Retrieved November 16, 2011 from the International Phonetic Association Website: http://www.langsci.ucl.ac.uk/ipa/vowels.html)

When we analyze the phonology of the language, we find that a typical dialect of American English – the General American speech, a dialect spoken through a wide area of the country outside of eastern New England and the South – is composed of a system of 15 vowel sounds, with 12 individual vowels and 3 diphthongs (Venezky, 1999). Fig. 2 represents the Cardinal trapeze for American English.

However, it is not the number of English vowels that creates difficulty in learning their written representations. It is the lack of consistency in their representations. For example, grapheme-to-phoneme correspondences may be variable. The letter E may represent the sound /i/ as in ***he***, but also can represent the sounds /e/ as in ***eggs***, /I/ as in ***pretty***, /ɛ/ as in ***best*** and /ə/, as in ***bigger***. Likewise, phoneme-to-grapheme correspondences vary. The sound /e/, as in ***bait*** can be represented by the letters A, AY, EY, AI, EA, and EIGH. Also, the first vowels of the semantically related words ***sign*** and ***signature***, although pronounced differently, are spelled with the same letter I. And the difference between some vowels may be a function of the tenseness of the tongue muscles, which is not a characteristic of many other languages. Two vowels (e.g., /i/ as in ***beat*** and /I/ as in ***bit***) can be produced with the tongue in the same position (high and front), and same level of lip rounding (i.e., none). Their main difference is that the tongue muscles are tense while producing /i/ of ***beat***, and they are lax when producing /I/ of ***bit***. The consequence of such similarity is that novice spellers trying to spell may treat both vowels as the same sound, since they may not be attentive to their difference in tension.

Figure 2. The vowels of American English.



Consonant sounds, on the contrary, have a higher regularity in their written representation, but even they are far from being consistently spelled. Out of 21 consonant letters, 14 represent only one consonant sound (B, D, F, J, K, L, M, N, P, Q, R., T, V, Z), and just 8 of those sounds are represented in only one way without alternative spellings (e.g., /b/ is only spelled with B). From the sound side, the situation is more complex. Venezky (1999) shows that, for a simple sound such as /k/, the initial phoneme in the word ***c**at*, eight types of spellings are possible: **kh** as in ***kh**aki*, **ch** as in ***ch**ord*, **cc** as in *a**cc**ord*, **c** as in ***c**oal* or ***c**at*, **q** as in *li**q**uor*, **ck** as in *pi**ck***, **kk** as in *tre**kk**ed*, and **k** as in ***k**id*.

According to various scholars (Dobson, 1957; Scragg, 1974, Baugh & Cable, 1993), a historical shift occurred in the oral pronunciation of vowels in the sixteenth century without a corresponding change in their written representation, and this was responsible for their erratic spellings. Before that period, English orthography was more regular in its representation of vowel phonemes (Taylor & Taylor, 1983), although there were limitations to such regularity (Venezky, 1999). But in the sixteenth century the arrival of the press and the fixing of spellings into stable forms impeded the possibility of written language accommodating itself to the variations occurring in oral language, so written and oral language became more different from each other. As a result, the high level of phoneme-grapheme regularity disappeared in English, thus making the detection of regularity in vowel spellings more difficult.

The distinction between short and long vowels.

According to Venezky (1999), the use of the terms "long" and "short" to distinguish between vowel categories is not historically accurate or mnemonically useful. He states that although some long-short pairs originated from Middle English vowels that differed only in length, that is not true for all pairs. Some long vowels (e.g., long A and long O) are actually on average phonetically shorter than the short vowels. Long and short vowels are defined today in terms of spelling: they are the paired sounds symbolized by the letters A, E, I, O, U, with the long sound corresponding to the letter's name (e.g., ***mat*** vs. ***mate***, ***fed*** vs. ***feed***, ***bit*** vs. ***bite***, ***dot*** vs. ***dote***, ***cut*** vs. ***cute***). The distinction between short and long vowels is a pedagogical distinction, and is not strictly a linguistic one. Venezky points out that this system includes only 10 vowels, leaving no place for the other vowels. His suggestion, instead, is to classify vowels according to whether they can end a syllable ("free"), or not ("checked"), which is important in English given the significance of its syllable structure.

Because the focus of this proposal is on the spelling system and pedagogical concerns, and because the terms long and short have been traditionally used in the educational literature and in dictionaries, these terms will be used here. In methods that use a systematic phonics approach to teach reading, vowel instruction typically occurs in two phases. The first phase is focused on teaching "short" vowels, whereas the second phase is focused on the "long" vowels (Taylor, 1984).

The short vowels typically occur in the middle of CVC (Consonant-Vowel-Consonant) words (e.g., / æ/ as in hat, /Ɛ/ as in let, /I/ as in pig, /ɑ/1 as in pot, /^/ as in pup). They tend be more consistently represented by the same letters (respectively A, E, I, O, U), which makes them highly regular in their letter-sound relationship. Since CVCs exist in large numbers in English, and since they entail straightforward one letter, one sound correspondences, they are considered easier to learn, and are, therefore, the words of choice for the controlled vocabulary words in beginner readers' books.

The long vowels are the sounds contained in the letter names for the vowels. Their representation in the spellings of words includes a marker signaling the presence of the long sound rather than the short sound. The final silent E, or a two-vowel digraph indicates a long vowel sound. Because the long vowel sounds are the names of the vowel letters, this gives beginners easy access to them. However, because they are not spelled with one letter but rather require a second marker letter, this makes acquisition more complex. It requires mastery of a contextual rule. A further complication is that this rule is not always followed.

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[1] Venezky (1999) uses /a/ to represent the sound for ***dollar***, ***toggle*** and ***lobby***, not using the sound / ɑ / in his depiction of the American vowels, probably due to the caught- cot merger. (for the majority of the speakers of the General American English, the vowels /ɔ/ from *caught* and /ɑ/ from *cot* have merged , being perceived and produced as the same sound, although not in NYC). However, since most phonetic representations for the American English use /ɑ/ to represent the sound in ***off***, ***fox*** and ***hot***, we kept that representation for the pronunciation of the short O letter-sound throughout this dissertation .

The classification of vowels into two discrete categories (be it short and long, or lax and tense) contributes an important source of regularity to the orthographic system but also creates an additional hurdle. The two types of regularities work differently, so their impact upon acquisition is likely to proceed differently. Therefore, to understand how sight word reading is impacted by vowel knowledge, we need to study the influence of each type of vowel separately.

Short vowels are simpler in their representation, and in most phonics programs they are taught first, so this is viewed as the place to start in studying the interaction between vowel knowledge and sight word reading. Once we understand better how one type of knowledge, – in this case short vowel knowledge – develops and how it impacts sight word reading, we can pursue another layer of complexity, by studying long vowels. Therefore, the purpose of this study is twofold: 1– to understand the development and the distribution of short vowel knowledge among early beginners; and 2 – to examine the contribution of short vowel grapheme-phoneme knowledge to the ability of children to learn to read and spell sight words.

Vowel knowledge and reading.

Upon hearing the words ***beet*** and ***bet***, native English speaking children realize they represent different things, because they contain different vowel phonemes. In oral communication, proper identification of phonemic categories is crucial, and children who have learned to speak a language do that naturally (Liberman, 1973).

However, in order to learn to read, it is not enough for beginners to recognize that two words sound different. They have to realize that the words are made of smaller sound elements – or phonological segments. Additionally, they have to be able to identify explicitly each one of those smaller segments that form words (Liberman, 1973).

Learning to become aware of the sounds that form words is not easy, but it becomes even harder when children are asked to match those sounds to letters, in order to read and spell words. If children are to master how phonemes (sounds) match up to graphemes (letters) in an alphabetic writing system, they have to be able to realize that each word is formed by a different combination of sounds, and those sounds are what we represent with letters when we write. Therefore, children's ability to fully understand and use the alphabetic writing system depends on at least two capabilities: the degree to which they can segment words into phonemes, and their knowledge of grapheme-phoneme correspondences (Share, Jorm, Maclean & Matthews, 1984; Ehri, 1999).

When reading, it has been found that the position of phonemes in syllables may influence the likelihood of making mistakes in reading them. For example, errors on the final consonant of a Consonant-Vowel-Consonant (CVC) syllable such as ***bet*** were found to be much more frequent than mistakes on consonants in initial position (Shankweiler and Liberman, 1972). However, that research also showed that errors on the medial vowels were much more frequent than errors on consonants in both initial and final position. These results appear to show that the difference in number of mistakes is due to a position effect, with middle position harder to read than final, and final harder to read than initial position. However, since consonants and vowels were not matched for their position in the syllable, (only vowels occupied the middle position), and since the words used were CVCs, there is no assurance that such an effect was not caused by the vowels themselves.

When Fowler, Liberman and Shankweiler (1977) tried to confirm those findings with a more elaborate experimental design that allowed better comparison between consonants and vowels, they found something interesting. They asked 20 second graders, 20 third graders, and 20 fourth graders to read words from cards and give a best guess if a word was not known. The words came from two different lists, which equalized the number of consonants in both the initial and final position in different words, and the vowels, which could occur in initial, medial or final position. The results showed a clear effect of position for consonants. More mistakes were made reading final than initial consonants, even when the words were controlled for complexity. However, for vowels, there was a much smaller position effect, since the number of mistakes was similar in all positions for second and third graders. Only fourth graders showed a position effect in reading vowels: they had fewer mistakes in initial and final positions than in middle position. These results indicate that differences in accuracy reading consonants and vowels are not explained by their syllable position only. Interestingly, consonant errors were systematically related to the particular phoneme represented. When consonant letters were incorrectly decoded, the sounds produced usually differed from the letters in only one feature: voicing, place of articulation, or manner of articulation. Vowel reading errors, however, seemed to happen randomly, without bearing any relationship to the phonetic features of the vowel written (i.e., tenseness, tongue advancement, tongue height and dipththongization). The authors could not explain why children would use a strategy for reading consonants but not vowels. They hypothesized that, because vowels and consonants have different functions in speech, mistakes in reading them may reflect those functions.

In a subsequent study, the same authors (Fowler, Shankweiler and Liberman, 1979) tried to explore in more detail what makes vowel mistakes so different from consonant mistakes, and especially, why vowels do not show a phonetic pattern as consonants do. It could be that measurement of vowel errors was inaccurate, rendering their phonetic patterning undetectable. But two other possibilities seemed more likely: 1- Children may have used a whole word guessing strategy that was more constrained by the consonants than by the vowels. Since consonants carry the informational load in words, guesses based mostly on readings of consonants may have been more accurate, or nearly so, whereas guesses based mostly on vowels may have been random in regard to their target phonemes- vowels have many more reading possibilities than consonants do; 2- Children may have used an analytic "sound out" strategy for reading unknown words, reading letter by letter, and assigning sounds for vowels based on their knowledge of orthographic relations. However, since their knowledge may have been incomplete, and since vowel spelling-to-sound relations tend to be one letter to many possible sounds, children may have assigned sound values for vowels that were inaccurate in the context of the target words, but were reasonable possibilities for the same vowels in other orthographic contexts. Since consonant letters have more stability in their sounds than vowels, with many consonants having a one letter to one sound correspondence, using such strategy to read consonants may lead to more success than using it to read vowels.

Fowler et al. (1979) were particularly interested in investigating to what extent children take the orthographic pattern into account when trying to read unknown words. They asked 20 second graders, 20 third graders, 20 fourth graders and university students to read a list of 96 nonsense words that contained all types of vowel spellings in English, and two other lists of real words, one with consonants in initial and final positions, and another with vowels in initial, middle or final position. Analysis of the responses showed that correct readings of the vowels exceeded chance for children of all grades, including those who had completed just one year of instruction. Also performance improved with grade. The results showed that children were able to use orthographic regularities to help in reading previously unknown words, although only the more skilled readers were able to take account of regularities governed by contexts in their word reading.

Such findings led Fowler, Shankweiler and Liberman (1979) to re-analyze the data from their previous study (Fowler, Liberman & Shankweiler, 1977), where vowel but not consonant reading errors appeared to be random. They found the vowel errors were not so random: when a child made an error reading a vowel, he/she was likely to produce a vowel that was a possible sound for that spelling. Similar findings regarding the influence of orthography were obtained by Treiman (1993), reviewed below, who found that children tended to spell vowels using their experience with orthography as a guide, and tended to select the most common graphemic representations for sounds that they did not yet know how to spell.

Fowler, Liberman and Shankweiler (1979) interpret the disparities found for mistakes in reading vowels as opposed to consonants as showing that vowel and consonant mistakes have different underlying causes. Whereas consonant misreadings are related to phonetic segmentation difficulties, vowel misreadings are more related to the complexity of the spelling to sound correspondences, and the structure of the English orthography.

Mason (1976) also showed that vowel mistakes were the most common type of error that children made in reading words in isolation. Additionally, she showed that the type of mistakes made varied according to the reading skill of the participants. Eighty-seven children from grades one to four were asked to read 32 monosyllabic words written on cards. The words varied in frequency and in the type of vowel spelling. Based on the number of pronunciation errors made by the children, they were divided into 7 performance groups. Less skilled readers made the largest number of non-responses or initial consonant errors, whereas more skilled readers tended to make more vowel overgeneralization mistakes. Although the total number of mistakes decreased with reading ability, their distribution also changed. Lower-ability children made more short than long vowel overgeneralizations, middle ability children made similar numbers of overgeneralization mistakes for both types of vowel, and high ability children tended to make more long than short vowel overgeneralization mistakes. The shift in the type of mistakes indicates the direction of growth of vowel knowledge as children advance in learning to read, especially regarding the acquisition of orthographic patterns. Mason, however, looked only at reading errors, not at spelling or recognition errors.

Taylor (1984) produced one of the most complete accounts of vowel knowledge acquisition in children. She evaluated fifty children from first and second grades in their vowel knowledge (both short and long) in reading and spelling tasks, including the Slosson word reading test, word reading of regular and irregular vowels, and nonsense word reading and spelling. Additionally, Taylor tested children’s knowledge of the difference between consonants and vowels, and between long and short vowels.

(Although this study dealt with both reading and spelling short and long vowels, it will be described here in the section on reading rather than spelling for organization purposes.)

Similar to Mason (1976), Taylor (1984) divided the children into five groups, according to their performance in the Slosson word reading task. Children were asked to identify letter names and letter sounds, and to read nonsense words spelled with regular vowel patterns (CVC, CCVC, CVCe, CVVC) that included both short and long vowel sounds. They were also asked to read real words which had both regular and irregular vowel patterns, with either one or two vowel letters in each spelling pattern. Additionally, children were asked to spell nonsense monosyllable words dictated by the researcher.

In general, children knew letter names better than letter sounds. Their ability to identify vowel sounds when shown the vowel letters was acquired relatively early by all groups, including the lowest reading group who could identify some short vowel sounds. The mean percentage of correctly identified short vowel sounds for all groups varied between 74% and 92%. The lower performing group differed significantly from the other groups in their knowledge of long vowel sounds. They produced very few of them, even as errors, despite the fact that they could name most vowel letters. It seems they did not believe the letter name could be also a sound. Many of their answers were non-responses.

One purpose of Taylor's study (1984) was to see to what extent children differentiated between consonants and vowels, and between the vowels themselves, and how important that would be for reading. Different tasks were devised for that purpose. The first one required children to recite the names of the vowels, without any visual aid. Another task required children to sort cards showing 20 letters into consonants and vowels. A third task asked them to sort 20 three or four letter spellings into piles of words having either one or two vowel letters. Three other tasks focused on sound subskills: the first task asked children to listen to 10 CV or VC nonsense words, and then repeat either the consonant or vowel heard in each word, as requested by the researcher. A second task asked children to sort pictures in two piles: one for pictures that had a short vowel sound in their names, and another for pictures having a long vowel sound in their names. The third task also asked children to sort pictures, but this time into piles of different short vowels according to whether the vowel in the picture's name matched the vowel in "***mitt***", "***net***" or "***bat***".

Results showed that many of the children were not aware of the distinction between consonants and vowels, which was not necessary for them to start reading. Although many of them could recite the vowel letters, even some more mature readers had trouble sorting spellings according to their vowel structure.

Awareness of the distinction between short and long vowels appeared to emerge later, since older children were more likely than younger children to know which spellings represented short and which sounds represented long sounds. Although most children were able to distinguish different short vowel sounds on hearing them, more advanced readers had higher means in their categorization of sounds.

In terms of reading short vowels in words and pseudowords, surprisingly, the middle groups performed worse than the low ability readers. Their mistakes, however, tended to be different. Whereas the lower reading groups tended to wrongly substitute one short vowel for another in their reading, the middle groups made more mistakes confusing the long and the short mates. The higher performing group did not show this pattern, however, but rather made more mistakes confusing short vowels among themselves, and fewer mistakes misreading short vowels as long.

When reading long vowels, students at the higher levels outperformed students at the lower level. In fact, the least advanced readers rarely produced a long vowel in their reading. They usually made it sound short, and ignored whatever other vowel letter that was present.

In spelling short vowels, the groups did not differ much, and none was very accurate. The types of errors varied by group. The less advanced readers either did not include vowels in their spellings, or chose the wrong vowel letter. More advanced readers added extra vowels creating a long vowel spelling (e.g., "***hig***" spelled HIGE), thus producing an overgeneralization.

In spelling long vowels, most readers could produce the correct letter, although only the most advanced students produced a marker for long vowels, either a silent E or double vowel letters.

In summary, knowledge of short vowels in reading was quite developed in all ability groups. Long vowel knowledge progressed steadily for all groups of children, and improved as children matured in their reading. However, emergence of long vowel knowledge in the middle ability group seemed to interfere with their short vowel knowledge, since their errors in short vowels increased, as compared to the lower reading group. Middle groups also confused the short and the long mates more often.

Of special interest to the present proposal is the comparison made by Taylor (1984) of short vowel knowledge across tasks, specifically, whether application of short vowel knowledge to reading and spelling tasks would lag behind its acquisition, and whether application would be similar across various tasks. Three different tasks were compared: producing short sounds in response to letters, reading short vowels in nonsense words, and spelling short vowels in nonsense words. Results showed significantly lower performance in the spelling task than in the other two tasks where mean performance was similar across children. This indicates that short vowel knowledge was applied upon its acquisition in reading, but not in spelling. The three tasks compared were production tasks, and one wonders whether vowel knowledge would be detected even earlier if vowel recognition tasks had been used as well.

Taylor's study (1984) was quite complete, but because the author wanted to study the development of both short and long vowels, the number of items used for each task was not large, thus impairing their reliability. For example, in the spelling task, she only included 5 items, one for each vowel. Since vowels are especially difficult for beginners to master, it may be that her data distinguished children who knew the vowels from children who did not. However, children who were in the process of learning vowels but who still confused them may have been portrayed as having no knowledge when they actually had partial knowledge. In focusing the proposed study on the development of short vowel knowledge, multiple items were included in each task to test knowledge of each vowel. This provided a more refined picture of children's knowledge of short vowels, both in their reading and in their spelling. Additionally, a vowel recognition task was incorporated, aimed at detecting emergent knowledge that may be present in early beginners before they can show knowledge of vowels productively.

The present study differs from Taylor's (1984). Whereas she studied the development of both short and long vowel knowledge, the proposed study aims to understand beginner's acquisition of short vowels and their ability to use them to read. In many ways the proposed study resembles Taylor's: short vowel letter-sound knowledge was measured in several tasks assessing identification of letters and sounds, reading and spelling words out of context, reading and spelling nonwords. Knowledge and use of vowels were compared across various tasks. However, tasks in the current study focused entirely on short vowels, and a few tasks were added to detect short vowel knowledge possibly earlier in young children. Also, children less knowledgeable about short vowels than those studied by Taylor were included. Because we wanted to detect the inception of short vowel knowledge, participant children in this study were tested earlier in the school year. The second part of this study, an experimental manipulation, went beyond Taylor's work to allow us to understand how children use the knowledge they have to learn to read new words.

Vowel knowledge in spelling.

Charles Read (Read, 1971) was one of the first scholars to realize that some children, even before receiving formal instruction in reading, start to represent the sounds of the language in their invented spellings. Going against the traditional view of spelling as a rote memory activity, Read pursued the idea that children actively make sense of the alphabetic code when they try to spell on their own. His analysis revealed that their spellings reflected accurate, though not always conventional, phonological awareness of the sounds in words. He showed that children's understanding of the relation between print and sound began with the discovery that some phonemes existed inside letter names that they knew.

Read studied 32 preschoolers who had started to spell on their own before they went to school, and examined their misspellings from a linguistic perspective. In terms of vowels, he observed that children tended to spell tense or long vowels using letter names (e.g., by spelling BIK for ***bike***). However, because lax or short vowels do not have letter names corresponding exactly to their sounds, children solved this problem by matching the phonological properties detected in letter names and in words. Short vowel sounds in words that were articulated similarly to sounds in letter names provided the basis for selecting letters. For example, if children wanted to spell the vowel sound in ***bet***, which is front and unrounded, but could not find a corresponding letter name that was identical, they would look for a similar sound, and pick the letter A having a name that is also front and unrounded. The fact that the letter A was one of the most used letters to represent the sound /E/ in children's misspellings supports this assertion. Read observed many such examples, where children consistently and creatively sought letters to represent the sounds they detected in words. Many of their misspellings used letters that, although inaccurate conventionally for representing the target sounds, were articulated in the same place as the desired sound.

Read (1971), however, never discussed what effect children's knowledge about print might have on their choices of letters to spell. Perhaps the thought of orthography influencing spelling was too advanced for his time. Read was already an innovator, proposing spelling as a creative act rather than a product of rote learning. It was eight years later that Fowler et al. (1979) detected orthographical influences on children's spelling.

Other researchers (Beers & Henderson, 1977; Morris, 1981; Gentry, 1982; Henderson, 1985; Ehri, 1986) examined whether Read's findings with preschoolers could be replicated in children learning to read and spell in schools. Based on their analyses of children's spellings in more controlled studies, they proposed similar theories of spelling development portraying in stages the evolution of children's thinking about print, from unawareness of its relation to sounds, to correct orthographic representations. In those studies, as in Read's study, children were viewed as cognitively active, capable of reflecting on the features of the language, and capable of building knowledge on their own about how the system works.

The stages proposed in each theory are similar, and are briefly described here, particularly in regard to the role of vowels in children's spelling development. The boundaries and names of the various theories are slightly different. Ehri's (1992) classification will be adopted mainly because it is more detailed in the earlier spelling stages, which is the focus of the proposed study. When other theories offer additional information to the understanding of vowels, they will be described as well.

Ehri (1992) proposed a developmental classification comprising four spelling stages: precommunicative, semiphonetic, phonetic, and morphemic. These stages were defined not only by analyzing spelling miscues and observing strategies used by children, but also by specifying the nature of the correspondence between written and spoken units that spellers showed in their invented spellings, that is, when they generated spellings whose conventional forms were unknown.

At the precommunicative stage the spellers show some knowledge of the alphabet through their writings, although letters are mixed with numbers and do not reveal any sound-letter correspondence. Therefore, children's writings are non-readable, and non-communicative.

When children start to use a few letters to represent sounds in words, they reach the semiphonetic stage. Semiphonetic spellings lack a complete mapping of all the phonemes present in the pronunciations of words. One reason is that semiphonetic spellers have not yet learned how to divide the speech stream into phonemic segments. So, even if they know letters and their names and sounds, the absence of expertise in parsing speech into the smallest phonemic segments impairs their spelling ability, and makes their spellings incomplete. Therefore, a characteristic of this stage is that only some sounds are represented. The letters selected are those whose names or name parts are heard in the words being represented (e.g., using L to spell ***elephant***, or R to spell ***are***). The use of letter names to match sounds in syllables or words is such a common strategy in this stage, that Henderson (1985) even named one of his stages – the letter name stage - after this strategy. Boundary sounds may be represented, but medial sounds are usually ignored. (e.g., BK to spell ***black***), and consonant voicing substitution errors may occur (e.g., spelling BT for ***bed***, where children confuse the voiced /d/ with the voiceless /t/).

Regarding vowels, children usually forget to include them or misrepresent them. If vowels say their own name and are clearly pronounced in the word, they may be more likely to be represented. Actually, the most distinctive difference between this stage to the next, phonetic stage, is the absence of vowels in stressed syllables of a spelling. (e.g., JRG for ***dragon***, or PKN for ***picking*** – examples from Morris, 1981). Short vowels are mostly unknown, and children may pick arbitrary vowel letters as fillers. (e.g., SAK, for ***stick***, example from Ehri, 1986).

At the next phonetic stage, children start applying letter-sound correspondences to create a more complete mapping of all the phonemes in the pronunciation of words, although letters are chosen mainly on the basis of sound. Ehri (1986) postulates that during this stage children learn to interpret conventional spellings as symbols for the pronunciations of words, and this in turn helps them improve their memory for the spelling of the words. They also start to make use of meaning to distinguish features of correct spellings.

Particular spelling forms are developed for tense and lax vowels, preconsonantal nasals, ed-endings, affricates and intervocalic flaps. Children become able to use more conventional spellings of short-vowels, and to represent consonant blends.

As indicated above, the most telling difference between this stage and the previous stage is children's representation of vowels. Both long and short vowels are represented by one letter. For long vowels, letter names are used (e.g., LAK for ***lake***, CED for ***seed*** – examples used throughout this section, unless otherwise mentioned, come from Ehri, 1986). For short vowels, children generally associate the five vowel letters with the short sounds (e.g., TRUK for ***truck***, NEKS for ***necks***), although they may mix up short vowels articulated in the same region of the mouth (e.g., spelling FESH for ***fish***, or HILPT for ***helped***).

Beers and Henderson (1977) distinguish two levels of spellings in children's invented spellings for short vowels. The first and less mature form of invented spelling involves spelling the short vowel with a vowel letter whose name contains some semblance of the target short vowel sound (e.g., spelling TIP for ***top***, or BINE for ***bunny*** using the letter I, where both short O and short U can be detected at the beginning of the diphthong naming the letter I). The second and more mature form of spelling short vowels, even if unconventional, involves spelling the vowel with a neighboring short vowel (i.e., articulated in the same region of the mouth). It is possible, however, as hypothesized by Ehri (1986), that the first type of invented spellings is more characteristic of a semiphonetic speller who uses a letter name strategy and does not know short vowel spelling rules, whereas the second type of spelling is more characteristic of a phonetic speller who knows how short vowels must be spelled, but who is confused about which letter is orthographically correct.

Ehri (1986) has suggested that, as children learn more conventional pronunciation-spelling associations for short vowels in various words, vowels become more distinguished and there is less variability in their perception as sounds, and children tend to match sounds and letters more accurately. Although children in the phonetic stage tend to represent all sounds heard, they might still fail to include all letters, especially in unstressed syllables where vowel and consonant sounds are not clearly distinguished as separate sounds. (e.g., CHIKN for ***chicken***, or WOTR for ***water***). In fact, their perception may be more phonetically accurate than what is represented by orthography (Ehri, 1986). At the phonetic stage, standard orthography, especially for vowels, is still being mastered.

The last stage in Ehri's (1986, 1992) classification is the morphemic stage. The main characteristic of this stage is that children shift strategies for spelling - from an exclusive dependency on the one-letter-for-each-sound strategy, to the use of more word based spelling patterns as well. Vowels appear in every syllable even when they are not heard, and nasals are represented before consonants. Higher order regularities- called morphemic regularities - start to be discovered: root words, prefixes, suffixes, as well as letter co-occurrence patterns (e.g., using silent E, or two vowel letters to mark a long vowel spelling). Morphemic spellers spell more words correctly than phonetic spellers. Still, when words are misspelled, they tend to resemble conventional spellings, and morphemes such as ING or ED tend to be represented. Overgeneralization errors also occur at this stage. The emergence of long vowel knowledge has been found to interfere with children's short vowel readings, as found by Taylor (1984), and described previously. In Ehri's view, development through this stage continues for several years as reader/spellers become more knowledgeable about the orthographic system. Other researchers have divided and expanded this later period (Beers & Henderson, 1977), but since describing additional phases would go beyond the scope of the present work, they are not detailed here.

Treiman (1993), in a longitudinal study examining the invented spellings of first graders, observed interesting similarities in the representation of vowels. She collected all forms of invented spellings generated in a first grade whole language class for the period of one year, and then created a computer inventory to compare and contrast conventional spellings with the invented spellings of the words written by the children.

Initially, children tended to represent the sounds of the vowels with the letters that were the most frequent symbols for those sounds in Treiman's (1993) inventory of conventional spellings. For example, in order to represent the sound /i/, children chose the most frequent letter used to represent /i/: the letter E. Since the name of that letter is identical to its sound, such a choice was clearly preferred by the children, who chose E to represent /i/ 526 times out of 1138 occurrences of that sound. Interestingly, the second letter chosen most often to represent /i/ was also the second most frequent grapheme used to represent /i/in the set of words in the inventory: the letter I, chosen in 84 times out of 1138 instances of /i/. By carefully analyzing all the children's spellings in comparison to the standard spellings of the words, Treiman was able to offer numerous insights about children's spelling choices for both consonants and vowels.

In terms of the representations of vowels, she observed that children used both their letter name knowledge as well as their knowledge about the frequency of certain phoneme-grapheme correspondences to produce spellings, something that Read (1971) had not reported. Frequent correspondences were represented more often than infrequent correspondences, and correspondences in which the name of the grapheme contained the phoneme were used more frequently than when the name of the grapheme did not contain the phoneme. In attempting to represent /e/, children would use the letter A, for example, in spelling BRTA for ***birthday***, THA for ***they***, or RAN for ***rain***. For representing the sounds, /ai/, /o/ and /u/, the most frequent choices were I, O and U, respectively. Although children made use of a letter name strategy, it was not equally common for all long vowels. For /e/, /i/, /ai/, and /o/, the children used letter names about 60% of the time. But for /u/, letter name spellings occurred in only 6% of the cases. A possible explanation for such discrepancy would be the less common occurrence of this phoneme in English. Compared to the phoneme /e/, whose frequency of occurrence is approximately 3%, and to /i/, that occurs in approximately 2% of the English words, the phoneme /u/ occurs in less than 1% of the English words (Laver, 1994). Therefore, its infrequent occurrence would decrease the chance of children associating it with the letter name U.

This longitudinal study showed that children were particularly affected by exposure to print, although not all of their spelling choices corresponded to legal choices in the conventional system. Some of their choices never occur in standard orthography, and some of their conventional spellings were used much more extensively than the frequency of use in the standard system. Phonology also played a role in how children spelled vowels, as described above. Some choices were clearly guided by children's phonological analysis of the sounds, particularly articulatory features shared by vowels (e.g., lip position: rounded /unrounded; and place of articulation: front/back). Children seemed to implicitly categorize vowels in groups based on perceived similarity, and then chose the same letter to represent related sounds within the groups. Some children were sensitive to changes in quality in a vowel during its production - they were able to distinguish when a vowel was a monophthong, or a diphthong – and tried to represent both parts of a diphthong in their spellings (for example, spelling AE as the sound /e/, or IE as the sound /aI/).

In terms of development in the representation of vowels across time, Treiman (1993) detected two differences between the spellings produced by children during the first semester and the second semester in first grade. The first difference involved the representation of the long vowels /e/, /i/, /ai/, /o/ and /u/. During the first semester, 61.9% of the spellings of those sounds made use of letter names. In the second semester, only 52.9% of the spellings for those sounds used letter names alone, a significant decrease. The decrease was accompanied by an increase in the representation of the silent E marker in the spelling of long vowels. The second change was a decrease in the number of omissions of spellings of /ɛ/, as in ***pet***. More children started to spell that sound with A. This was the most preferred letter to represent that sound in the majority of the spellings.

Henderson and Beers (1977) proposed that children evolve from using a lower level strategy –using letter names– to a higher level strategy – using articulatory neighbors – when spelling short vowels. It seems that for long vowels the same applies. Letter names appear as the first and main strategy, to be followed soon by higher level, more correct orthographic strategies.

When analyzing vowel omissions in the children's spellings, Treiman (1993) observed that children were especially prone to omit vowels when they occurred in unstressed syllables, or when a blend of phonemes matched the letter name of a sonorant consonant such as R and L, for example, ***arm*** spelled RM or ***elbow*** spelled LBO, or the names of nasals /m/ and /n/, for example in ***ant***, spelled NT, or ***him*** spelled HM. Children also omitted vowels when a vowel was linked to a liquid, such as /l/ or /r/, as in spelling BRD for ***bird*** but not for nasals, such as /m/ or /n/. Vowels were also omitted more often when they were in the middle of the words and in longer words.

More recently Treiman and colleagues (Treiman, Kessler & Bick, 2003; Treiman, Kessler, Zevin, Bick & Davis, 2006) have investigated how orthographic contexts in words, both before the vowel letters (onsets) and after the vowel letters (codas), affect their pronunciation, and how readers and spellers with different level of reading ability and print exposure respond to those contexts. Their investigation broadens research initiated by Zinna, Liberman & Shankweiler (1986), who had found that children, when reading ambiguous vowel digraphs in words, were sensitive to both word frequency and to the consistency of the orthographic neighborhood the vowel belonged to. Zinna et al. (1986) had concluded that the ability to read vowels in words is affected by the consistency of pronunciation of words sharing that particular medial vowel-final letter unit. They had also concluded that with reading experience, children learn to identify systematic relationships between orthographic structure and pronunciation, and make use of that to read new words and ambiguous pseudowords.

Treiman and colleagues (Treiman et. al, 2003) were interested in investigating whether readers use context free or context sensitive associations when pronouncing vowel graphemes. For example, before the consonant K, the vowel letters ***oo*** are usually pronounced as /ʊ/ as in ***book***, ***cook*** and ***hook***. However, with a different consonant like M following the vowel, the vowel letters are usually pronounced /u/ , as in ***room***, ***monsoon***. Faced with nonsense words like ***poom*** or ***pook***, how do readers with different levels of ability pronounce them? College students showed the influence of orthographic context both before and after the vowel, above and beyond frequency effects for the patterns used. This means that they read the target words not based on the expected pattern (/u/ as in ***room***, the most common pronunciation) if frequency of occurrence was their only guide. But they showed awareness of non-explicit rules that make pronunciations dependent on the consonantal context around the target vowel (Treiman et al., 2003). In a later study (Treiman et al., 2006), first, third, fifth graders and high school students were presented with the same set of nonwords to read. Interestingly, even first graders showed the effect of at least some vowel context in their pronunciation of nonwords, although the effect increased in strength with children's age and print exposure. Continuing this line of investigation, but focusing now on spelling, Caravolas, Kessler, Hulme and Snowling (2005) studied influences on children's vowel spelling development by assessing their vowel spelling ability at two points in time: the end of reception year in England (kindergarten) and six months later, in the middle of year 1. Using a method developed by Kessler and Treiman (2001), they computed the unconditional and conditional probabilities of occurrence for correspondences going from sound to letter in spelling. Unconditional probabilities are the proportion of all words with a given phoneme spelled with a particular grapheme, given all possible spellings of that phoneme. Conditional probabilities take into account the identity of another phoneme in the syllable when computing the proportion of all words with a certain target phoneme spelled with a certain grapheme, given all possible spellings for the target phoneme. They found that children as young as 5 ½ year-olds who had been taught short vowel letter sound relations at school, but who had not been taught letter names nor had been explicitly taught any other vowel letter-sound relations already showed the influence of how consistent certain letter-sound relations for vowels were in the language. Unconditional consistency of vowel spellings had a stronger influence than any other factor in the accuracy of children's spelling. The two next factors to show influence were the extent to which the target vowel contained the specific letters taught to the children as representing short vowels, and the number of letters in the vowel grapheme. Word frequency, proposed by the authors as the impact of sight word learning on vowel spelling accuracy, also showed influence at both times of measurement, although much smaller than the other factors. The authors concluded that since children had not been explicitly taught about the probabilities with which certain vowel graphemes occur in English words, they had learned implicitly about them through exposure to print.

Hayes, Treiman, and Kessler (2006) asked second graders, third graders, seventh graders and college students to spell monosyllabic nonwords that differed in their vowels (short or long) but shared the same consonants in their codas, or shared the same onset. The interest was to see if the participants would be affected by the vowel context when selecting the correct consonants to follow the vowels, in both a production and a recognition task. Findings again showed that even the younger spellers took vowel context into consideration when spelling codas or onsets, and that influence increased with age. The interesting idea proposed by Treiman and Kessler (2006) based in all their findings is that of a statistical learning hypothesis, where individuals would be equipped since infancy to learn by both making pattern generalizations and considering particular contexts where some patterns are applied. In their view, context sensitivity develops gradually, and at different times for consonant to vowel associations, for both spelling and reading.

The last source of information to be briefly reviewed here regards the use of letter names to spell vowels. The last years have brought forth a renewed search for more understanding regarding the role letter names play in literacy acquisition (Foulin, 2005), and its relationships with phonological awareness, and letter sound knowledge. In both experimental (Cardoso-Martins, Mesquita & Ehri, 2011; Piasta & Wagner, 2010b; Levin & Ehri, 2009; Pollo, Treiman & Kessler, 2008; Pollo, Kessler & Treiman, 2005; Share, 2004; Cardoso-Martins, Resende & Rodrigues, 2002), meta-analytical (Piasta & Wagner, 2010a) and longitudinal research (McBride-Chang, 1999) letter name and letter sound knowledge have been studied. Although the general conclusion has not changed much – letter knowledge is a bridge to phonemic sensitivity, to learning the alphabetic principle, and still one of the best predictors of learning to read – , and much has been learned regarding the development of letter-name and letter-sound knowledge for consonants, vowels have been mostly left aside in English.

In most studies reviewed where letter-names and sounds were assessed in English, either vowels were explicitly avoided because they did not fit perfectly into a category to be compared (Ellefson, Treiman & Kessler, 2009; Treiman, Pennington, Shriberg & Boada, 2008; Justice, Pence, Bowles & Wiggins, 2006), only one of their sounds was assessed (Ritchey & Speece, 2006), or any sound was accepted as correct (Evans, Bell, Shaw, Moretti & Page, 2006) – which does not offer much discriminatory power. None of those recent studies, however, focused specifically on characteristics of vowel letter-sounds and their relationship with reading and spelling.

As we have seen so far, much evidence regarding readers and spellers' vowel knowledge has been published, both quantitative and qualitative. However, no studies have focused exclusively on the relationship between short vowel knowledge and word learning. The proposed study is intended to fill this void, by studying in detail children's knowledge of short vowels.

The present study focused primarily on children spelling at the semi-phonetic and phonetic stages, because this is when vowel knowledge develops. Various tasks were used to investigate children's knowledge of the alphabetic system, their ability to recognize, identify and represent short vowels using letters, and their ability to use this knowledge to read and spell words.

Some questions of interest were whether children who know short vowel grapheme-phoneme relations (phonetic spellers) would benefit from this knowledge in learning new words. Would semi-phonetic spellers, who do not possess vowel knowledge, also be able to learn to read and spell words with vowels? Ehri (1986) postulates that when children are able to produce correct spellings, they have acquired at least working knowledge of the English vowel writing system. Therefore, according to her theory, semi-phonetic spellers will not be able to learn correct spellings if they do not have some vowel knowledge. The proposed study is intended to offer empirical evidence bearing on these questions.

Sight word reading.

Ways to read words.

Readers may read words in four different ways: by decoding, by analogy, by contextual recognition or by sight (Ehri, 2005). The first three ways are used to read unfamiliar words, and the fourth is used to read words that have already been seen before.

When you read by decoding, or phonological recoding, you use knowledge of grapheme-phoneme rules to identify words, by sounding out and blending the letters or blending the syllables of the words into sounds. For example, when reading ***spill***, you might sound out /s/, /p/, /I/, /l/, and then blend those sounds together to form ***spill*** .

When reading by analogy, you use a word that you know to read a word that you do not know. For example, using the known word ***bike*** to derive the pronunciation of the unknown word ***spike***. However, in order for this strategy to work properly, the readers needs to know that ***spike*** can be separated into *sp* and the unknown part – ***ike***. Additionally, they have to remember they know a word with a similar spelling with a known pronunciation – ***bike*** – which can also be segmented into ***b*** and ***ike***. Then, they have to be able to hold the initial ***sp*** in mind, and blend it with the spelling ***ike***. Ehri and

Robbins (1992) showed that readers need to have some decoding skill to be able to use analogies in reading unfamiliar words.

Another way to read words is by contextual recognition or prediction. You use your knowledge of the context as well as letter clues to anticipate or guess a word that would fit properly in that position, both regarding syntax and semantics. The difficulty in reading by context is that you need to know most of the words around the target word to be able to have a sufficient context for identifying the word. Early beginners often make use of pictures to guess words, but they have a hard time guessing words when letters are their only source of information.

The last form of reading – reading by sight – is used mainly when the words are familiar (Ehri, 2005). Upon their presentation, words are recognized immediately because they have been seen many times in print, and therefore their meanings and pronunciations are immediately accessed in memory and recognized. Sight word reading is the only form of reading that is performed automatically without voluntary attention, and therefore, provides the most efficient way to read text. It frees up cognitive resources for use in comprehending the text.

Sight word reading is the first process beginners use to recognize words (Ehri, 1990,1992). To be read by sight, a word has to have become part of the person's reading vocabulary. Reitsma (1983) showed that, following four presentations of a certain word, children showed evidence of retaining that word in memory.

The question of how sight words are stored in memory has generated some controversy among researchers, who have offered different explanations and theories in trying to solve it. However, a good theory has to explain how readers are able to learn, store and recall thousands of words while bypassing a thousand others already stored in memory with very few mistakes in the search. Additionally, it must explain readers' ability to remember new words learned after very few encounters, and the nature of the connection linking the written form of the word to the individual's lexical memory. Not all theories are able to do that.

Dual route theory (Baron, 1977,1979; Coltheart, Davellar, Johassen, & Besner, 1977) claims that the only way to learn to read words by sight is through creating a visual association between the word's meaning and something in its physical shape – a letter, a sequence of letters, a spatial cue in the word's spelling, etc. The mental lexicon is accessed through a direct visual route, which, according to them, is much faster than the phonological recoding route. For dual route theory, the two routes – visual and phonological – never merge. The phonological route is never incorporated or linked to the memory of written words in the lexicon. Rather, the word's pronunciation is accessed after the word's meaning has been reached via a direct route. Therefore, for dual route theory, the connections established between written words and the lexicon to read words by sight are completely arbitrary, are learned by rote, and do not involve letter-sound relations.

However, not all claims from dual route theory are supported by evidence, and some research findings, such as the importance of phonological awareness in learning to read, are not explained by it (Ehri, 1992). Phonological recoding is said to have no role in sight word reading, but the theory cannot explain why children who lack decoding skill fail to become good sight word readers (Gough & Tunmer, 1986).

A different theory of sight word learning is proposed by Ehri (1990, 1992). Her theory predicts that when we learn a new word, we use the phonemic value of the word's letters as a mnemonic device to connect the word's spelling to its pronunciation in memory, and to its meaning. The word is then encoded through its phonological value, as interpreted by the reader. Therefore readers use their knowledge of the alphabetic system with its grapheme-phoneme relations to form connections between letters in the spellings seen and phonemes detected in the pronunciations of the words. Upon seeing that word again, its pattern of letters immediately activates its stored pronunciation, as well as its meaning in the lexicon. This process is responsible for the speed with which we recognize words that we have learned. In Ehri's theory, connections are systematic, not arbitrary, with letter-sound relations a fundamental part of the mnemonic system used to establish those connections.

The difference between Ehri's sight word learning theory (Ehri, 1990, 1992) and dual route theory can be shown in an example taken from Ehri (1998). If sight words were learned by rote, then it would not matter whether the spelling LFT stands for the word ***elephant*** or for the word ***monkey***, since with repetition and practice both should be equally easy to learn. However, research findings show (Ehri & Wilce, 1985) that LFT as a symbol of ***elephant*** is much easier to learn if the learners know that the letters L,F and T represent the sounds for /l/, /f/ and /t/, and if they can detect those three sounds in the pronunciation of the word ***elephant***. The reason, according to the author, is that by using this knowledge, learners can establish systematic letter-sound connections between the individual letters in the spelling seen and the sounds heard in the pronunciation of the word already stored in memory.

Although easier to remember, spellings such as LFT for ***elephant*** are not fully reliable, since those three letters could also be symbols for words like ***lift*** or ***left***. A more complete spelling would limit the number of alternative words that could be represented by it. Therefore, complete spellings that match all sounds heard in a word should enable more reliable sight word learning. Still, the role of the learners cannot be discounted. If they lack sufficient grapho-phonic knowledge about the system to be able to form complete connections between spellings and sounds, the representation in memory will remain partial, incomplete and unreliable.

Evidence for this type of connection forming process in readers of different abilities was gathered by Ehri and Saltmarsh (1995). The authors investigated whether beginning and disabled readers would retain full letter information about sight words in memory. They compared three groups of readers differing in reading ability – first grade advanced readers, first grade novice readers, and older disabled readers. They assessed students'spelling, nonword reading, and their ability to learn and recall sight words. Participants learned to read sixteen target words, with simplified phonetic spellings (e.g., ***messenger*** spelled MESNGR) either spelled in format A (e.g., MESNGR) or B (e.g., MESNJR). Students completed at least ten practice trials, with feedback given when necessary. Three days later they were asked to read those sixteen target words again, but the original words were mixed with spellings that had been altered: single letters had been added, deleted or replaced (e.g., MESNGR could appear as MESNJR or MEZNGR) in the initial, final or medial position, and the participants were timed in their reading.

Results showed that the 3 groups read original words faster than some types of altered spellings. When phonetically equivalent letters replaced original letters in familiar words, readers showed longer latencies, indicating that they recognized the letter substitutions. This was interpreted to show that they were not decoding the words, but were searching in their memory for the original spellings. Regarding the location of the changes in spellings, beginning readers were affected by letter changes in initial, medial and final position, while disabled readers were affected only by initial and final letter alterations. Interestingly, disabled readers took significantly more trials to learn to read the target words, indicating deficiency in their sight word learning processes. This fact, combined with their inability to detect the alterations in medial position led the authors to suggest that disabled readers acquired only partial grapho-phonic word representations in lexical memory, by processing only partial letter information, which might explain their impaired memory for words, since they were not processing all the graphemes in the words when learning them.

Results of this study indicated that the more mature beginning readers had acquired fully formed sight words in memory, whereas disabled readers and novice beginning readers had formed only partial representations of the words in memory. The next section will describe in more detail the development of sight word learning.

Phase theory of the development of sight word learning.

According to Ehri's developmental phase theory of word learning (Ehri 1991, 1994, 1995, 2005) children move through four different phases in their learning of words: pre-alphabetic, partial alphabetic, full alphabetic and consolidated. The phases are distinguished by the types of connections formed to retain sight words in memory.

The pre-alphabetic phase portrays the initial period when children are still clueless about how sounds of words are represented by letters. If they are able to read any words, they do this by remembering distinctive visual characteristics of the words, like the tail of the letter *g* in the word ***dog***, or a logo from a favorite restaurant, like the golden arches in McDonald's. However, children are unable to identify the same words out of the logo context, because the visual features they associated with the meanings of the words are no longer there. (Masonheimer, Drum & Ehri, 1984). Ehri calls this type of word reading pre-alphabetic reading (Ehri, 1992), or visual cue reading in earlier studies (Ehri, 1987; Ehri & Wilce, 1985, 1987a, 1987b), while other authors refer to it as logographic reading (Frith, 1985).

A pre-alphabetic representation, in which the reader associates the meaning of a word to its physical characteristics (for example, the two eyes- the two letter O - in the middle of the word ***look***), is not a very effective way of remembering how to read many words. The associations formed are arbitrary, not systematic, and the visual cues chosen may not be exclusive of the selected word, which can cause the reader to confuse similarly spelled words (e.g., ***book***).

The next phase – partial alphabetic – starts when children begin to realize that letters have sound values, and they can use those letters to represent and remember words, although in a very rudimentary way. Ehri (1992,1999) describes their reading process as partial alphabetic reading (or phonetic cue reading in earlier studies), where there is a mix of visual information with partial alphabetic information, mainly in the form of sounds from letter names. Although not very efficient, partial alphabetic reading is easier than pre-alphabetic reading, because it uses systematic associations between letters and sounds to access the words in memory.

Evidence for the difference in the two forms of reading was gathered by Ehri and Wilce (1985). They compared non-readers (pre-alphabetic readers), novice readers who were able to read a few words, and veteran readers who could read several words. Students practiced reading either visually distinctive spellings that contained no letter-sound correspondences (e.g., xgsT for ***balloon***, Fo for ***knee***, or WBC for ***giraffe***), or phonetic spellings, that were less distinctive visually but contained letter sound relations, especially letter names (e.g., BLUN for ***balloon***, NE for ***knee***, or JRF for ***giraffe***). Children were taught one set of visual spellings and one set of phonetic spellings through the paired associate method. They were shown the spellings, and told how to read them during a study trial. Then they were asked to read the words by themselves, and corrective feedback was given. Results showed that pre-alphabetic readers learned visual spellings better than phonetic spellings. In contrast, both veterans and novice readers, who were at least partial alphabetic readers, read phonetic spellings more easily than visual spellings. This experiment showed that as soon as children possessed at least some letter-sound knowledge, they could make use of it to learn to read words by sight. Ehri (1999) regards this as sight word learning because children read the words from memory. They did not decode the words, because the simplified spellings were not decodable and also because the pre-alphabetic readers and novice readers lacked the ability to decode novel words.

To perform partial alphabetic reading, children have to possess some phonetic segmentation skill. That is, they have to be able to parse words into some constituent sounds. Also they must know some letter names and letter sounds (Ehri, 1999). However, children’s detection of sounds inside words is rudimentary and limited to the more salient initial and ending sounds. Partial alphabetic readers also lack full knowledge of the spelling system, particularly vowels.

Beginners in the partial alphabetic phase have a less efficient way of storing words in memory to read them by sight because they are not able to perceive and use all the grapho-phonic connections in words to retain them in lexical memory. They only store partial connections between some letters in spellings and their sounds in pronunciations. For example, upon seeing and hearing the word ***ticket***, they might detect the sound /ti/ at the beginning of the word, the sound that is also present in the name of the letter T. That single letter can be used for establishing a connection between the word's spelling and its meaning and pronunciation in memory. However, because only one letter was used to remember how to read ***ticket***, other words that also begin with T may be read by the partial alphabetic reader mistakenly as ***ticket***.

Word reading accuracy improves in the next stage. Children in the full alphabetic phase are able to use all grapho-phonic correspondences linking letters in spellings to phones in pronunciations to differentiate among similarly spelled words and to store them in lexical memory. The difference in performance between children in the partial alphabetic phase, and children in the full alphabetic phase was demonstrated by Ehri & Wilce (1987b). The authors selected novice readers from kindergarten who were partial alphabetic readers, and trained half of them to analyze nonsense words into their phonemes. This group was taught to read words by paying attention to all their letter-sound correspondences, which in fact transformed them into full alphabetic phase readers. The other group remained partial alphabetic readers. They practiced individual letter-sound relations. Then both groups were taught to read 15 words not previously practiced, in a paired-associate task, with corrective feedback given if necessary. Results showed that full alphabetic readers performed much better than partial alphabetic readers. They learned more words in fewer trials, and they remembered them better. When asked to spell the words they had learned, full alphabetic readers spelled more words correctly, and wrote more correct letters, including more vowels and consonant clusters than partial alphabetic readers.

Incidentally, although both groups had similar short vowel knowledge at the start of the experiment, their knowledge became significantly different after the training, as seen through the results of a short vowel letter-sound task administered before and after training. Full alphabetic readers acquired significantly more short vowel knowledge, although it is not known if such knowledge came from the word reading task, or from decoding training.

As children become able to decode a greater variety of new words, and as they accumulate fully connected sight words in memory, they move into the last phase, the consolidated alphabetic phase, when they start to use orthographic patterns, morphemes and multi-letter units to parse and read words. These larger units are recognized and used to form connections when storing words in memory. This eases the load in memory, because clusters of graphophonic relations are stored and recognized rather than individual grapheme-phoneme connections (e.g., ***cleanliness*** would possibly be stored as *clean-li-ness* [/klin/, /lI/, /nes/] , instead of as /k/, /l/, /i/, /n/, /l/, /I/, /n/, /e/, /s/). Speed and accuracy of word recognition improve, as well as memory for spellings.

In the proposed study, the ability to learn and store sight words was investigated in children possessing different levels of short vowel knowledge. The influence of their knowledge in learning words written with and without vowel letters was measured with a task similar to the one used by Ehri and Wilce (1985), who taught children of different reading abilities to read visual and phonetic spellings through the paired associate method (described previously).

Children with different levels of short vowel knowledge were taught to read words with and without vowels. The reasoning is that as they mature in their knowledge of the grapho-phonemic system, and move from the partial to the full alphabetic phase in reading (Ehri, 1999), they should become able to use more complete knowledge of the alphabetic system to connect letters to sounds in the new words being learned.

Since knowledge of vowel spellings is one of the most important distinctions between less mature readers in the partial alphabetic phase and more mature readers in the full alphabetic phase, if children have secure knowledge of short vowel spellings, they should be able to use them to learn new words faster, and to remember their spellings better, because those words should become more completely and accurately represented in their lexicons. In contrast, children who lack short vowel knowledge should find it more difficult to deal with an extra letter in a word, a letter that cannot be used as a mnemonic because its sound is not known. Therefore, the hypothesis tested is that children with high vowel knowledge will learn words written with vowels more easily than no-vowel words, whereas children with low vowel knowledge will learn no-vowel words easier than words with vowels.

Rationale and Hypotheses

This study had two main objectives: 1 – to understand the development and the distribution of short vowel grapheme-phoneme knowledge[2] among beginners across different tasks; 2 – to examine the contribution of short vowel grapheme-phoneme knowledge to the ability of children to read and spell sight words.

The following research questions guided this study's investigation of the first objective:

1. How much do beginning readers know about short vowel grapheme-phoneme representations in reading?
2. How much do beginning spellers know about short vowel phoneme-grapheme representations in spelling?
3. Is there any evidence that children use short vowel grapheme-phoneme knowledge in recognition tasks before they actively produce short vowels in reading and spelling tasks?
4. Which tasks are the most reliable and least time consuming in detecting children's short vowel grapheme-phoneme knowledge?

Various tasks were developed to seek answers to these questions. They allowed us to investigate knowledge of short vowels in early beginners as well as their knowledge of other sounds, and how much ability they had in using that knowledge to read and spell words and nonwords. Results were expected to show us which task was the most reliable and least time consuming in identifying short vowel knowledge in children.

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[2] In this study, the term short vowel grapheme-phoneme knowledge is being used interchangeably with short vowel letter-sound knowledge or short vowel knowledge. It is meant to include both knowledge of grapheme-phoneme vowel decodings and phoneme-grapheme vowel spellings, but it is not meant to include phonemic categories of vowel sounds that do not involve how the sounds are spelled.

Some methodological questions arose in the assessment of knowledge through different tasks: how much would task demands influence the outcomes, and how different were the demands placed on children by the different tasks. For example, if a child could identify the sound of a vowel letter, would she be able to use that vowel letter-sound for reading? For spelling? Which tasks were more sensitive to minimal levels of knowledge possessed by children, and which tasks assessed only well-established knowledge? Because this study assessed vowel knowledge through different tasks, it was expected to yield useful information regarding which tasks reflect children's knowledge more reliably.

Additionally, the following hypotheses were tested in the present study:

Hypothesis 1. Attribution of vowel letter-sound knowledge will vary depending on the level of difficulty of the task (e.g., vowel production tasks being more difficult than vowel recognition tasks).

Hypothesis 2. Children's level of short vowel letter-sound knowledge will correlate significantly with word reading and spelling abilities. Theories of spelling development state that vowel knowledge is indicative of a higher level of maturity in reading and spelling. So, it is hypothesized that a higher level of short vowel knowledge in children will correlate significantly with both reading and spelling.

Hypothesis 3. Children with high short-vowel grapheme-phoneme knowledge will learn to read words spelled with vowels more easily than words spelled without vowels. This is because more complete representations that fully specify the pronunciations of words are retained in memory when vowels are spelled. When vowels are omitted from written words, the words are more ambiguous and harder to identify.

Hypothesis 4. Children with low short vowel knowledge will learn to read words spelled without vowels more easily than words with vowels. This is because words are shorter when vowel letters are not included. It should be easier to form connections to remember three letter words than four letter words and to distinguish among them if there is no mnemonic help from the vowel system.

Hypothesis 5. Children's knowledge of short vowels follows a developmental sequence: some vowels are better known than others for most children.

Chapter 3

Methods

This study was conducted in two parts. The first part was a correlational study examining relationships between performance on various measures of children's short vowel grapheme-phoneme knowledge and their reading and spelling abilities. The second part was an experimental manipulation, where two groups of children differing in their vowel knowledge learned to read two sets of spellings, one with vowels and one without vowels.

Participants.

The participants in this study were one child from kindergarten and 23 first graders enrolled in a public school (*N=24*). Parents provided written consent for their child's participation. No child with any history of speech or hearing impairments, or emotional problems, as identified by the school, was considered for participation. The children's school was in an ethnically diverse neighborhood and had 85% of its student population on free or reduced-price lunch. (69% free and 16% reduced price lunch). Children were drawn from four different classrooms in the school. There were 14 girls and 10 boys that participated. One child was Caucasian, two children were of Asian descent, six children were African-American, and fifteen were of Hispanic/Latino heritage. The mean age was 77 months, and the standard deviation was 4.30.

All children spoke English proficiently, as identified by the school. The school had a high concentration of Spanish speaking families, but none of the children were part of a bilingual class, although ESL classes existed at the school. Children had all been in an English speaking class for at least one full year. They interacted well with the researcher, showing no signs of difficulty in expressing themselves or understanding what was talked about or requested from them.

Reading instruction used in the students' classrooms followed loosely the "*Month by Month Phonics Program*", by P. Cuningham and D. Hall (2002), which the teachers were using for the first time. The children's routine included working on their word wall, reading with big books, individually or in pairs, doing choral reading and echo reading. There was not a strong emphasis on phonics in the school, and children who needed additional help were directed to the reading specialist who worked with them to learn sight words from the word wall.

Short vowels were taught with word families. The order of presentation of the individual short vowels followed A – I – O – U – E. Testing occurred at the beginning of first grade, from October to December. At the time testing started, children had already been introduced to A and I. At the time testing ended, children had reviewed A- I, and they had been introduced to short O. Some classes were reviewing A-I-O whereas the other class had already stated working with short U.

Materials.

General tasks were administered to screen children for participation in the study, to assess their level of short vowel letter-sound knowledge and their ability to use this knowledge to read and spell. Task performance was also used for the purpose of assigning students to high and low vowel knowledge groups. A word learning task was given to investigate the ability of children of different levels of vowel knowledge to learn words with and without vowels. Tasks were given in the order listed below. Although teachers had stated that children were familiar with both capital and lower case letters, most tasks used capital letters, except where noted.

Tasks.

Most tasks used were not new, and have been used in the past to investigate letter sound knowledge in children (Ehri & Wilce, 1985, 1987; Taylor, 1984). Previous studies have shown that children's spelling of vowels is strongly influenced by their knowledge of letter names (Treiman, 1993). However, the tasks used here focused mostly on children's identification and use of short vowel letters, whose sounds are not found in their letter names. Reported reliabilities for all tasks were based on the present sample, except for the Woodcock Word identification subtest of the WRMT-R, whose reliability was drawn from the test manual.

Task 1 (Letter name knowledge) and Task 2 (Letter sound production – vowels (V) and consonants (C)) dealt with assessing children's knowledge of letter names and letter sounds. Previous experience has shown us that children who know fewer than 8 letter names usually do not know any letter sounds and cannot read or spell, so all children who could not name at least 8 letters were excluded from the study.

Task 1 - Letter Name Knowledge. Children were asked to name all 26 letters of the alphabet, presented in random order on cards, as quickly as possible. Capital letters were used, except for the letter I, which was presented in lower case to avoid confusion. One point was given for each correct response. Reliability in this task was not calculated due to lack of sufficient variance.

Task 2 - Letter Sound Production (vowels - V- and consonants - C-). Children were asked to give the sounds of all 26 letters of the alphabet, presented in random order on cards. Capital letters were used, except for the letter I, which was presented in lower case to avoid confusion. For each sound produced, one point was given. For vowel letters, if the child did not provide all sounds, he/she was asked, "Do you know of any other sound this letter makes?" Points were given only for the correct short vowel sounds, although knowledge of long sounds was recorded. For consonants having more than one correct sound (C, G), either sound was accepted. The total number of points possible was 26, 21 points for consonant sounds, and 5 for vowels. Cronbach's Alpha internal consistency reliability for vowel sounds in this task was .80. Consonant sound's reliability was not calculated due to lack of sufficient variance.

Task 3 -Vowel Sound-Letter Writing. The objective of this task was to assess the ability of the children to spell short vowel sounds they heard in isolation. In order to succeed in this task, children had to search their memory for the correct symbol to represent each vowel sound that they heard. Results from this task were also combined with results of a more complex spelling task, in order to clarify whether beginning readers were able to spell vowel sounds only in isolation or also when embedded with other sounds in words. The researcher pronounced each short vowel sound in isolation, and the child was asked to write, on a blank sheet of paper, the letter that represented that sound. The order used was I-O-A-U-E. One point was given for each sound correctly depicted. Cronbach's Alpha reliability coefficient for internal consistency for this task was .67.

Task 4 - Vowel Sound-Letter Recognition. This task assessed children's ability to recognize the correct short-vowel letter representation for a sound they heard. This task was expected to be easier than Task 3 because children had only to pick from one of three letter choices instead of recalling and writing the letter representing that sound. Because recognition tasks are easier than production tasks, we expected that children would be able to recognize the correct spelling choice even when they were not able to locate the representation of some sounds in memory to spell them. Children were asked to find/point to some letters (on cards) that represented sounds dictated by the researcher. These sounds were the five short vowel sounds. The cards displayed three letters, one correct answer and two foils, in mixed up orders. Letters were written in capitals, except for the letter I, which was displayed in lower case. There were 10 cards, two targeting each vowel. One point was given for each correct vowel letter recognized. Cronbach's Alpha internal consistency coefficient for reliability in this task was .74.

Taylor (1984) found that vowel letter knowledge in children appears first in reading and only later in spelling. Although her research was not limited to short vowels, there is every reason to expect that the same would hold true in the present study for short vowels even for early beginners, and that knowledge for reading short vowels in words would appear before knowledge for spelling short vowels in words.

Ideally the foregoing tasks all assessing letter-sounds in isolation were expected to portray the status of children's knowledge and allow comparisons between their letter-sound knowledge and their ability to read and spell. Such short assessments have been used in the past in numerous studies (Ehri & Wilce, 1983, 1985, 1987; Taylor, 1984; Bhattacharya & Ehri, 2004). To compare the relationship between measures of letters and sounds assessed in isolation and measures taken in the context of reading or spelling, additional tasks that assessed children's knowledge when actually reading or spelling were included, as well as more items assessing each vowel in each task. Tasks 5, 6 , 7 and

9 assessed grapheme-phoneme relations in context, either by reading or spelling. These were harder tasks than identifying letters and sounds in isolation. Besides recognizing and matching letters and sounds to symbols in their lexicon, children had to blend sounds together and to process and eliminate alternative choices.

Task 5 - High-Frequency Short Vowel Word Identification Task. The objective of this task was to determine how well children could read high frequency words containing short vowels. The literature on spelling development shows that children's knowledge of spellings is particularly affected by the frequency of occurrence of certain graphemes in the print they are exposed to (Treiman, 1993; Cassar & Treiman, 1997). It was expected that if children could recognize a large number of high frequency words that contained short vowels, they would have at least implicit knowledge of the short vowel system. Therefore, this task's ultimate goal was to investigate whether there was any relationship between knowledge of specific words and knowledge of short vowels. Additionally, general results from all the vowel tasks could show whether there was a pattern in the acquisition of short vowels. Some vowels might be better known than others for most children.

Children were asked to read a set of words drawn from the Harris and Jacobson's (1972) pre-primer, primer and first grade word lists (total = 54 words). All high frequency words chosen contained short vowels and were regularly spelled, and they were presented in lower case letters. The numbers of words across vowels were not equal, but the distribution reflected the frequency of occurrence in the Harris and Jacobson list, where short A is the most frequent sound for short vowels, followed by E. Pictures of words not on the list were mixed up with the words to provide a sense of accomplishment to children whose reading identification skills were low. One point was given for each written word correctly read. The reliability for this task using the Spearman Brown split-half coefficient was .98.

Task 6 - Woodcock Word Identification. This standardized, nationally normed subtest of the Woodcock Reading Mastery Test, Revised, (WRMT-R), (Woodcock, 1987) was used to assess children's level of word identification at pre-test. Children read a sample of words that they might identify either by decoding or by sight, starting with high frequency words and progressing to lower frequency, harder words. Since this is a standardized test, it allowed the placement of each child along a continuum of beginning reading skill. It also allowed the investigation of relationships between general word reading ability and short vowel knowledge as measured by the various vowel tasks. Children were given the test on cards in lower case letters. They continued reading words until they failed to read at least 6 consecutive words in the same set. One point was assigned to each word correctly read. The reported reliability of this test is .98.

Task 7 (Pseudoword reading test) and Task 9 (Pseudoword spelling) asked children to decode or to spell target nonwords. The nonwords had no meanings, although they could be decoded or spelled using legal letter sound relations.

Task 7 - Pseudoword Reading Task. The objective of this task was to evaluate each child's use of grapho-phonemic associations to decode nonwords, especially those containing short vowels. Pseudowords were used to rule out familiarity effects for words. Children were asked to read 10 nonwords, 5 vowel-consonant (VC) spellings (AP, IB, EK, OP, UT) and 5 Consonant-Vowel-Consonant (CVC) spellings (TAF, FIP, PEB, VOT, NUK). All were displayed in capital letters. Each child was assigned three scores:

one score indicating the total number of pseudowords read (total = 10); an initial vowel score indicating the number of initial vowels correctly pronounced (total = 5); a middle vowel score indicating the number of middle vowels correctly pronounced (total = 5). Reliability for this task was .79, using the Cronbach's Alpha internal consistency coefficient.

Task 8 - Spelling Test of Real Words. Children were given a spelling task to assess their ability to represent short vowels, both at the beginning and middle of words. Although in spelling real words there is always the risk of children knowing the word from memory and spelling it, the risk should be diminished by using words that are more advanced than children's current grade level. Ten simple words, 6 one-syllable words (SACK, FIT, MUG, DECK, KNOCK, ITCH), 3 two-syllable words (ACTOR, ECHO, UPPER) and 1 three-syllable word (OFFICER) were used in this task. There were two words for each of the five vowels. One word had the vowel at the beginning of the word, and the other had the vowel embedded in the word. One point was given for each vowel correctly represented in those spellings. Reliability for this task using the Cronbach's Alpha coefficient of internal consistency was .82.

Task 9 - Pseudoword Spelling. The objective of this task was to assess children's written representation of short vowels in words not previously seen. Pseudowords were used to exclude memory for known spellings as a factor influencing performance. Children were asked to spell some sounds that are common parts of English words. They were given examples of real words that sound like their spelling target, to make sure the sound is correctly identified by the children. Additionally, children were asked to repeat what was heard, to make sure they did not misperceive any sound. For example, they were asked: “I want you to spell AB as in ***lab***. Say ***lab***. (child responds). Say AB (child responds). Spell AB”. The parts of words used, and their sound-alike words were: AB (***lab***), IP (***lip***), UCK(***luck***), ET(***net***), OP(***mop***), AP(***lap***), ICK(***sick***), UT(***nut***), ECK(***neck***), OT(***dot***). One point was given for each vowel correctly represented in those spellings. Reliability for this task using the Cronbach’s Alpha internal consistency coefficient was .87. Combining the 20 items in the two spelling tasks (real words and pseudowords) increased the Alpha coefficient to .92.

Task 10 - Word Learning Task. This task had two main objectives: The first objective was to see whether the presence or absence of letters representing short vowels in words would affect children’s word learning. The second objective was to see whether children who possess knowledge of short vowel letter-sound relations would perform differently from children lacking vowel spelling knowledge.

Children were taught to read two sets of simplified spellings (set K and set L) displayed in capital letters, consisting of ten words each, through the paired associate method, in a repeated measures design. Depending on the speed of learning for the first set, children learned the second set on the same day or on the next day.

The words were taken from the fourth grade level of the Harris and Jacobson graded word list (Harris & Jacobson, 1972) and were similar in their frequency. Two-syllable words with clear short vowel pronunciations were chosen. Two lists consisting of ten words each were created. On each list there were two words spelled with each of the 5 short vowels. All children learned the two lists, but the lists were counterbalanced across children for order and presence or absence of vowel letter.

The spellings of the words taught to children were modified to match the type of spellings produced by partial alphabetic readers who can only form partial connections between letters in words and sounds they heard in the pronunciations of the words (Ehri, 1985, 1987; Treiman, 1993). These modified spellings are called simplified spellings (Ehri, 1985, 1987). Simplified spellings have been used in the literature researching sight word learning because they provide information about the word learning processes of younger readers who cannot yet decode but who can use some letter sound and letter name information to learn to read words. Simplified spellings use only a few letters of a word, and they resemble the immature spellings of partial phase readers who focus only on the most prominent letters-sounds of the words in their spellings. For example, instead of teaching the full spelling RUBBER, only RBR or RUBR were taught. Preferably letters with one-letter-to-one-sound correspondences were used.

Each list of 10 words was built to maximize the spelling similarity among the target words. A limited set of letters was used to spell all words, and five word pairs each showed the same initial letter in each list, so as to make spellings of words more similar. This was done for two reasons: to make sure children were not learning words on the basis of visually distinctive cues only, which has been shown to occur (Ehri, 1985), and to require careful attention to letter details in the spellings being learned.

One of the sets contained vowel letters in their spellings, and the other set did not. Presence or absence of vowel letters in a set, and the order in which each set was learned were counterbalanced across children. This resulted in four different conditions (C1, C2, C3, C4). The spellings that were taught in each set are shown in Table 1.

Table 1

Spellings of Word With and Without Vowel Letters Taught in the Word Learning Tasks

Words	Vowel Present	Vowel Absent
Word Set K		
Castle	KASL	KSL
Message	MESJ	MSJ
Kitten	KITN	KTN
Model	MODL	MDL
Tunnel	TUNL	TNL
Rattle	RATL	RTL
Pencil	PESL	PSL
Ticket	TIKT	TKT
Possum	POSM	PSM
Rubber	RUBR	RBR
Word Set L		
Ladder	LADR	LDR
Devil	DEVL	DVL
Simple	SIPL	SPL
Bomber	BOMR	BMR
Bubble	BUBL	BBL
Fasten	FASN	FSN

(*table continues*)

Table 1 (continued)

Words	Vowel Present	Vowel Absent
Lettuce	LETC	LTC
Fiddle	FIDL	FDL
Dollar	DOLR	DLR
Summer	SUMR	SMR

On the first study trial, children were shown the spelling and a picture of the word that each spelling represented. They also heard the word used in a sentence. On subsequent test trials, they were shown the spellings in different random orders and asked to read them. Corrective feedback was provided after each response, or, after 10 seconds following the presentation of the spelling if the child did not respond. The criterion for learning each set was reached when a child was able to identify correctly all words in a set twice. The maximum number of trials for each set was fifteen.

One point was given to each word correctly identified, and children reaching criterion earlier than the 15th trial received points for the remaining trials not given. The number of trials to reach criterion, the number of words read during trials 1-5, and the number of words read on each trial were used as outcome measures of this task. The parallel forms reliability in this task was calculated using a Pearson's correlation for the two sets of words (set K and set L) for the number of words learned over 5 trials, which reached a coefficient of .90.

Task 11 - Spelling Words Learned. Immediately following their learning of each word set, children were asked to spell the words they learned. This was done twice, once after each set was learned. The number of correct letters and the number of words spelled correctly were the scores for this task. The parallel forms reliability for this task was calculated using a Pearson's correlation for the two sets of words (set K and set L) for the total number of letters correctly spelled (according to model) divided by total number of letters possible, which reached a coefficient of .62. Task 11 complemented Task 10. It investigated how much the word learning exercise impacted children's memory for vowels. Would children remember correctly the spellings learned, or would their memory be affected by their knowledge (or lack of it) of short vowels? Ehri’s theory (1992,1998, 2005) predicted that only children with some knowledge of the vowel system would be able to remember and spell short vowels in words. According to her, children need to know letter-sound relations to store new words in memory by bonding letters seen in a word to phonemes heard in its pronunciation. With practice this enables immediate word recognition.

The idea behind these tasks, especially Task 10, was to see how efficient children’s word learning process is, and whether that process is affected by children’s knowledge of vowels. As pointed out in the literature review, children in the partial alphabetic phase have very limited knowledge of vowels and are not very skilled at representing spellings for the sounds they hear in words. Incomplete representations of spellings in memory may lead to confusion between similar words. Vowels are an important part of spellings in English, and they can aid in disambiguating words if children know them well enough to use them. It is hard to say what is enough, though. Children with a limited knowledge of vowels would be expected to have more difficulty in learning words spelled with vowel letters than words without them. According to Ehri’s theory (1992, 1998, 2005), they would not be able to establish connections between sounds heard in the pronunciations of words and all the letters in the spelling seen. In fact, letters representing the vowel sounds might even be ignored or become an extra burden in the learning of a word, slowing down the learning process.

On the other hand, Ehri’s theory (1992, 1998, 2005) would predict that readers with a higher level of knowledge of the alphabetic system, especially of the vowel system in English, would have an easier time making connections between more complete spellings and pronunciations in words, and therefore, learn them better.

Procedure.

Pre-test phase.

The children were pre-tested on various tasks aimed at measuring their knowledge of the alphabetic system including their knowledge of grapheme-phoneme and phoneme-grapheme relations, especially their recognition and production of short vowel spellings. They were also given several word reading and spelling tasks. Performance on the vowel tasks were used to separate the children into high and low vowel letter knowledge groups.

Training phase.

Based on their combined score in reading high frequency words and Woodcock words, the children selected to participate in the training were ordered from high to low. The top four children on the list were randomly assigned to the four conditions, with each child assigned to a different condition. The next four children were randomly assigned to the four conditions, and so on until all sets of four children had been assigned to the conditions.

Conditions:

Children learned to read two sets of ten words (Set K and Set L), each word represented as a simplified spelling. One set of words contained vowel letters whereas the other set did not. The five short vowels were equally represented in each set, so that each child learned two words with the same short vowel in each set. The order of presentation of the sets, and the presence or absence of vowel letters were counterbalanced across the four conditions, as described next.

Condition 1:	Learned First	Set K – words spelled with vowels
	Learned Second	Set L – words spelled without vowels
Condition 2	Learned First	Set K – words spelled without vowels
	Learned Second	Set L – words spelled with vowels
Condition 3	Learned First	Set L – words spelled with vowels
	Learned Second	Set K – words spelled without vowels.
Condition 4	Learned First	Set L – words spelled without vowels
	Learned Second	Set K – words spelled with vowels

The within-subject comparison was intended to answer the question "Does the presence of vowel spellings in words facilitate word learning?" The number of vowelized words learned was compared to the number of no-vowel words learned by children. The hypothesis tested was that children with high vowel spelling knowledge would learn words written with vowels more easily than no-vowel words (i.e., in fewer trials), whereas children with low-vowel spelling knowledge would learn no-vowel words faster.

After the word learning task, children were asked to spell the words just learned, one set at a time. Depending on the child, the pre-tests lasted between one and three sessions, each session varying between twenty to thirty minutes. Children were usually pre-tested in successive days, and most children finished it in two sessions, the first session going up to the spelling of words and nonwords, and the second session continuing from there. When all children had been pre-tested, they were assigned to their conditions, and training began. Depending on the child it could last one or two sessions.

If the child was fast and learned the first set in few trials, the second set was taught as well in the same session. Six children learned both sets of words in one session, and 14 children learned only one set of words per session. After each set, the child was asked to spell the words learned.

Analysis of the data.

Data from the pre-tests were scored. Correlations were examined between the various vowel measures and reading and spelling measures to investigate their relationships and to determine which measures best predict children's short vowel spelling knowledge.

Scores on vowel tasks were transformed to z-scores and summed to get a total score, and children were divided in two groups according to their performance on the total score. Children in the lower half of the distribution were considered the low vowel knowledge group, and children in the upper half were considered the high vowel knowledge group. T-tests were used to compare the high and the low short vowel letter knowledge groups on variables other than their knowledge of vowels to determine whether the groups formed differed on other tasks as well.

Once the groups were formed, performance in the learning task (the experimental manipulation) was analyzed to investigate whether the presence or absence of short vowel letters in words affected children's word learning, and whether the extent of their vowel knowledge would make a difference as well.

A preliminary two-way ANOVA was used to assess the effect of the control variables resulting from counterbalancing (i.e. word set K vs. L, and words with vowel letters learned first vs. second). The dependent variable was the difference in the number of trials to criterion between learning words with vowel spellings and learning words with no-vowel spellings. The independent variables were word set and learning order.

Two and three-way analyses of variance were used to analyze the results. The independent variables were reader group (low vowel knowledge vs. high vowel knowledge), and two repeated measures variables, trials (T1 vs. T2 vs. T3 vs. T4 vs. …. T15) and vowel presence in the words learned (no vowels spelled vs. vowels spelled). Our dependent variables were: (1) number of words learned per trial, (2) number of words learned after 5 trials and (3) total number of trials to reach criterion.

Memory for the spellings learned was also tested using ANOVAs. The independent variables were participant group (low vowel knowledge vs. high vowel knowledge) and presence of the vowel letter in the set learned (vowel present vs vowel absent). The dependent variables were the number of totally correct spellings and the number of letters spelled correctly across the 10 words.

We expected that children with high vowel knowledge would learn words containing vowels more easily than no-vowel words. In contrast, we expected children with low vowel knowledge to learn no-vowel words easier than words with vowels.

Chapter 4

Results

Characteristics of participants.

The twenty-four children who participated in this study are characterized in Table 2. Twenty-three of them were in first grade, and one child was in kindergarten. Because the kindergartner's performance was very similar to that of students in first grade, she was retained in the sample. Fourteen of the children were girls, and ten were boys. Their mean age was 77 months old at the time of the testing, with a standard deviation of 4.3.

Table 2

Descriptive Statistics of Student Performance on Vowel Knowledge and Word Reading Tasks

Characteristics	Rel.	Max	Mean (*N*=24)	*SD*	Range[a]	% Correct
Age in months	-	-	77.00	4.30	68-83	-
Task 1- Letter name knowledge	-[b]	26	25.91	0.28	25-26	99.7 %
Task 2(C) Consonant letter sound production	-[b]	21	20.04	1.48	14-21	95.4%
Task 4 – Vowel sound letter recognition	.74	10	8.12	2.00	3-10	81.2 %
Task 3 – Vowel sound letter writing	.67	5	3.08	1.53	0-5	61.6 %
Task 7 Vowel reading in VC pseudoword	.79	5	2.96	1.52	0-5	59.2 %
Task 2(V) Vowel letter sound production	.80	5	2.50	1.81	0-5	50 %
Task 8 and Task 9 – Vowel spelling in words and pseudowords	.92	20	10.00	5.94	0-20	50 %
Task 5 – High frequency short vowel word identification (whole word)	.98	54	26.04	18.42	1-54	48.2 %
Task 7 (CVC) – Vowel reading in CVC pseudoword	.79	5	2.38	1.67	0-5	47.6 %
Task 7 – Correct pseudoword reading	.79	10	4.12	3.54	0-10	41.2 %
Task 6 – Woodcock word identification	.98	112	22.83	18.19	1-75	1.6 GE

Note. Rel. = Reliability; GE=Grade Equivalent.
[a]Values displayed are actual ranges of children's scores. [b]Reliability was not calculated due to lack of sufficient variance.

As evident in Table 2, all children had mastered letter names, including vowel letters, except for two children who did not remember correctly one consonant name. Children's consonant letter-sound knowledge was also fairly high, with only two individuals knowing fewer than 20 consonant sounds (one knew 18, and the other 14).

Knowledge of short vowel spellings was much lower than consonant knowledge, with means ranging from 50% to 81% correct across the four tasks. The correct recognition of letters to represent sounds heard, given three choices, was an easier task, with only eight children below the mean of 80% correct, which is well above chance. The fact that children were quite successful pointing out the correct sound when provided with choices, suggests that they had more knowledge of vowel sounds than they were able to demonstrate in tasks that demanded production of vowel spelling-sound associations. If a stricter criterion is adopted, where a point is given only if children respond correctly to both instances of word recognition for each vowel, the same results are reached. Correlations between the more loose and the more strict scoring system are high and significant, ranging from .893 to 1. Hence, the loose scoring criterion was used in the analysis and throughout the dissertation.

It is interesting to notice that vowel word spelling means (50% correct), and vowel pseudoword reading means (53 % correct) were similar. In both cases, the mean was about half of the maximum score possible, and the standard deviations were large. However, it is important to point out that children performed differently in reading pseudoword vowels, depending on the position of the vowel in the syllable. Vowels in VC pseudowords such as AP were somewhat easier to read (59.2% correct) than vowels in CVC pseudowords such as TAF (47.6% correct), a significant difference (*t* (23) =2.17, $p < .05$).

In the high frequency and Woodcock word identification tasks there was great variability in children's performance identifying real words. There were some children able to read many words, while there were others who read almost none.

In terms of decoding skills as measured in the pseudoword reading task, the group also varied. Seven of the children were not able to decode a single nonword, even simple VC nonwords. Ten children were able to decode six or more nonwords correctly, whereas the other seven children decoded between one and four nonwords.

Short vowel letter-sound knowledge .

In order to evaluate more closely children's knowledge of short vowel spellings, their scores on the separate vowels in the various tasks were analyzed. One question of interest was whether some tasks would be more effective in detecting children's short vowel letter-sound knowledge than others. Because the participants were quite young and became tired if single tasks were too long, a larger number of different vowel tasks were administered, with fewer items in each task.

Table 3 shows the scores on the various tasks for each vowel.

Table 3

Mean Percentage Correct Short Vowel Scores and Standard Deviations Per Task

	A	E	I	O	U	Total mean and *SD* for tasks
Vowel sound-letter recognition (out of 3 choices)	.98 (.10)	.79 (.29)	.85 (.28)	.83 (.32)	.60 (.42)	.81 (.20)
Vowel sound-letter writing	.87 (.33)	.50 (.51)	.62 (.49)	.70 (.46)	.37 (.49)	.62 (.31)
Vowel reading in VC pseudowords	.79 (.41)	.42 (.50)	.71 (.46)	.54 (.51)	.50 (.51)	.59 (.30)
Vowel letter-sound production	.75 (.44)	.37 (.49)	.50 (.51)	.54 (.51)	.33 (.48)	.50 (.36)
Vowel spelling in words and pseudowords	.78 (.37)	.36 (.40)	.53 (.40)	.46 (.43)	.36 (.34)	.50 (.30)
Vowel reading in CVC pseudowords	.63 (.49)	.38 (.49)	.50 (.51)	.46 (.51)	.42 (.50)	.48 (.33)
Mean (*SD*)	.80 (.24)	.47 (.33)	.62 (.33)	.59 (.34)	.43 (.34)	

A repeated measures two-way analysis of variance, with vowels (A x E x I x O x U) and tasks (sound letter recognition X sound letter writing X reading in VC pseudoword X letter sound production X spelling in words and pseudowords X reading in CVC pseudowords) as independent variables, and performance scores[3] as the dependent variables showed a significant main effect for vowels (F (4, 92)=11.13, p <.000), a significant main effect for tasks (F(5, 115)= 11.76, p<.000) and no interaction effect F(20, 460)= .888, p > .05.

Post-hoc pairwise comparisons performed on vowels and corrected for an increase in alpha type errors[4] showed that short A was known significantly better than O, E and U, but not significantly better than short I, the second best performance. The difference in means between short I and short A, and between short I and short U, did not reach significance once the post-hoc corrections and the new significance level were in place. Short O means were closer to short I means, and higher than short E and short U, which had similar means, but the differences between short I, short O, short E and short U did not reach significance. Based on the results above, the pattern found shows that short A> O, E, U, whereas the other vowels means were not distant enough to reach significance.

Across all five tasks, short A was the best known of all short vowels. It had a higher mean than any other vowel, and usually the smallest standard deviation. There are

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[3] Performance scores for each vowel in each task were transformed into the same scale by dividing each vowel's score in each task by the number of times each vowel was tested in that task. Therefore, the value for each vowel is between zero and one, and the sum of the five vowels in each task is between zero and five.

[4] These pairwise comparisons were corrected through a Bonferroni correction for an increase in alpha type errors incurred while running multiple t-tests by dividing the criterion alpha used (alpha = .05) in the general *f*-test by the number of possible comparisons (10). In the present case, for vowels, .05 / 10 = .005, which became the new criterion of alpha for rejecting the null in the paired sample *t*-test.

several possible explanations for this. Short A is the most common short vowel sound in high frequency words. The letter A begins the alphabet. Also, it is usually the first short letter sound to be taught in school, so it is the one known the longest, and for which memory should be best. McBride-Chang, (1999), and Justice, Pence Bowles and Wiggins (2006), found support for a relationship between children's knowledge of certain letters and their order in the alphabet – the earlier letters being known best. They also found a strong relationship between letters best known and letters present in children's names. Out of 24 children in this study, 22 had the letter A in their first names. However, short vowel sounds are very different from the vowels in letter names, and the impact of vowel letter name knowledge in learning short vowels, be it positive or negative, is still unknown. From the 22 children whose names contained the letter A, only 9 had the letter A representing the short sound, and two of those, whose first name started with the short A, still were not able to say its short sound when looking at the letter A, even though that relationship had already been taught at school. These relationships need further investigation.

It is interesting that I and O were the next best known short vowel spellings. Short E would be expected to be the next best-known short letter sound because it comes next in the alphabet. Also short E is quite frequent in simple words, and 13 of the children had the letter E present in their first names. But I and O, which were present in only 3 of the children's first names, were better known than short E, although the difference was not significant once corrections for the increase in alpha type error were made. Additionally, Table 3 shows that, across tasks, E and U were the only letters yielding the lowest percentage correct scores, with E lowest in 3 of the tasks and U in four of the tasks. This provides additional evidence that short E and short U were known least well. It is worth remembering, however, that those vowel-letter relations had not been taught at school yet. Although this could have influenced the outcomes found, it is not clear how much.

Post-hoc pairwise comparisons[5] of tasks showed that performance on the vowel sound recognition task was significantly higher than all the other tasks, and this was consistent for all vowels. It was the easiest task for the children. Upon hearing a vowel sound, recognition of a correct vowel letter out of three choices was easier than spelling that sound, for all vowels (i.e. 81 % vs. 62 % correct). The differences among the performance scores on the other tasks did not reach significance after controlling for the increase in alpha-type errors. But the difference in means suggests that dictating vowel sounds and asking for corresponding letters elicited significantly more correct answers from the children (62% correct) than presenting them with letters and asking them to provide their vowel sounds (50% correct), t (23) =2.69, $p < .05$.

These findings indicate that writing letters for vowel sounds was easier than producing sounds associated with vowel letters. A possible explanation is that when you hear a short sound, you immediately link it to a letter. There is no competition among two short sounds regarding which letter to use. However, when you look at a letter, two sounds are associated with it, the short and the long sound equivalent to the letter's name. This competition may impair performance. To determine whether there was any evidence for this, we analyzed the children's mistakes in producing sounds for vowel letters. Table 4 displays responses for each vowel across the 24 children.

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[5] Also corrected for the increase in alpha-type errors.

Table 4

Sounds Produced by Children (N=24) in Response to Vowel Letters.

Children's performance	A	E	I	O	U	Total
Total Number of Correct sounds given	18	9	12	13	8	60
Sound not known, or no response given	1	1	3	0	4	9
Said Short I (/I/ as in **i**t)	2	1	-	0	0	3
Said Short U (/^/ as in **u**p)	2	4	2	2	-	10
Said complete letter name (long sound)	0	7	0	1	0	8
Said part of letter name	0	0	6 initial sound of letter I- /a/	5 initial sound of letter O- /o/	7 Initial sound of letter U- /ya/ 4 final sound of letter U- /oo/	22
Said another incorrect sound	1	2	1	3	1	8
Total number of responses	24	24	24	24	24	120

Note. The maximum number of vowel sounds produced for each letter was 24.

Of interest here were the mistakes children made, especially those that involved use of a long vowel instead of the short one.

At least eleven, out of 24 children, used some sort of a letter name strategy to derive the sounds required. A letter name strategy is when you use the name of the target letter, or part of it, to generate a sound for that letter. For example, if you do not know the sound for the letter B, but you know its name, you might use its name – /bi/ – to help you find its sound. The child might decide to divide the name into smaller parts: The articulatory onset of the letter name, which is the beginning of the sound before the vowel – in this case /b/ – and the vowel /i/. Using this strategy the child may derive a correct sound out of a letter name.

While this strategy may work for many consonants whose names contain relevant sounds, as in the case of the letter B, and for long vowels whose names are their sounds, it does not work for short vowels whose sounds are quite different from their letter names.

A common mistake children made for the letters I, U and many instances of letter O was to use part of the letter name of the targeted letter to provide the sound required. Children might, for example, say that the sound of the letter I is /a/ because this is the first sound of the diphthong articulated in the letter name /aI/ (see appendix for sounds in letter names). Extracting a partial cue from a letter name does not work for short vowels. Table 4 shows the high number of mistakes children made using this strategy. Although they used partial cues from letter names to generate their answers, they did not offer the complete letter name – the long sound – for vowels in their responses, except for the letter E, and one case for letter O. Interestingly, the letter E is the only letter whose name is a long sound with no glide. This suggests that children may have recognized the need for a sound different from the letters' names and this prompted the strategy of drawing from part of the names.

As seen in Table 4, given that some children extracted partial cues in the articulatory onsets of the names of the letters I, O and U to derive their sound, and since the letter E is the only letter name with no glide – and therefore no partial clues available –, it makes sense that their use of the long E as an alternative for the short E sound is also a letter name strategy that involves generating the sound of the letter by using its name.

These findings suggest that the use of this letter name strategy for producing vowel sounds may happen only when children have not acquired the short vowel sounds yet. When the letter is well known, as in the case of the letter A, the letter-name strategy disappears, as well as the large number of mistakes. Although it is not a productive strategy, since it does not help to generate the proper short vowel sound, its use is more advanced than simply stating the full letter name for the letter sound.

The use of a vowel letter-name strategy could also occur when children hear the short vowel sound and have to produce a letter match. The names of some consonant letters include short vowel sounds: the short vowel sound of E (/ɛ/)[6] in F (ef - /ɛf/), L (el - /ɛl/), M (em - /ɛm/), N (en - /ɛn/), S (es - /ɛs/), and X (ex - /ɛks/),); the short vowel sound of U (/^/) found in the first syllable of W (du- /d^/). In addition, the articulatory features of some long vowel sounds are close to short vowel sounds, specifically, the name of E(/i/) and short I (/I/), the name of A (/e/) and short E (/ɛ/), the onset of the name

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[6] The symbols written between slashes are IPA phonetic transcriptions. Please refer to appendix 1 for more information on letter sounds and IPA transcription and to figure 2 for neighboring areas for vowel sound production.

of I (/a/) and short O (/ɑ /) or short U (/^/). Table 5 shows the mistakes children make when they heard a short vowel sound and had to write a letter to represent it.

Table 5

Letters Produced by Children (N=24) in Response to Listening to Short Vowel Sounds.

Children's performance	A /æ/	E /ɛ/	I /I/	O /ɑ/	U /ʌ/	Total
Total Number of Correct letters given	21	12	15	17	9	74
Letter not known, or no response given	0	0	0	0	1	1
Wrote A (Wrong answer)	-	7[a]	3	2	2	14
Wrote E (Wrong answer)	0	-	4[a]	1	3	8
Wrote I (Wrong answer)	2	4	-	1[a]	2[a]	9
Wrote O (Wrong answer)	0	0	0	-	3	3
Wrote U (Wrong answer)	0	0	0	1	-	1
Wrote consonant whose letter name contains target sound or close sound	1[a] (letter N)	1[a] (letter X)		2[a] (letter R)	1[a] (letter R)	5
Wrote inadequate letters	0	0	1 (Q)	0	1 (OU- markers for long vowel ?)	2
Wrote word or part of word	0	0	1 (it)	0	2 (P, part of UP)	3
Total number of responses	24	24	24	24	24	120

Note. The maximum number of spellings produced for each letter was 24.
[a] Use of a letter name strategy.

Although letter name strategies were evident when spelling short vowel sounds, they were less common than seen in Table 4, and the number of correct responses was higher. Various children used letter name strategies when spelling short vowel sounds. Some of them used consonants to represent the sounds heard, showing their lack of familiarity with short vowel letter-sound representation. For example, in trying to find a letter to represent the short sound /ɛ/, a child spelled the letter X, which has inside its letter name, /ɛks/, the target sound. Other children used part of vowel letter names to represent the desired sounds. For example, children seeking letter representation for the sounds for short O, /ɑ/ or short U , /ʌ/ used the letter I, /aI/. The sound in the articulatory onset of the letter name for I, (/a/), is very similar to the sound of both /ɑ/ and /ʌ/. Findings like this have been described in the literature (Beers & Henderson, 1977). Another common letter-name strategy consisted in writing the letter A to represent the sound/ɛ/. The letter name of A, /eI/, has in its onset the sound /e/ that is perceived by adults and children as very similar in sonority to the target sound /ɛ/. The reason for such choice is that both /ɛ/ and /eI/ are front and unrounded vowels that differ only in tension. The same reasoning is at the root of mistakes using the letter E to spell the sound /I/. The letter name of E, /i/, differs from the short I sound /I/ only in tension, and children who are not secure in their knowledge of letter-sound relations sometimes use a letter name that has a similar sound to what they need to spell. Examples like this have also been described by both Read (1971) and Treiman (1993).

Although children produced more correct responses when asked to write a letter for a sound heard than when they had to produce a sound for a letter seen, the difference was not very large (74 vs. 60). In both cases there was evidence of letter-name strategies being used, although some seem more direct and simple than others.

Correlations.

A second question of interest was whether scores across the vowel tasks were significantly correlated. This was confirmed in a correlational analysis. Also calculated were the correlations between the total vowel scores achieved in each task and the grand total (sum of all vowel scores across tasks, a composite score) to see which of the measures would best reflect the general vowel knowledge of the children.

The grand total used was the sum of all *Z*-scores across tasks. Raw scores were converted to *Z*-scores by dividing scores by their standard deviations to transform all vowel measures into the same metric and to give them equal weighting in the composite score. Correlations between the composite *Z*-score and *Z*-scores[7] on each vowel measures are shown in Table 6.

Table 6 shows Pearson *r*'s for all the tasks that measured vowel knowledge. It also shows the correlations of the vowel measures with the reading measures (High Frequency Word Identification and Woodcock Word Identification Task), and decoding measure (total number of Pseudowords correctly read). Similar numbers were found when correlations were calculated with percentages instead of raw scores or *Z*-scores.

[7] The correlations between *Z*-score total and the *Z*-scores for each vowel measure are the same for the correlations between *Z*-score total and vowel measures before standardizing scores.

Table 6

Correlations between Vowel Measures and Reading Measures

	1	2	3	4	5	6	7	8	9	Mean[a] (SD)
1 Vowel letter-sound production										2.50 (1.82)
2 Vowel sound-letter writing	.813**									3.08 (1.53)
3 Vowel sound-letter recognition	.793**	.846**								8.13 (2.01)
4 Vowel spelling in words and pseudowords	.672**	.708**	.609**							10.00 (5.94)
5 Vowel reading in VC pseudowords	.733**	.826**	.687**	.583**						2.96 (1.52)
6 Vowel reading in CVC pseudowords	.525**	.602**	.480*	.585**	.661**					2.38 (1.66)
7 Total *Z*-score (sum of all *Z*-score vowel measures)	.885**	.936**	.862**	.812**	.876**	.752**				0.00 (5.12)
8 HF Word ID	.537**	.510*	.512*	.710**	.453*	.599**	.648**			26.04 (22.83)
9 Woodcock Word ID	.490*	.475*	.413*	.641**	.400	.538**	.577**	.890**		22.83 (18.19)
10 – Number of correct pseudowords read	.665**	.688**	.585**	.851**	.705**	.796**	.837**	.834**	.720**	4.12 (3.54)

Note. * *p*< .05, ** *p* < .01. *N*=24.
[a]Mean and standard deviation before scores were standardized to compute correlations

As seen in Table 6, all vowel measures correlated significantly with each other, with values of r ranging from .48 to .85. This shows that the tasks tapped a similar knowledge source. They were not measuring totally different abilities. Additional evidence is offered by the fact that children exhibited the same pattern across the tasks in their knowledge of the five vowels, with A known best and U and E known least well.(See Table 3).

We examined which single measure best predicted a child's overall vowel knowledge in order to determine which task would be most predictive. Findings indicate that the vowel measure correlating the highest with the total score was the task of vowel sound-letter dictation, which involved asking the child to write letters for specified short vowel sounds. The correlation involving the production of short vowel sounds given the letter is slightly lower. These findings indicate that asking children to spell short vowel sounds spoken in isolation can provide a good estimate of their short vowel letter-sound knowledge.

Relationship between high frequency word identification and short vowel letter-sound knowledge.

One purpose of the High Frequency Word Identification task was to investigate whether there was any relationship between knowledge of specific words containing short vowels and general short vowel knowledge. Investigating further how their knowledge of high frequency sight words was distributed across the five vowels would allow a comparison with the distribution of short vowel letter-sound knowledge assessed in isolation. It was expected that the pattern found for high frequency words containing short vowels, evident in Table 3, would be similar to the pattern found for individual short vowel letter-sound tests, and that children who had knowledge of particular short vowel letter-sound relations would be more likely to know high frequency words containing that vowel, even if the direction of the causality was unclear.

Words from the High Frequency Word Identification task were separated into their five vowel groups. Since there was a different number of words for each vowel, each child's number of correctly read words for each vowel was divided by the total number of words for that vowel. Out of the 54 high frequency words, 17 words contained short A, 8 words contained short E, 15 words contained short I, 7 words contained short O, and 7 words contained short U. If, for example, a child read 10 out of 17 high frequency (HF) words containing short A, his/her score would be 10/17= .59. Therefore, each child's score for each vowel was a number between zero and one, and the closer to one, the higher the percentage of words a child was able to read for each vowel. Means and standard deviations for the children's number of correctly read high frequency (HF) words for each vowel are displayed in Table 7. Table 7 also shows correlations between HF word scores for each vowel and the children's scores for each vowel from the individual vowel letter-sound tasks (values taken from Table 3).

Table 7

Correlations between High Frequency Word Reading Scores per Vowel and Combined Scores on Individual Vowel Tasks

	1	2	3	4	5	6	7	8	9	Mean (SD)
1 HF Words A										.52 (.36)
2 HF Words E	.847**									.37 (.36)
3 HF Words I	.931**	.931**								.44 (.36)
4 HF Words O	.918**	.845**	.913**							.55 (.35)
5 HF Words U	.895**	.819**	.879**	.873**						.56 (.33)
6 Tasks - A	**.466***	.410*	.427*	.271	.390					.80 (.24)
7 Tasks - E	.441*	**.491***	.491*	.322	.526**	.491*				.47 (.33)
8 Tasks - I	.679**	.531**	**.644****	.512*	.645**	.523**	.574**			.62 (.33)
9 Tasks - O	.563**	.491*	.533**	**.381**	.492*	.521**	.556**	.577**		.59 (.34)
10 Tasks - U	.509*	.535**	.518**	.385	**.607****	.432*	.836**	.571**	.501*	.43 (.34)

Note. * $p < .05$, ** $p < .01$. $N = 24$.

Correlations among pairs of HF words containing different vowels are uniformly high, ranging from .82 to .93, indicating that the word sets are measuring the same construct, the ability to read words. In contrast, correlations between these vowel word sets and tasks measuring the respective vowel letter-sound characterizing each word set are much lower, ranging from .38 to .61. In fact, in three cases, vowel letter-sound tasks show higher correlations with vowel word sets containing a different vowel letter. These findings indicate that knowledge of vowel-specific letter-sound relations is a less important contributor to the ability to read words containing those vowels.

When mean scores reading HF words by vowel type were ordered from the highest to the lowest, the following pattern resulted: U > O > A > I > E. In order to see if differences between the means for the high frequency words were significant, a repeated measures one way ANOVA was run, with vowels (A vs. E vs. I vs. O vs. U) as the independent variable and word reading scores as the dependent variable. Results showed a significant difference between means among the five vowels, F (4,92) = 11.063, $p < .001$. Post-hoc pairwise comparisons[8] showed that means for words with U, O and A were each significantly higher than means for words with I and E. (i. e., U, O, A > I, E). This finding was unexpected, since it clearly deviated from the pattern of individual vowel means gathered on individual letter-sound tasks (i.e., A > O, E, U). Whereas means for short O and short U letter-sound relations assessed in isolation were the lowest among the five vowels, they were the highest when assessed in the context of a word reading task.

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[8] These pairwise comparisons were also corrected for an increase in alpha type errors

It had been expected that children who knew some short vowel letter-sounds would find easier to learn words that contained those letter-sound relations. The reason behind that proposition would be that it would be easier to anchor more words in memory if more connections were made between the letters of the words and the sounds of their pronunciations. The short A letter-sound relation, being the best known among the children, and showing fairly high word reading means, fit expectations. Likewise, short E fit as well, showing the lowest means for both individual letter-sound relations and high frequency words. But this hypothesis fails to explain how children could learn to read high frequency words with short U and short O without already possessing mastery of those individual letter-sound relations.

In order to investigate how much variance in children's reading of high frequency words could be explained by various predictors, a stepwise multiple regression was carried out. The unit of analysis was each word. The dependent variable was the total number of correct responses for each of the 54 words, and the predictor variables were vowel knowledge, word frequency, number of letters in words, and imageability. The vowel knowledge measure was the mean value for each vowel across all tasks, as reported in Table 3. The measure of word frequency used was taken from Carroll, Davies & Richman (1971) for each of the 54 HF words[9]. The imageability ratings used were taken from Cortese & Fugett (2004), but ratings for only 48 out of 54 words were found.

Significant correlations were found between the total number of correct responses for the 54 words – and two of the predictors, number of letters in each word (Pearson's *r*

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[9] Preference was given to use Carroll, Davies & Richman (1971) instead of a newer word frequency count by Zeno, Ivens, Millard & Duvvuri (1995) because it offered frequencies for all 54 of our words, whereas Zeno had frequencies for only 53 words. Analysis were run with both lists, one at a time, and results were the same.

= -.534, $p < .001$, an inverse correlation) and word frequency (Pearson's $r = .372$, $p < .01$).

However, only number of letters in each word explained significant variance in the dependent variable ($R^2 = .252$; $F = 15.591$, $p < .001$). This indicated that words with a smaller number of letters were more likely to be correctly identified than longer words. Despite our expectations, neither vowel knowledge nor specific word frequency was able to explain any additional variance in children's knowledge of the 54 high frequency words above and beyond the number of letters in words.

High versus low vowel knowledge

In order to investigate further children's levels of vowel letter-sound knowledge, individual children's sums of z-scores across all tasks were compared. As evident in Figure 4, the distribution of children's composite scores across the vowel tasks yielded a bimodal distribution.

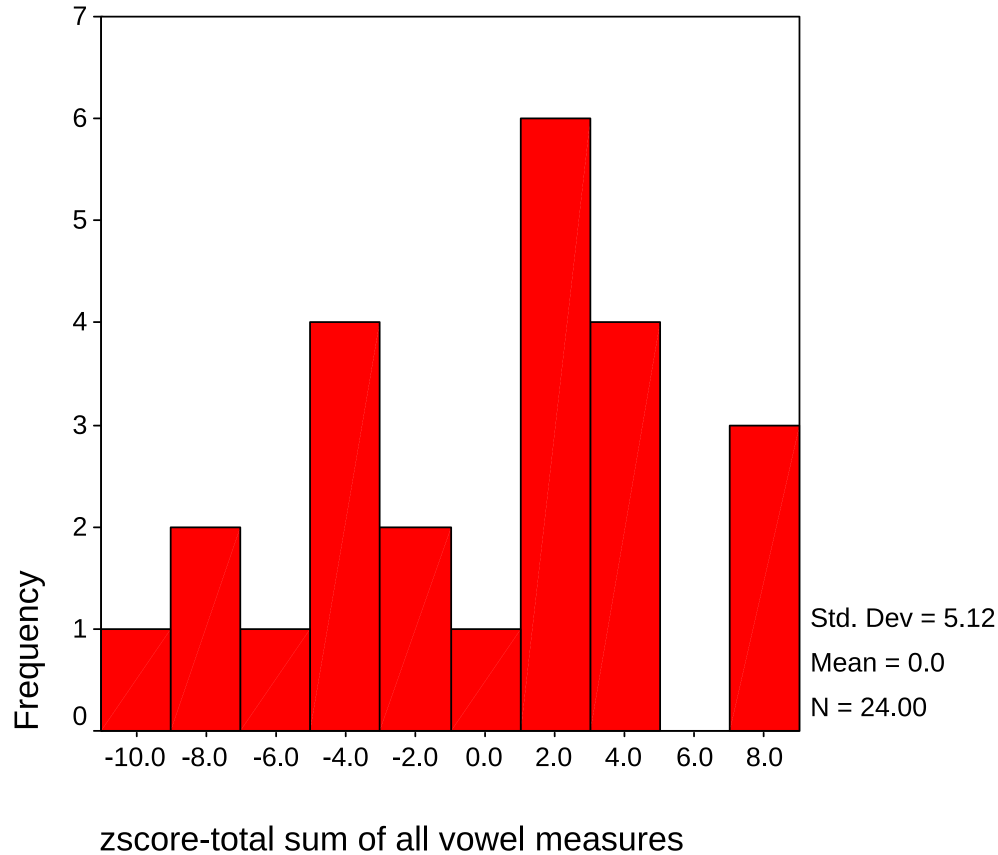

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Figure 3. Children's distribution of the total sum *Z*-score (sum of all *Z*-score vowel measures).

Two clusters of scores were apparent: One cluster for negative values below the mean of zero and another cluster for higher scores above the mean. Therefore, two separate groups of children were formed, one group scoring at or below zero, and another group scoring above zero. The low vowel knowledge group had 11 children, and the high vowel knowledge group had 13. The two groups had similar number of Hispanic children in each one of them, with 7 children in the high vowel knowledge group, and 8 children in the low vowel knowledge group. Table 8 shows the means and SD's for the two groups, as well as *F* values and significance levels achieved when the groups were compared in analyses of variance, with the various measures listed in the table as the dependent variables, and vowel knowledge group as the independent variable.

Table 8

Differences between High and Low Vowel Knowledge Groups

	High V. Know. (*n*=13) Means (SD)	Low V. Know. (*n*=11) Means (SD)	*F*	*p*
Age in Months	77.54 (4.82)	77.45 (3.70)	< 1	n.s.
Letter Name Knowledge (max = 26)	26.00 (0.00)	25.81 (.40)	2.64	n.s.
Consonant Letter Sound Knowledge (max =21) % perfect score	20.54 (.52) 53.80%	19.45 (2.02) 27.30%	3.50	n.s.
Short Vowel HF Word Identification (max = 54) % zero score	34.00 (16.13) 0%	16.63 (17.01) 0%	6.57	.018 *
Woodcock Word Identification (max =112) % zero score	28.77 (19.67) 0%	15.82 (14.03) 0%	3.32	n.s.
Correct Pseudoword Reading (max = 10) % zero score	6.31 (3.01) 7.77%	1.54 (2.11) 54.50%	19.37	.000 **
Vowel Letter Sound Production (max =5) % zero score	4.00 (.70) 0%	.73 (.79) 45.50%	115.25	.000 **
Vowel Sound Letter Writing (max = 5) % zero score	4.15 (.90) 0%	1.82 (1.08) 18.2%	33.53	.000 **
Vowel Sound Letter Recognition (max = 10)	9.62 (.77)	6.36 (1.50)	46.79	.000 **

(*Table continues*)

Table 8 (continued)

	High V. Know. (*n*=13) Means (SD)	Low V. Know. (*n*=11) Means (SD)	*F*	*p*
Vowel Spell. in Words and Pseudowords (max=20)	13.85 (4.71)	5.45 (3.56)	23.52	.000 **
Vowel Reading in VC Pseudoword (max=5)	3.84 (1.07)	1.91 (1.30)	16.07	.001 **
% zero score	0%	18.20%		
Vowel Reading in CVC Pseudoword (max=5)	3.23 (1.69)	1.36 (.92)	10.664	.004 **
% zero score	7.70%	18.20%		

Note. * = $p < .05$, ** = $p < .01$, n.s. = not statistically significant

As can be seen, the two groups differed significantly on all the vowel measures. The variables which did not distinguish the groups were age, letter name knowledge, consonant sound knowledge (with both measures close to ceiling), and the number of words read on the Woodcock word identification test. Although the mean of the High Vowel Knowledge group on the Woodcock was almost double the mean of the Low Vowel Knowledge group, variation of scores within the groups was large, causing differences to fall short of statistical significance.

Experimental manipulation: reading words with and without vowels.

Does short vowel knowledge help children learn to read words? Results in Table 6 showed that short vowel knowledge was strongly correlated with the ability to read real words. The composite vowel knowledge score was significantly correlated with both the Woodcock word identification task, r =. 577, and the short vowel high frequency word identification task, r =. 648. However, such correlational data do not indicate the direction of causality, that is, whether children decode and read better because they have more vowel knowledge, or whether they know more short vowels because they can read and decode better. Experimental manipulations are needed to resolve this issue.

Two questions of interest were whether the presence or absence of short vowels in words would affect children's word learning, and whether the extent of their vowel knowledge would make a difference as well. Our hypothesis was that the presence of vowels would facilitate word learning among students with high vowel knowledge but not among students with low vowel knowledge.

Children were assigned randomly to four word learning conditions. They were given 15 trials to learn each of two sets of written words – one set spelled with vowels, the other set spelled without vowels. The criterion for learning each set was reached when a child was able to identify correctly all words in a set twice. The maximum number of trials for each set was fifteen and children reaching criterion earlier than the 15th trial received points for the remaining trials not given.

Four of the twenty-four children did not complete the whole task, with two children not participating in the training phase, (one moving away, and one becoming seriously sick), and two others completing only the first set of the training due to absences. Two of the children were in condition 2 (i.e., set K without vowels first) , one child was in condition 3 (i.e., set L with vowels first) , and one child in condition 4 (i.e., set L without vowels first) of the counterbalanced conditions. Out of the four children, 1 was in the high vowel knowledge group, and 3 were in the low vowel knowledge group. These children were left out of the data analyses.

Analyses of variance were applied to performance. Our main independent variables were vowel knowledge of students (low vowel knowledge vs. high vowel knowledge), and vowel presence in the words learned, (no vowel set vs. vowel set). In a preliminary analysis, the effects of counterbalancing were examined (C1 vs. C2 vs. C3 vs. C4).

The levels of vowel knowledge (low vowel knowledge and high vowel knowledge) were formed based on children's composite vowel z-scores. For the "presence of vowels" repeated measures variable, the performance of each child in the "no vowel" set was compared to his/her performance in the "vowelized" set. Three dependent variables were examined: number of words learned summed across the first 5 trials, total number of trials to reach criterion, and number of words learned per trial.

In a preliminary ANOVA, effects of counterbalancing were tested. A 2 X 2 independent samples ANOVA was conducted, with vowel list order (Vowel list learned first vs. Vowel list learned second) and Word set (set K first vs. set L first) as the independent variables. The dependent variable was the difference in number of trials needed to reach criterion between the vowel present set and the vowel absent set.

Results showed no significant main effect for either vowel list order, or word set. The interaction was not significant either. These results show that neither the word set nor the vowel treatment order impacted children's performance. The test of the intercept was not significant, F (1,16) = 2.49, $p > 0.05$, indicating that whether vowel letters were present or absent in words exerted no differential influence on the number of words learned. An additional analysis using the same independent variables, but using as the dependent variable the difference between the vowel present set and the vowel absent set in the number of words learned after 5 trials generated similar results. The control variables involving vowel list order and word set were subsequently dropped from further analysis. Means, standard deviations and F values for the initial preliminary analysis are shown in Table 9.

Table 9

Means, Standard Deviations and Analysis of Variance (ANOVA) Results for Word Set Order as a Function of the Order of Learning Vowels in Word Lists

Conditions	Set K First M (n)	Set K First SD	Set L First M (n)	Set L First SD		*F*	*p*
Vowel First	-.17 (n = 6)	1.72	-2.00 (n = 5)	3.74	VO	.115	n.s.
Vowel Second	0.00 (n = 4)	.82	-1.40 (n = 5)	2.61	WO	2.05	n.s.
					VO x WO	.04	n.s.

Note. Dependent variable is the difference in the number of trials needed to reach criterion between vowel presence and vowel absence. Negative values indicate that the difference favored the vowel absent condition. VO = vowel list order; WO = word set order.
n.s. = not statistically significant.

In order to investigate the influence of short vowel knowledge on children's learning of new words, we performed additional statistical analyses. A two-way ANOVA was performed, with vowel knowledge group (high vowel knowledge vs. low vowel knowledge) and presence of vowel letter in the target word (vowel present vs. vowel absent) as independent variables. The latter was a repeated measure. The dependent variable was the total number of words learned summed across five trials.

In this analysis, a main effect of vowel knowledge group was detected, indicating that children with higher vowel knowledge learned significantly more words in five trials than children with lower knowledge. However, there was no main effect for presence of vowels. The interaction was not significant either. Means, standard deviations and *F* values are shown in Table 10.

Table 10

Mean Number of Words Learned Summed over Five Trials and Mean Number of Trials to Criterion In Learning Words as a Function of the Presence or Absence of Vowel Letters In the Words and the Vowel Knowledge, High or Low, of Children Learning the Words

	High Vowel Knowledge		Low Vowel Knowledge				
Conditions	M	SD	M	SD		*F*	*p*
Words learned							
V.Present (50 max)	38.92	12.67	24.50	13.53	G	5.49	*
V.Absent (50 max)	36.47	10.41	25.13	13.11	V	0.63	n.s.
					G x V	1.76	n.s.
Trials to criterion							
V.Present (15 max)	6.41	4.66	11.88	4.39	G	5.95	*
V.Absent (15 max)	7.92	3.96	11.88	4.61	V	1.89	n.s.
					G x V	1.89	n.s.

Note. There were 12 high-vowel knowledge children and 8 low-vowel knowledge children. G = vowel knowledge group; V = vowel letter presence.
* = p<.05. n.s. = not statistically significant.

A similar two-way repeated measures ANOVA was performed, with vowel knowledge (high vowel knowledge vs. low vowel knowledge) and presence of a vowel letter in the target words (vowel present vs. vowel absent) as the independent variables. The dependent variable was the number of trials to reach criterion.

There was again a main effect for vowel knowledge group, but no main effect for the presence of vowels in the words learned, and no significant interaction either. Children with higher vowel knowledge performed better, learning in significantly fewer trials, than children with lower vowel knowledge, and this was not affected by the presence or absence of vowels in the words learned.

An additional ANOVA was conducted with vowel knowledge, vowel presence and trials as the independent variables. The latter two were repeated measures. The dependent measure was the number of words learned on each of the trials (15 maximum). One question of interest was whether the difference favoring children with higher vowel knowledge persisted across trials. There was no significant main effect for vowel presence, but there were significant main effects for vowel knowledge group, and for trials. None of the interactions was significant. Test statistics are reported in Table 11 and mean performance shown in Figure 5.

These results indicate that children with higher vowel knowledge were able to learn more words than children with low vowel knowledge, and the advantage was maintained throughout the task. Performance improved over trials for both groups, and the groups improved at the same rate. Figure 5 shows children’s performance across 15 trials.

Table 11

Analysis of Variance Results for Main Effects and Interaction Effects of Level of Vowel Knowledge, Vowel Presence and Trials on the Number of Words Learned in Each Trial.

Source	df	SS	MS	*F*	sig
		Between Subjects			
Vowel Knowledge (VK)	1	840.034	840.034	7.634	.013 *
Vowel Knowl.(Error)	18	1980.718	110.040		
		Within Subjects			
Vowel Presence (VP)	1	3.300	3.300	.423	.524 n.s.
VP x VK	1	.100	.100	.013	.911 n.s.
Trials	2.843 [a]	785.306	276.265	32.739	.000 **
Trials x VK	14	13.012	.929	.542	.906 n.s.
VP x Trials	5.503 [a]	12.212	2.219	.932	.470 n.s.
VP x Trials x VK	14	17.612	1.258	1.344	.182 n.s.
VP (Error)	18	140.385	7.799		
Trials (Error)	51.167 [a]	431.761	8.438		
VP x Trials (Error)	99.049	235.928	2.382		

Note. [a] = d.f. corrected by applying the Greenhouse-Geisser epsilons.

* = $p < .05$. ** = $p < .01$. n.s. = not statistically significant.

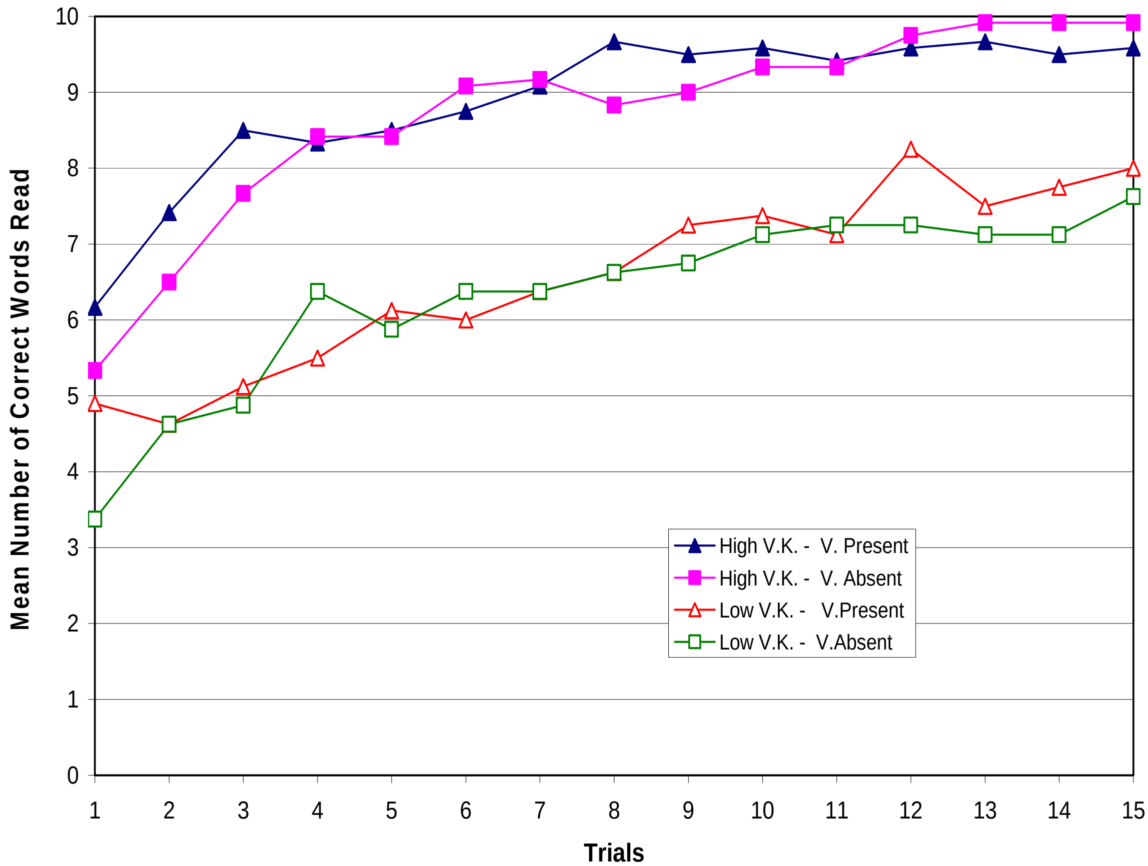

Figure 4. Children's performance in the experimental task based on their level of vowel knowledge and the presence or absence of vowels in the words learned

So, contrary to the hypothesis, the high vowel knowledge group did not benefit from the presence of vowel letters in learning words. We had anticipated that the presence of vowels in words would create an extra source of information that would enhance word identification for children able to use that system, whereas vowel presence might be a source of additional confusion or difficulty for children lacking vowel knowledge, given that words with vowel letters were longer than words without vowels. However, the evidence did not support this possibility.

Relationship between words learned and short vowel letter sound knowledge.

Although vowel presence in spellings did not seem to influence word identification, it is possible that learning of individual words may have been affected by the presence or absence of vowel letters, or that some vowel letters may have helped learning more than others. Would the patterns of no difference between vowel present and vowel absent spellings found previously also hold for individual pairs?

Analyses of variance were run for each individual word. The independent variable was the presence or absence of a vowel letter in the spelling of each target word, and the dependent variable was the total number of correct readings of that vowel across the first 5 trials for each child. Table 12 shows the mean number of correct responses over the first 5 trials for each word taught with and without vowels averaged across students.

Table 12

Differences between the Mean Number of Correct Responses over the First Five Trials for Each Word Learned With and Without Vowels Averaged for Each Student

	Vowel Present Means (SD) *n*=	Vowel Absent Means (SD) *n*=	Difference
Castle	3.18 (1.47) *n*=11	3.44 (1.81) *n*=9	- 0.26
Message	3.00 (2.14) *n*=11	3.44 (2.19) *n*=9	- 0.44
Kitten	3.36 (2.29) *n*=11	3.78 (1.72) *n*=9	- 0.42
Model	3.27 (1.79) *n*=11	3.67 (1.58) *n*=9	- 0.40
Tunnel	2.73 (1.79) *n*=11	3.33 (1.73) *n*=9	- 0.60
Rattle	3.09 (1.92) *n*=11	2.78 (1.92) *n*=9	+ 0.31
Pencil	2.91 (1.87) *n*=11	3.22 (1.72) *n*=9	- 0.31
Ticket	3.36 (2.06) *n*=11	4.00 (1.41) *n*=9	- 0.64
Possum	3.18 (1.66) *n*=11	2.33 (2.00) *n*=9	+ 0.85
Rubber	2.73 (2.15) *n*=11	4.56 (0.73) *n*=9	- 1.83
Ladder	3.56 (1.88) *n*=9	2.91 (1.70) *n*=11	+ 0.65

(*Table continues*)

Table 12 (continued)

	Vowel Present Means (SD) (*n*=)	Vowel Absent Means (SD) (*n*=)	Difference
Devil	3.89 (1.76) *n*=9	3.55 (1.69) *n*=11	+ 0.34
Simple	2.67 (2.06) *n*=9	1.91 (2.07) *n*=11	+ 0.76
Bomber	3.78 (1.72) *n*=9	3.18 (1.72) *n*=11	+ 0.60
Fasten	3.56 (1.74) *n*=9	2.00 (1.84) *n*=11	+ 1.56
Lettuce	3.33 (1.73) *n*=9	2.73 (1.79) *n*=11	+ 0.60
Bubble	4.00 (1.66) *n*=9	4.09 (1.04) *n*=11	- 0.09
Fiddle	2.78 (1.99) *n*=9	2.55 (1.97) *n*=11	+ 0.23
Dollar	4.11 (1.36) *n*=9	3.09 (1.70) *n*=11	+ 1.02
Summer	4.33 (1.66) *n*=9	3.73 (1.49) *n*=11	+ 0.60

Note. Negative values indicate that the difference favored the vowel absent condition. Positive values indicate that the difference favored the vowel present condition.

In 19 out of 20 pairs of words learned, no significant difference was found in learning spellings with or without vowel letters in them. The only pair which showed a significant difference favoring words learned without vowel letters (*rubber*, with RBR > RUBR) also showed a significant difference in the homogeneity of the variance [10]of the two groups. Logarithms, inverse computations and square root transformations used were unable to assure similar variances for both groups, and this particular result may be unreliable.

For the other words, however, results were clearer. For example, KASL or PESL was not easier or more difficult than learning KSL or PSL. The presence of a vowel letter was not enough to facilitate or make more difficult the learning of new words when compared to a similar word and that was true for almost all words seen individually.

Another interesting question related to the learning of words was whether any set of words sharing a particular vowel would be facilitated in learning if the child had previous knowledge of that short vowel. Would the learning vary depending on the children's level of vowel knowledge? Means of previous letter sound tests had ascertained that children's short vowel letter-sound knowledge followed a certain pattern (A > I> O> E > U), although significant differences were found only between knowledge of short A and knowledge of short O, E and U, (A> O, E, U), as shown in Table 3. Would the pattern of means for words learned be consistent with the pattern of means observed in this study's letter sound tests? Moreover, since the letter A was the best known short vowel, and the only one significantly different from three of the other vowels, would such

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[10] Levene Test of Homogeneity of Variances

knowledge be reflected in the superior learning of words with A, when compared to learning words using the other vowels ?

In order to answer those questions, the words used in the learning task were separated by vowel, and the numbers of correct responses for each word sharing the same vowel were summed up for the first five trials. Each child had his/her own score of number of correct words across 5 trials per vowel (Max = 2 words per vowel x 5 trials = 10) for vowel present, and for vowel absent spellings. Although vowel presence was not expected to affect learning, in view of the previous analyses, it was worthwhile to investigate whether interactions between vowel presence and vowel word pair set would appear, as well as interactions with the level of vowel knowledge of the participants.

A three-way repeated measures ANOVA was run, with level of vowel knowledge (high vs. low) as a between factor, and vowels used in the target words (A words vs. E words vs. I words vs O words vs. U words), and the presence of vowels letters in the spellings of the words learned (vowel present x vowel absent) as within factors. The number of correct words per vowel summed across 5 trials was used as the dependent variable. Table 13 presents the *F* table for this analysis.

Table 13

Analysis of Variance Results for Main Effects and Interaction Effects of Level of Vowel Knowledge, Vowel Presence and Word Vowel on the Number of Correct Words Summed up after 5 Trials.

Source	df	SS	MS	*F*	sig
		Between Subjects			
Vowel Knowledge (VK)	1	317.241	317.241	5.488	.031 *
Vowel Knowl.(Error)	18	1040.454	57.803		
		Within Subjects			
Vowel Presence (VP)	1	1.687	1.687	.632	.437 n.s.
VP x VK	1	4.688	4.688	1.755	.202 n.s.
Word Vowel (WV)	4	53.078	13.270	5.090	.001**
WV x VK	4	33.538	8.385	3.216	.017*
VP x WV	4	31.958	7.990	2.139	.085 n.s.
VP x WV x VK	4	3.058	.765	.205	.935 n.s.
VP (Error)	18	48.088	2.672		
WV (Error)	72	187.692	2.607		
VP x WV (Error)	72	268.892	3.735		

Note. * = $p < .05$. ** = $p < .01$. n.s. = not statistically significant.

Significant main effects were found for both vowel knowledge, and vowels used in words. There was a significant interaction between vowel knowledge and vowels in words. No other significant effects or interactions appeared. Table 14 presents means and standard deviations for this analysis. Since no significant effects were found for vowel presence, the means for vowel presence and vowel absence were collapsed.

Table 14

Means and Standard Deviations for the Number of Correct Words per Vowel Summed up after 5 Trials (MAX = 10) as a Function of Vowel in the Words Learned and the Level of Vowel Knowledge.

	High Vowel Knowledge		Low Vowel Knowledge	
Vowels In Words	M	SD	M	SD
Number of correct words per vowel learned after 5 trials				
Words With A	7.08	2.86	4.56	2.70
Words With E	7.71	2.24	4.63	3.07
Words With I	7.58	2.07	3.75	3.25
Words With O	7.42	2.04	5.44	2.97
Words With U	7.88	2.70	6.44	2.48

Note. There were 12 high-vowel knowledge children and 8 low-vowel knowledge children.

To locate the source of the interaction between level of vowel knowledge and vowels used in words mean scores were examined. As evident in Table 14 and Figure 6, the low vowel knowledge children showed greater differences across words with different vowels than the high knowledge group, whose knowledge of words with different vowels was more similar.

In order to pinpoint the locus of the interaction statistically, post-hoc analyses were carried out. Pairwise comparisons on vowels in words learned were performed separately for children in the low vowel knowledge group and for children in the high vowel knowledge group. Additionally, independent samples t-tests were run comparing low and high vowel knowledge groups for each of the five types of vowels in words learned.

For the high vowel knowledge group, post-hoc pairwise comparisons using the Bonferroni corrections for the increase in alfa-type errors showed that the only two vowels to differ significantly in the number of words learned by children across five trials were short A and short U, with U superior to A ($t(11) = -3.644$, $p<.005$).

For the low vowel knowledge group, however, the difference in the words' means fell short of statistical significance, once the higher significance levels of the post-hoc tests were in place (Bonferroni corrections for the increase in alfa-type errors due to multiple comparisons). Although the low vowel knowledge group showed larger differences in means for words learned with different vowels, their smaller sample size ($n=8$) may have precluded differences reaching statistical significance. The effect size for the interaction in the original three-way ANOVA was , according to Cohen (1988), large (Partial Eta Squared =.152), showing that there was a strong relationship between the variables. The observed power for that analysis was .8, sufficient for identifying an effect, if indeed there was one. However, on separating the analysis for the low and the high vowel knowledge groups, the sample sizes shrank, power was clearly diminished, and so was statistical significance.

When comparing low vs. high vowel knowledge children regarding their learning of words with the same vowel, for each of the five vowels, the differences were not significant except for words containing E and I. However, once the new significance level of the Bonferroni corrections for multiple comparisons were in place, only words containing the short vowel I had means that significantly differentiated high and low vowel knowledge children, ($t(18) = -3.240$, $p < .005$), although means for words with E had a p marginally close ($p = .018$) to the new significance level ($p < .01$). Figure 6 shows the interaction between children's level of vowel knowledge and word learning as a function of different vowels.

Ordering the means of the correct words per vowel across 5 trials from the highest to the lowest shows U > O > E > A > I, for the low vowel knowledge children, and U > E > I > O > A for the high vowel knowledge group. These orders are quite different from the orders involving letter-sound knowledge from individual vowels (A > I > O >E > U), especially in regard to short U and short A. Although short U was only significantly different from short A for the high vowel knowledge group, it is still intriguing that words containing short U were learned more easily than words containing short A, the vowel for which children had shown higher mastery individually. Even for low vowel knowledge children, short U words had the highest means, whereas short U letter-sound relations was the least well known among the five vowels.

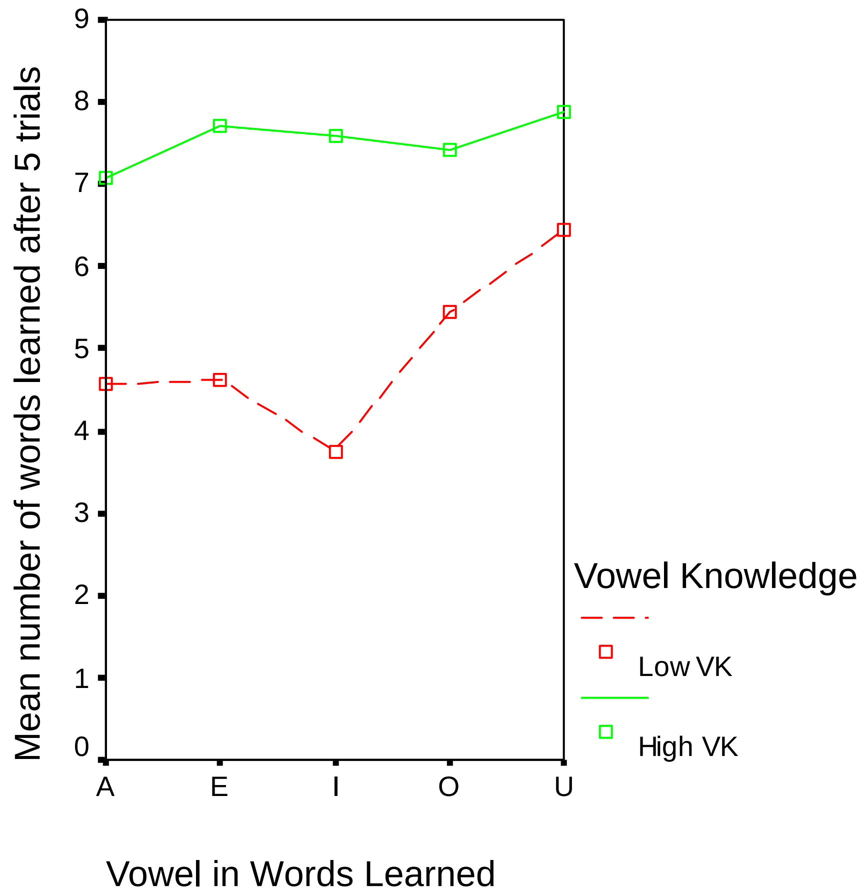

Figure 5. Children's performance in learning to read words as a function of the different vowels in words and their level of vowel knowledge.

The learning task: children's response types.

Children's responses during the first five trials of the learning task, when errors were most prevalent, were analyzed. Table 15 displays the mean number of various response types for high and low vowel knowledge children for vowel present and vowel absent conditions. It is evident that the mean numbers of correct responses, non-responses and errors were similar in the two conditions with very large standard deviations. When mean performance between the high and low vowel knowledge groups was compared, large differences can be seen. Children in the high vowel knowledge group were correct more than 70% of the time, in both vowel present and vowel absent conditions, whereas children in the low vowel knowledge group had close to 50% correct. They had more non-responses and more than double the number of mistakes as their high vowel knowledge counterparts.

Table 15

Mean Number and Percentage of Correct Responses, Non-Responses and Errors as a Function of Children's Level of Vowel Knowledge and the Presence of Vowel Letters During the First Five Trials (max = 50 possible responses)

		High Vowel Knowledge		Low Vowel Knowledge	
		V Present	V Absent	V Present	V Absent
Corr. Response					
	M	38.92	36.42	24.50	25.13
	SD	(12.67)	(10.41)	(13.53)	(13.11)
	%	77.70	73.00	49.00	50.20
No Response					
	M	4.00	6.42	9.00	10.25
	SD	(4.86)	(5.05)	(9.07)	(5.97)
	%	8.00	12.90	18.00	20.50
Errors					
	M	7.17	7.08	16.50	14.63
	SD	(10.02)	(8.06)	(8.88)	(11.16)
	%	14.30	14.20	33.00	29.20

Note. Percentages were calculated based on total number of responses, which was the sum of correct responses, non-responses and errors.

Analysis of errors.

During the word learning task, children misread the words in various ways. Three types of errors were distinguished: pronouncing individual sounds for some of the letters seen in the words (e.g., reading MODL as /m/, or TKT as /ti/- /keI/ - /ti/); pronouncing another word from within the list of 10 words (intra-list intrusions); pronouncing another word from outside the list (extra-list intrusions). The rationale behind this categorization was to analyze mistakes in the use or misuse of letter-sound information that might reveal the nature of the knowledge that children were using to read words and that might suggest whether information about vowel letters was being used or disregarded.

Extra-list intrusions were mistakes that identified the target word as another word not included among the list of words being learned. It was further divided into 4 categories: extra-list intrusions preserving all letters of the target word, e.g., reading the simplified spelling MDL as *middle* rather than the correct word *model*; extra-list intrusions preserving only one letter of the target word, e.g., reading the simplified spelling BMR as *Bill* , instead of the correct word *bomber*; extra-list intrusions preserving 2 or more letters of the target word, e.g., reading the simplified spelling BBL as *Bill* , instead of the correct *bubble*; and extra-list intrusions sharing no letters or presenting only a semantic connection to the target word but with no letters shared , e.g., reading the simplified spelling TUNL as *kid* rather than the correct word *tunnel*.

Intra-list intrusions were mistakes made by identifying the target word as another word from the same list. They were also divided into four categories: Intra-list intrusions preserving the first letter, e.g., reading the simplified spelling KITN as *castle* instead of the correct word *kitten*; Intra-list intrusions preserving only the last letter, e.g., reading the simplified spelling FDL as *simple* rather than the correct *fiddle*; Intra-list intrusions preserving only middle letters, e.g., reading the simplified spelling PSL as *message* instead of the correct word *pencil*; and Intra-list intrusions sharing no letters with the target word, e.g., reading the simplified spelling BMR as *fiddle* rather than the expected word *bomber*.

The errors made by all children in the first five trials were identified, classified and summed up. Separate error totals were generated for children of low and high vowel knowledge, both in the vowel present and the vowel absent conditions. Each total, which was the sum of extra-list, intra-list and letter sound errors, was then used to create percentages for each type of mistake, in order to compare the groups. Table 16 shows the percentage of errors, separated by group of vowel knowledge and by the presence or absence of vowels when learning words, as well as means, standard deviations and totals in raw numbers.

Table 16

Raw Numbers and Percentage of Errors of Various Types as a Function of Vowel Knowledge and Presence/Absence of Vowel Letters in the Word Set Learned in the First Five Trials

	High Vowel Knowledge		Low Vowel Knowledge	
	V Present	V Absent	V Present	V Absent
Total Number of Errors (Raw Numbers)				
M	7.17	7.08	16.50	14.63
SD	10.03	8.06	8.88	11.16
Sum	86.00 (100%)	85.00 (100%)	132.00 (100%)	117.00 (100%)
Extra-List Errors (%)				
All Letters Shared	10.47	16.47	2.27	5.98
Two + Letters Shared	26.74	28.24	17.42	5.98
One Letter Shared	5.81	12.94	9.09	13.68
No Letters Shared	1.16	0.00	3.79	0.85
Total Extra-List Errors	44.18	57.64	32.57	26.49
Intra-List Errors (%)				
First Letter Shared	45.35	37.65	48.48	45.30
Last Letter Shared	0.00	1.18	8.33	8.55
Middle Letters Shared	2.33	0.00	3.79	4.27
No Letters Shared	1.16	0.00	1.52	5.13
Total Intra-List Errors	48.84	38.83	62.12	63.25
Letter sound (%)[a]	6.98	3.53	5.30	10.26

Note. There were 12 high VK children and 8 low VK children.
[a]This error involved producing the sound of a letter or the name of a letter when reading a word.

We can see in Table 16 that the twelve children with higher vowel knowledge made fewer errors than the eight children with lower vowel knowledge. Their pattern of errors also differed.

Table 16 shows that, among those with high vowel knowledge, all of their guesses shared at least one letter with the spellings in view and most shared two or all of the letters. These children were adept at matching up words in their vocabularies to partial spellings. Children with lower vowel knowledge produced twice as many intra-list errors (62%-63%) as extra-list errors (33%-26%). This indicates that children with lower vowel knowledge were having difficulty distinguishing among the words in the list well enough to read them accurately. From Table 16, it is evident that most of their word errors shared the same initial letters with the written words. Whether vowel letters were present or absent made little difference.

The most common type of mistake among all children was an intra-list error where the target word was erroneously identified based solely on the first letter. Independent of the presence or absence of the vowel, and of the level of vowel knowledge, that type of mistake alone accounted for 37.65% to 48.48% of the total number of mistakes. Since those were errors collected up to the fifth trial, children who had not learned to identify the words were possibly using the first letter strategy to recall the target words, and were still unaware that such strategy alone would not help them disambiguate words sharing the same initial letter. It shows, however, that children pay attention to the initial letters in words to read them, a type of mistake commonly occurring among children in the partial alphabetic phase. Additionally, it shows their efforts to locate a word in memory with a particular initial letter from inside the list learned and not outside. The percentage of extra-list mistakes sharing any one letter, including those sharing just the first letter (varying from 5.81 % to 13.68%) was smaller than the percentage of intra-list errors sharing the first letter (from 37.65% to 48.48%). However, the relatively small numbers of mistakes allow us only to speculate with confirmation awaiting a larger sample in future research.

The second most common mistake for most children was producing an extra-list word that shared two or more letters with the target word. What is interesting here is that this mistake is a more advanced error than that sharing just the first letter from the list. It shows that children were paying attention to at least two letters in the word to be identified, and were trying to match them to familiar words, showing greater grapheme-phoneme mapping skill, discounting the fact that the target words belong to a closed list. This type of mistake decreased as familiarity with the list increased. However, it occurred in higher percentages exactly in the children with higher vowel-letter knowledge.

Memory for spellings.

After each word learning task, participants' memory for the spellings learned was tested. Two-way repeated measures ANOVAs were used to analyze their productions. The independent variables were group (high vowel knowledge vs. low vowel knowledge) and presence of vowel letters in the set learned (vowel present vs. vowel absent), a repeated measures variable.

Each word spelled by the children was scored in different ways. For the measure "number of words correctly spelled according to the model", each child was given a point if his/her spelling corresponded exactly to the spelling of the word seen in the word learning task. Also the total number of correct letters that were seen in words was scored.

One point was given for each letter and the total was divided by the total number of letters in each word set (i.e., 40 for the vowel present, 30 for the vowel absent set).

There were also scores for the number of correct consonants that children included in their spellings and for the total number of correct vowels included in the correct position of words, even if the target word had no vowel. Additionally, how many times a vowel was placed in the second position of a word was examined. It was expected that exposure to a written word form with vowels would prompt children to use more vowels, whereas exposure to a set without vowels would prompt the use of consonants. Finally, the number of words that were both correctly read and spelled in the last trial of the learning task, be it after reaching criterion or after 15 trials if criterion was not reached were compared. Thus, there were six different dependent measures.

Means and standard deviations for each of those measures can be seen in Table 17. The scores are partitioned by the children's group (either high vowel knowledge or low vowel knowledge), and also by vowel presence or vowel absence in the set.

Table 17

Means and Standard Deviations for the Various Spelling Measures

DV	High Vowel Knowledge		Low Vowel Knowledge	
	Vowel Present Set	Vowel Absent Set	Vowel Present Set	Vowel Absent Set
Total number of words correctly spelled (accord. model - max=10)	4.00 (2.63)	4.17 (3.54)	.63 (1.06)	2.50 (2.33)
Total number of letters correctly spelled (accord. model) divided by the total number of letters in each set.	.84 (.14)	.88 (.09)	.54 (.20)	.72 (.19)
Number of times any vowel was spelled in the second position of the word (max=10)	8.50 (1.88)	4.58[a] (3.87)	8.00 (2.0)	4.25[a] (2.91)
Number of times correct vowel was spelled in the second position of word, even if target word had no vowel (max=10)	6.75 (2.30)	3.67[a] (3.17)	2.87 (.99)	1.13[a] (.99)
Total number of correct consonants in spelling (max=30)	26.50 (4.12)	26.25 (2.73)	18.62 (7.93)	21.50 (5.63)
Words read correctly in last trial that were also spelled correctly (max=10)	4.00 (2.63)	4.08 (3.55)	.62 (1.06)	2.25 (1.98)

[a]Note that there were no vowels in the target word for the vowel absent condition.

In the ANOVA to compare high and low vowel knowledge groups, a significant main effect was found for five of the six dependent measures (see Table 18). This means that children having higher knowledge of short vowels spelled more words and letters correctly than children with lower vowel knowledge. Children with higher vowel knowledge both read and spelled the same words correctly more often than children with low vowel knowledge.

Table 18

Analysis of Variance Results for Main Effects and Interaction Effects of Level of Vowel Knowledge, Vowel Presence on Various Dependent Measures

Source	df	SS	MS	*F*	sig
		Total number of words correctly spelled			
		Between Subjects			
Vowel Knowledge (VK)	1	61.004	61.004	6.337	.022*
VK (Error)	18	173.271	9.626		
		Within Subjects			
Vowel Presence (VP)	1	10.004	10.004	2.087	.166 n.s.
VP x VK	1	7.004	7.004	1.461	.242 n.s.
Error	18	86.271	4.793		
		Total number of letters correctly spelled divided by the total number of letters in each set			
		Between Subjects			
Vowel Knowledge (VK)	1	.504	.504	13.141	.002**
VK (Error)	18	.691	.038		
		Within Subjects			
Vowel Presence (VP)	1	.113	.113	13.694	.002**
VP x VK	1	.048	.048	5.855	.026*
Error	18	.148	.008		

(*Table continues*)

Table 18 continued

Source	df	SS	MS	*F*	sig
Number of times vowel was used in the second position of the word					
Between Subjects					
Vowel Knowledge (VK)	1	1.667	1.667	.173	.682 n.s.
VK (Error)	18	173.208	9.623		
Within Subjects					
Vowel Presence (VP)	1	141.067	141.067	21.481	.000**
VP x VK	1	.067	.067	.010	.921 n.s.
Error	18	118.208	6.567		
Number of times correct vowel was used in the second position of word, even if target word had no vowel					
Between Subjects					
Vowel Knowledge (VK)	1	98.817	98.817	14.890	.001**
VK (Error)	18	119.458	6.637		
Within Subjects					
Vowel Presence (VP)	1	56.067	56.067	15.966	.001**
VP x VK	1	4.267	4.267	1.215	.285 n.s.
Error	18	63.208	3.512		

(*Table continues*)

Table 18 continued

Source	df	SS	MS	*F*	sig
		Total number of correct consonants in spelling			
		Between Subjects			
Vowel Knowledge (VK)	1	382.538	382.538	9.053	.008**
VK (Error)	18	760.562	42.253		
		Within Subjects			
Vowel Presence (VP)	1	16.537	16.537	1.745	.203 n.s.
VP x VK	1	23.438	23.438	2.473	.133 n.s.
Error	18	170.563	9.476		
		Words read correctly in last trial that were also spelled correctly			
		Between Subjects			
Vowel Knowledge (VK)	1	65.104	65.104	6.739	.018*
VK (Error)	18	173.896	9.661		
		Within Subjects			
Vowel Presence (VP)	1	7.004	7.004	1.650	.215 n.s.
VP x VK	1	5.704	5.704	1.344	.261 n.s.
Error	18	76.396	4.244		

Note. * = $p < .05$. ** = $p < .01$. n.s. = not statistically significant.

The number of times any vowel letter was written in the second position of a word did not significantly differentiate the two vowel knowledge groups. Both groups included vowel letters about 80% of the time when they had seen vowel letters in the words they learned and about 44% of the time when they had not seen vowel letters in the words. This indicates that they did store in memory information about whether vowel letters were present in the words. However, the number of times a correct vowel letter was used in second position (even if the target word had no vowel), did significantly differentiate the two groups, indicating that the high vowel knowledge group remembered the correct spellings of vowels better than the low knowledge group. When the target word had no vowel, the high vowel knowledge group was more likely to know the correct letter-sound correspondence, whereas the low vowel knowledge group was not .

The main effect of the presence of vowel letters in words was significant for only three measures. One was the percentage of letters correctly spelled according to the model. As evident in Table 17, children spelled correctly a greater proportion of the letters in words containing no vowel letters than in words containing vowel letters, most likely because there were fewer letters to remember, and they were all consonants, which were more familiar. A significant interaction found between presence of vowel letters and vowel knowledge group for this measure was also detected. Whereas the high vowel knowledge children recalled about the same proportion of correct letters when they spelled words learned with vowels and no vowels, the low vowel knowledge children spelled a greater percentage of correct letters in words not having vowel letters than in words having vowel letters. In other words, having to recall 3 versus 4 letters correctly in words made little difference when children had high vowel knowledge but it made a substantial difference for children with low vowel knowledge. Figure 7 represents this interaction.

The second significant effect of vowel presence was the number of times a vowel was spelled by placing it as the second letter in a word. Although children incorrectly wrote vowel letters in about 44% of the words that did not contain vowel letters, they wrote letters correctly in about 80% of the words that did contain vowel letters, indicating that they tended to remember whether or not the words they had learned contained vowel letters.

The third significant effect of vowel presence was detected on the number of times a correct vowel letter was used in the second position of a word, even if the target word had no vowel. The fact that children wrote more vowel letters correctly that were seen in words than vowel letters that were not seen confirms that children did store vowel letters in memory, and children with greater knowledge of vowel letter-sound correspondences did this to a greater extent.

These findings show that children wrote significantly more vowel letters in the vowel position in the set of words containing vowel letters than they wrote in the vowel absent set, which means that they were affected at least partly by exposure to word models when they spelled the words. However, even children with low vowel knowledge placed vowel letters in the second position of words that were supposed to have none, for example, spelling SAR for the expected SMR (*summer*), MOJ for MSJ (*message*), or FAN instead of FSN (*fasten*). This shows that even children with very limited short vowel knowledge seemed to have a sense that most stressed syllables have vowel letters in them. Since spelling is considered a more productive activity than reading, the fact that children are starting to represent vowels even when they are subtly asked not to means that they are beginning to move from the partial alphabetic towards the full alphabetic phase, by building their own more complete representation of the written world.

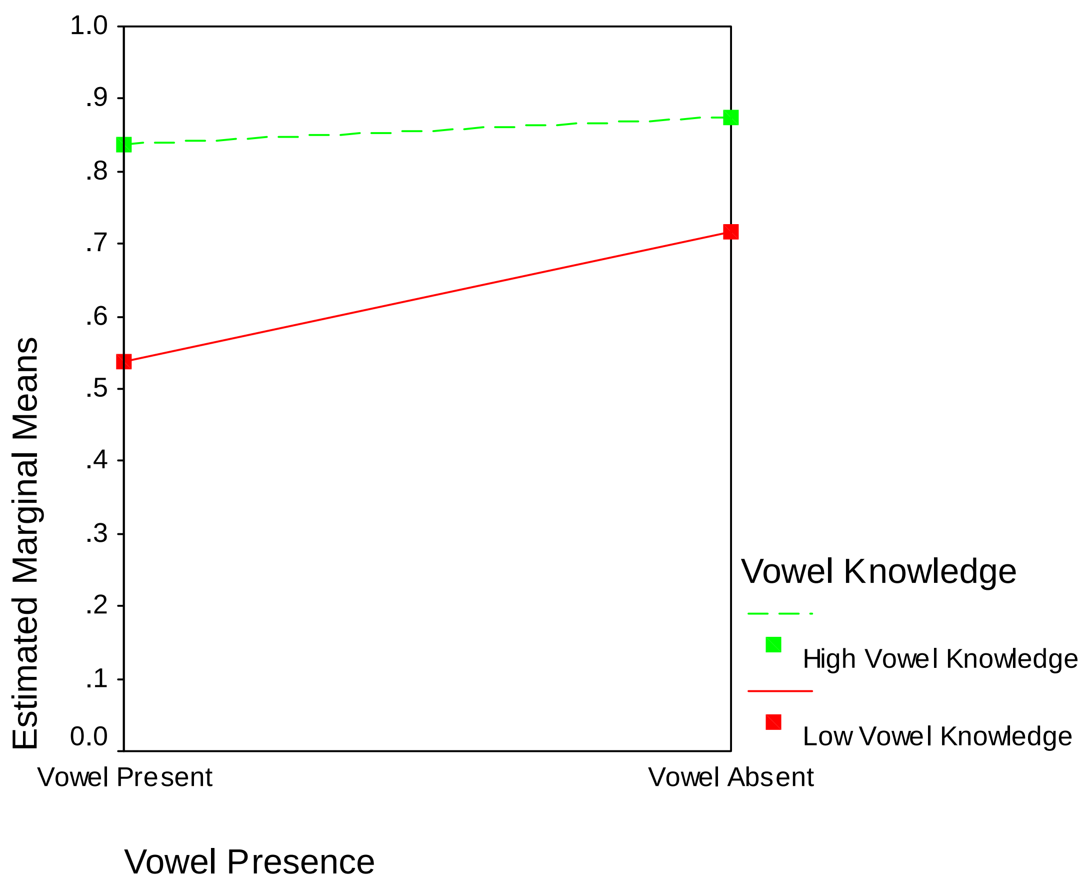

Figure 6. Interaction between vowel presence and vowel knowledge group for the percentage of correct letters spelled.

Characteristics of children who learned the target words in fewer than ten trials.

In order to properly understand the relationship between short vowel letter-sound knowledge and word learning, it may be necessary to explore the characteristics of the children who actually were able to learn new words in a reasonable number of trials. Few children learned all words in 5 trials or less (*N* = 6). Some did not learn all words even after 15 trials (*N* = 5). Most intriguing are the children who learned both sets of words in 10 trials or less. Are there characteristics they share that are lacking in the children who never learned and might explain the difference in performance? What type of short-vowel letter-sound knowledge did they possess? What type of decoding skills did they have? Would any other characteristic set them apart from the children who did not learn both sets of words?

It was seen in previous analyses that children with high short vowel letter-sound knowledge learned words significantly faster than children with low vowel knowledge, and remembered their spellings better. Therefore, another question of interest would be: how much vowel letter-sound knowledge should a child have in order for that to make a difference in their learning?

To answer these questions, children were reclassified into three groups based on their performance on the word learning task: children who learned the target words and reached criterion on at least one word set in fewer than 10 trials, children who learned the words and reached criterion on at least one word set between 10 and 15 trials, and children who never learned the target words and did not reach criterion. If any child's performance qualified for more than one group, the child was placed in the group based on her best performance (i.e., fewer number of trials).

Of the 24 children in the study, four never completed both sets of the word learning task. Two out of those four children, however, had finished at least one of the sets in the word learning – either the vowel present or the vowel absent set, whereas the other two children never started the task. Although the word learning data from those two children who finished at least one set of the learning task could not be used for earlier analyses – since half of their learning data was missing – they were included here for additional information. One of those children had learned set K with no vowels in 6 trials, and the other never learned the set L with vowels in fewer than15 trials.

In total, 22 out of the original 24 children were divided into 3 groups. Thirteen children were placed in the group who learned at least one of the two word sets in fewer than 10 trials. Three children were placed in the group that learned at least one task between 10 and 15 trials. Six children were placed in the group who never reached criterion on any word set.

Data from the pre-tests of the two remaining children (out of the original 24) who dropped out before participating in the learning task were examined. Since their scores were very low and similar to the children who never learned, they were placed in that group as well. At the end, data from all 24 children were analyzed. Table 19 shows a table comparing the three groups of children, and their scores in word learning task, word and pseudoword reading, and their vowel scores in individual tasks at the pre-tests.

Table 19

Means, Standard Deviations and Percentages in Various Measures for Children divided by Number of Trials Needed to Reach Criterion in the Word Learning Task

Measures	≤ 10 Trials to Criterion N = 13	10≤Criterion≤15 N = 3	Never Reach Criterion N = 6
Number of trials to criterion (VP)	4.75 (2.38)	13.33 (1.53)	15 (0)
Number of trials to criterion (VA)	6.42 (2.84)	12.67 (2.52)	15 (0)
Short Vowel HF Word Identification (max=54)	39.46 (12.84)	19.33 (9.61)	6.75 (5.28)
Woodcock Word Identification (max=112)	33.15 (18.27)	17.00 (1.73)	8.25 (7.66)
Totally correct VC Pseudoword reading (max=5)	3.61 (1.12)	1.67 (1.53)	.50 (1.07)
Totally correct CVC Pseudoword reading (max=5)	3.15 (1.68)	.67 (.58)	0 (0)
Individual task scores for A (max=10)	9.30 (.95)	8.0 (1.73)	6.25 (2.91)
% Children 70% Mastery Level	100%	66.70%	50%
Individual task scores for E (max=10)	6.38 (2.93)	3.67 (2.89)	2.37 (2.20)
% Children 70% Mastery Level	53.80%	33%	12.50%
Individual task scores for I (max=10)	8.31 (2.14)	4.67 (2.52)	3.25 (2.31)
% Children 70% Mastery Level	84.60%	33%	12.5%

(*Table continues*)

Table 19 continued

Measures	≤ 10 Trials to Criterion N = 13	10≤Criterion≤15 N = 3	Never Reach Criterion N = 6
Individual task scores for O (max=10)	7.85 (2.19)	3.33 (3.51)	3.25 (2.55)
% Children 70% Mastery Level	76.90%	33%	12.50%
Individual task scores for U (max=10)	5.54 (2.88)	4.67 (4.72)	2.13 (1.46)
% Children 70% Mastery Level	46.20%	33%	0%

Note. % Children 70 % mastery level corresponds to the percentage of children who reached a correct score of at least 7 out of 10 possible points in the individual vowel tasks.

Children's scores on the high frequency word reading task and the number of words read correctly on the Woodcock Word Identification test were quite different for the three groups, but since there were only three children in the middle group, emphasis will be given towards comparing children who never learned words to criterion, and children who did it in fewer than ten trials.

The two more extreme groups were very different in their word reading abilities. Whereas the mean number of high frequency words read by the children who never learned the words was close to 8, the mean for the fast learners was 39.5. On the Woodcock, the mean score for the fast learners was almost four times bigger than the mean scores for the children who never learned the words to criterion.

In terms of their decoding ability, children who learned words in fewer than 10 trials were also the best decoders, as seen on the pseudoword reading tasks. Only two children in the group that never reached criterion were able to decode a Vowel-Consonant (VC) pseudoword like AP, and none could decode a CVC (Consonant-Vowel-Consonant) pseudoword like TAF.

In terms of their vowel knowledge, when we look at the raw scores for each vowel based on the various tasks summed up (total for each vowel =10), there was a clear difference in terms of scores in favor of the children who learned in fewer than 10 trials. This was expected, since children who knew more vowels learned in fewer trials. But how much vowel knowledge is enough to make or show a difference? If you assume an accuracy level of at least 70% correctness for each vowel in order for the vowel to be considered as mastered by the child, and then count the number of vowels each child had mastered, an interesting picture emerges. Table 19 shows the percentage of children in each of the three groups who achieve a level of mastery of at least 70 % correctness for each vowel. In the group that never learned, the best known vowel was still unknown by half of the group. Only two children mastered more than one vowel, and no children mastered more than two. In the group that learned in fewer than 10 trials, at least three vowels were known by 75% of the group, i.e., eleven out of 13 children. For the two other children, the third vowel reached 60 % accuracy, quite close of the 70% accuracy level used as a mastery level in this analysis.

This is an interesting possibility – the finding that children had to be able to manipulate with some mastery close to 3 vowels (vowel letter-sound relations) if they were to learn new words with more efficiency. But this possibility alone is not enough to allow us to understand the relationship between word learning and vowel knowledge. It is a correlational relationship at best. If you accept theoretically that children who learn more words know more vowels, you would still have to explain the exceptions: how one child who knew only one vowel by the criteria used, was able to learn 20 new words by sight - albeit slowly? And how another child, who had mastered 4 vowels at 60-70% accuracy, could learn almost no new sight words?

Having greater vowel letter-sound knowledge may not be sufficient for learning new words. In fact it may be more of a consequence rather than a cause of word learning. We will come back to this in the discussion.

When learning the target words in the learning task, three strategies were most used: 1- Lexical retrieval: children provided a fast and correct answer; 2– Decoding: children tried to sound out some or all letters of the spellings, in order to generate a word; 3- Guessing based on first letter. Although the first and the third strategies might appear similar if a child guessed fast enough, the difference between them was that a lexical retrieval was fast and usually correct, with the child rapidly learning the whole set, whereas with guessing based on the first letter there was a large number of mistakes and confusions among words that shared similar letters, and it took children longer to learn each set. Children who learned the target words in fewer than ten trials either used lexical retrieval or some sort of decoding strategy, but not guessing based on first letter. There were those who had a mixed approach – reading more familiar target words by lexical retrieval but using the sounds of the letters to guide their identification of words that they still had trouble with. Children who learned between 10 and 15 trials either decoded or guessed their words based mostly on the first letter, and all children who never learned guessed their words based on one letter in the word, usually the first.

So although there were many children that seemed to be at the same level in terms of their ability to learn sight words, there were still differences in terms of the tools children possessed to identify and learn the new target words. Those tools, in turn, could be influencing both their learning of the target words, and their acquisition of short vowel letter-sound relations.

Hypotheses testing.

As a summary, various hypotheses were tested in this research with the following findings:

Hypothesis 1. Performance in the vowel tasks varies depending on the level of difficulty of the task.

Findings showed that performance in the vowel recognition task was significantly better than all the production tasks, be it in reading or in spelling short vowel letters. Therefore, hypothesis 1 has been supported.

Hypothesis 2. Greater short vowel letter-sound knowledge in children will correlate significantly with word reading and spelling ability.

According to findings, children with greater short vowel grapheme-phoneme knowledge showed superior performance in the reading tasks, including the Woodcock Word Identification Task, the pseudoword decoding task, and the short vowel high frequency word reading task. They also showed superior ability to spell words and pseudowords. Thus, hypothesis 2 was supported.

Hypothesis 3. Children with high short-vowel grapheme-phoneme knowledge will learn to read words spelled with vowels more easily than words spelled without vowels.

Results failed to support this hypothesis. Findings showed that children with high vowel knowledge learned both types of words equally well regardless of whether spellings included vowels. Thus, hypothesis 3 was not confirmed.

Hypothesis 4. Children with low short vowel knowledge will learn to read words spelled without vowels more easily than words spelled with vowels.

Results did not support this hypothesis. Children with low short vowel knowledge did not show any difference in their learning of words that contained vowels and words that did not. Vowel letters in the words to be learned did not affect their learning.

Hypothesis 5. Children's knowledge of vowels follows a developmental sequence: some vowels are better known than others for most children.

Results showed that children's knowledge of vowels followed a general pattern of A> O, E, U. Thus hypothesis 5 was supported.

Chapter 5

Discussion

This study had two main objectives: 1 – to understand the development and the distribution of short vowel grapheme-phoneme knowledge among beginners; 2 – to examine the contribution of short vowel grapheme-phoneme knowledge to the ability of children to read and spell sight words. In order to do that, various research questions were asked, and hypotheses were tested. In this chapter, answers to those questions will be offered, and the results of the testing of our hypothesis will be discussed.

How much do beginning readers know about short vowel grapheme-phoneme relations?

Short vowel letter-sound knowledge and tasks.

In our sample, children were tested in October, November and December, fairly close to the beginning of the school year. Although children knew all of their letter names, and most of the letter sounds, their knowledge of vowels was the most elusive. Because different tasks were used, our assessment showed different levels of knowledge, depending on the task and the target vowel. Tasks that required recognition only were easier for the children than tasks that required production of responses. Recognition of the correct vowel letter out of three choices, given a short vowel sound, was correct around 80% of the time. But if children had to produce an answer by themselves with no choices given, their chances of having it correct were much lower, and varied from 41 to 62% correct. This shows that children were more aware of vowel letter–sound relationships than they were able to demonstrate in production tasks, and that their knowledge of short vowel letter-sound relations may emerge earlier than previously demonstrated in studies using only production tasks (Taylor, 1984).

Spelling short vowels in isolation (62% correct) was easier than spelling them as part of words or pseudowords (50%), probably because spelling one sound is more direct and faster than segmenting a word into smaller pieces and finding the letter for each sound heard, which is also more challenging operationally. The same did not seem to hold for reading short vowel letters, where there was not a significant difference between reading a vowel letter in isolation compared to reading it as part of a pseudoword. The difficulty in identifying the vowel letter seemed the same. There was, however, a significant difference between reading a vowel letter that came at the outset of a word, and a vowel letter that was sandwiched between two consonants, in a CVC format. This is important, and it agrees with Uhry and Ehri (1999), who found that children had an easier time segmenting VC format words than CV format words, and a harder time segmenting CVC format words. The evidence indicates that children respond differently to different assessment formats: whether or not they show their knowledge depends on the questions asked. Their knowledge of short vowel letter-sound relations may appear in recognition tasks, but may not show up yet in tasks that demand stronger or more ingrained knowledge. And children who are not able to read pseudowords like FIP, or even identify its vowel sound, may be able to correctly identify the vowel sound in IB, when the vowel letter is the first one to be seen, not obscured by an initial consonant. Research shows that beginning readers pay greater attention to the first and last letters than to the middle letters in words, (Ehri & Saltmarsh, 1995; Ehri, 1997) so it is not unreasonable to expect that only more advanced learners look inside words. Besides that, many beginning readers still lack blending skills that enable them to combine the sounds /f/, /I/ and/p/ into the word FIP.

These findings seem to contradict Taylor's findings (1984). Her children performed similarly in reading vowel letters individually or inside pseudowords, but significantly worse when spelling pseudowords, whereas our children performed differently in reading and spelling but not significantly so. However, in analyzing Taylor's tasks, we found that all her short vowel pseudowords had a CVC format, both for reading and spelling, whereas ours had both a VC and a CVC format. As reported above, children's performance tended to be much worse when the target vowel letters were embedded inside words, even when only vowel accuracy was evaluated, and not the whole word. It may be that our tasks, being easier, allowed for higher levels of performance, resulting in a smaller difference between reading and spelling short vowels than Taylor found. Whereas Taylor concluded that short vowel knowledge was applied as soon as it was acquired in reading but not in spelling, we suggest that perhaps the greater difficulty of her tasks may have missed the beginnings of short vowel knowledge. Our findings showed that spelling short vowel sounds in isolation was even easier than reading individual vowel letters to provide their short sounds. Very likely this stemmed from the competition between short and long vowel sounds that impaired performance when children look at vowel letters and try to give the correct sounds. We were able to show that children used their short vowel knowledge in both reading and spelling, although depending on the difficulty of the task their performance varied. The present research complements that of Taylor's. We were able to detect short vowel knowledge through recognition tasks, before such knowledge appeared in productive reading or spelling tasks. We also showed the relevance of the assessment format in detecting children's knowledge, especially if such knowledge is not completely secure. This is particularly important, because assessment measures tend to assume that abilities either are present or absent, but in the case of short vowel letter-sound relations, they may be just obscured by task constraints.

Which task or tasks would be more effective in detecting children's short vowel grapheme-phoneme knowledge?

Some methodological questions that arose when assessing knowledge through different tasks were how much the task demands would influence the outcomes, and how different were the demands placed on children by the different tasks. For example, if a child could identify the sound of a vowel, would he/she be able to use that vowel sound for reading? And for spelling? Which tasks were more sensitive to minimal levels of letter-sound knowledge possessed by children, and which tasks assessed only well-established knowledge? Because this study assessed short vowel grapheme-phoneme knowledge through different tasks, it yielded useful information in terms of which tasks reflect children's knowledge more accurately.

Short vowel letter-sound knowledge does not seem to happen in an all or none fashion. Rather, children's knowledge is variable and depends on the task. As seen earlier, recognition tasks were quite easy for most children – only 8 of our participants had scores lower than 80% correct –, whereas tasks that required combinations of abilities were more difficult. For example, in the task of reading pseudowords, children needed to correctly identify each letter, connect it to its sound, and blend sounds together sequentially. When spelling, children needed to parse words into different phonemes, remember which letter or letters represent each phoneme, choose the appropriate letters and write each one down in their correct sequence. It is not surprising that performance was poorer on the latter tasks.

One of the objectives of this study was to examine the consistency of children's short vowel letter-sound knowledge across tasks. Highly significant correlations among all the tasks indicated that knowledge supported consistent performance even though the ease with which children used that knowledge varied with each task, depending on its difficulty. In most cases, if children knew short A and short I, this pattern of knowledge was evident across tasks.

In order to assess overall vowel knowledge, we created a composite score that drew information from all the tasks. Correlations of the composite score with the individual measures revealed all of them to be highly significant, varying from r =.48 to .85, which showed they were all measuring vowel knowledge. However, the individual task that was best at predicting the composite score was the vowel sound-letter writing task, which asked children to write letters for short vowel sounds pronounced individually by the experimenter. Its correlation reached .94, with $p < .01$.

This task was simple to administer, and it was focused on the specific ability assessed. Compared to the task of vowel letter-sound production, which was also highly correlated with the total score, it held one advantage: by measuring the vowel letter knowledge associated with the sound, it was more direct and avoided calling into attention the competition between the short and the long vowel that share the same letter. Although there were mistakes in both types of tasks, accuracy was higher in the sound-letter writing task.

One very interesting finding in comparing those two tasks was the presence of a large number of letter-name strategies or partial letter-name strategies when children were trying to choose the correct vowel sound or vowel letter to provide as an answer.

Letter name strategies often occur when children are unsure of the target sound or target letter required by a task. They then use the letter-name or part of the letter name of the target letter seen or heard to help identify it or its sound. Since the sounds of many letters are contained inside their names, this strategy generates some success, especially for consonants. But for vowels, this strategy is problematic. Short vowel sounds are not contained in their vowel letter names and cannot be derived from them, which leads to the wrong identification of short vowel sounds and to their confusion with long vowel sounds.

When children were asked to provide a sound for a letter seen, the largest number of mistakes involved partitioning the long-vowel name of the target letter and producing part of it as the letter's sound. For example, children might say that the sound of the letter I is /a/ because this is the first sound articulated in the letter name /aI/, which is a diphthong that combines a vowel and a glide.

When children were asked to provide a letter for a sound heard, they also erred by producing letter name and partial letter name strategies. They tended to use more consonant names and vowel names other than the "long" match of the target vowel. For example, children might write the letter E in response to the short I sound heard /I/ because the name of the letter E (/i/) is very close phonetically to the target /I/ . This letter-name strategy suggests a more advanced type of mistake that involves focusing on the area in the mouth where the sound is articulated.

According to Beers and Henderson (1977) and Ehri (1986), use of letter names and partial letter name strategies characterizes partial alphabetic phase readers. More mature spellers, at the full alphabetic phase, – who know of short vowels but whose knowledge is unstable – would tend to use vowel sounds produced in neighboring regions of the mouth when unsure about which vowels to use.

In the current study, 24 children, when shown 5 vowel letters, produced one sound for each letter. Half of the mistakes in the letter-sound production task were made when children confused the short and the long vowel sharing the same letter, using misleading letter-name strategies. In the sound-letter writing task, although 41% of children's mistakes were also caused by incorrect letter-name strategies, the mistakes were more varied, children achieved a higher rate of success, and the competition between short and long vowel was not so evident. This shows that, when children know less about letter-sound relations, the task used can influence the outcome. The best task to be used in research is one that is less likely to induce error, and most likely to reflect what the child knows. Therefore, if assessment of short vowel letter-sound knowledge is required, the simplest and most efficient way to assess this knowledge is with the vowel sound-letter writing task.

Which short vowel letter-sound relations are best known?

When we looked at which isolated short vowel letters and their sounds were better known by the children, the pattern found followed the order A > I > O > E > U, with significant differences appearing between A> O, E, U.

It is easy to see that A should be the most well-known short vowel letter. It is the most common short vowel in high frequency words. The letter A begins the alphabet, it is the first one to be taught at school, and it is quite frequent in many children's names. Justice and al. (2006) suggested that the names of the letters in the children's names influence the ease or the order in which they are learned. Perhaps this is true for long vowels, where the name of the letter is the same as their sounds. However, for short vowels, where the sound is quite different from its name, there is an opposition in place. In our sample, children who had short vowel sounds in their names did not seem more knowledgeable about that short vowel than children who did not have that vowel in their name. Out of 24 children, 22 had the letter A in their names, and 9 had it representing the short vowel A sound. Two of those children, whose name started with the short vowel A sound, still were not able to say its short sound when looking at A. However, since short vowel sounds differ from their letter names, and compete with their long vowel mates in the task of letter-sound learning, it is not clear how much learning occurs when children are highly exposed to a name – their own – containing short vowel letter-sound relations. Because of the potential interference/competition between the short and the long vowel letter-sound relations, researchers in reading and spelling tend to avoid vowels when studying the relationship between letter names and letter sounds, focusing instead on consonants with a one letter to one sound relationship (Ellefson, Treiman & Kessler, 2009; Treiman, Pennington, Shriberg & Boada, 2008; Justice, Pence, Bowles & Wiggins, 2006). Although vowel letter-sound relations may elude neat research categories, more research is still necessary as evidenced by findings of the present study.

One possible explanation for the order of short vowel letter-sound knowledge that was observed in vowel tasks is that children's knowledge resulted from the effect of teaching. Teachers in first grade did teach those sounds in the A-I-O order. In the previous year at this school, children were taught the letter names and sounds, following the alphabet order (with vowel order being A-E-I-O-U). Their performance when tested followed a pattern of A as the best known vowel (60% correct), followed by E (36% correct), with O and I coming next with very close means (26% and 25% respectively), and U (15%) as the least known. The fact that children's knowledge did match the order in which vowels were taught in class suggests that teaching may be a very strong factor governing children's learning of vowel sounds. McBride-Chang (1999) and Justice et al. (2006) found a relationship between children's knowledge of certain letters and their order in the alphabet – the earlier letters being known best. The same effect could be at work for letter sounds, with sounds taught earlier (i.e. A, I and O in the present study) being the most well-known.

However, A, I and O are also the sounds that are more distinctive in terms of their sonority and place of articulation. It is possible that children find it easier to learn the sounds that are more distinctive and less confusable when they are taught letter-sound relations for short vowels. It may be that phonological distinctiveness anchors their learning and strengthens the teaching effect.

A third possibility exists. It may be that the order of acquisition found (A-I-O plus E or U) mimics the distribution of frequency of short vowel letters in words, so the most frequent is learned first. Additionally, high frequency words may boost letter-sound associations for short vowel letter-sounds. For example, frequent words like ***as***, ***as***, or ***am*** may give the letter A a stronger association with the short A sound. That is quite possible and deserves further investigation. This would be consistent with recent studies from the Treiman group (Treiman & Kessler, 2006; Pollo, Kessler & Treiman, 2009) who claim that the probability by which graphemes and phonemes are learned follows the statistical likelihood of its presence in the written language that the child encounters.

Looking at the Harris and Jacobson's (1972) high frequency word list for pre-primer, primer and first grade readers, we find that, for words containing regular short vowel letter-sounds, short A words occurs in 30 % of the words, followed by short I (23 %), short O and short E (18% each) and short U (11 %). The very similar frequency of short O spellings and short E spellings does not invalidate the claim that the most frequent short vowel letter-sound relationships would be learned first. It however cautions us to avoid predicting an exact order of learning. The relationship between grapho-phonemic relations and their frequency of occurrence deserves more study.

Short vowel letter-sound knowledge and high frequency words.

The strong significant correlation found in the present study between short vowel letter-sound knowledge (composite score) and knowledge of high frequency words (r =.648, $p < .01$) shows that children with higher short vowel letter-sound knowledge are also the ones able to read more high frequency words containing short vowels. However, whether they learn more words because of their short vowel letter-sound knowledge, or they acquire short vowel letter-sound knowledge because of their knowledge of high frequency words, or whether the relationship results from a third factor is still unclear.

Multiple factors are always at work when children learn new words. Factors such as the number of letters in words and their imageability have been shown to influence children's word learning (Balota, Cortese, Sergent-Marshall, Spieler & Yap, 2004). Although all words used in the short vowel word identification task were considered high frequency, other word specific factors could have influenced which words were easier to read.

In the present research, children were asked to read short vowel high frequency words drawn from Harris and Jacobson's (1972) lists of pre-primer, primer and first grade words. It was expected that their knowledge of high frequency words would match their knowledge of short vowel letter-sound relations, with the words best known being the ones which had the vowel letter-sound relations best known as well. Findings showed that high frequency words containing the vowel letters U, O and A were significantly better known than high frequency words with I and E. If knowledge of specific short vowel letter-sound relations had been necessary prior to learning words with those vowels, then children in the present study should have had strong knowledge of short U, short O and short A letter-sound relations, which was not what we found. Tasks that measured individual letter-sound knowledge showed that, although short A was well known, and short O was reasonably known, the short U letter-sound relation was quite unknown. However, in terms of high frequency words, if a child were to know one word only, that word would probably be UP, which was known by 22 out of the 24 children. Four words out of five containing short U were known by at least half of the children. The fact that children were able to identify accurately a number of high frequency words with the letter U in their spellings, but still did not know which sound that letter made, further confirms that word learning can occur without explicit knowledge of a vowel letter-sound relation.

This was also evident in the results of a stepwise regression to see which factors predicted children's knowledge of high frequency words containing short vowels.

Knowledge of short vowel letter-sound relations measured individually did not explain any significant variance in children's knowledge of high frequency words containing short vowels, nor was word frequency or even a quality such as imageability of the word important. The only predictor that partially explained significant variance was the number of letters in the words, where words with fewer letters were more likely to be known than longer words. But even that amount of explained variance was not much (R^2 =.25). Therefore, vowel letter-sound knowledge may be important, but perhaps not necessary for initial word learning, since learning does seem to occur in the absence of vowel letter-sound knowledge.

A better explanation for what we found would be that children derive knowledge about letter-sound relations by learning high-frequency words. Children may have learned high frequency words by using cues other than vowel letters to learn those words. Perhaps partial cues from known consonants in words guide children in their learning of some high frequency words, although it becomes hard to distinguish FAST from FAT if the child only knows the F and the T for the spellings. Ehri has shown examples of this in her partial alphabetic phase (Ehri, 2005).

Having learned various high frequency words that contained the same vowels, children would have their knowledge of short vowel letter-sound relations enhanced. Since word specific learning would occur before knowledge of vowel letter-sounds, this hypothesis could explain knowledge of letter-sound relations even for with O and U, besides A and E.

It is possible that a reciprocal relationship exists. Knowledge of some well-known letter-sound relations could enable the learning of certain words, and likewise word specific learning could enable learning the letter-sound patterns of short vowels.

Short vowel letter-sound relationships are regular and are quite frequent in beginning level books. It is possible that children learn short vowel letter-sound relations through exposure to books and familiarity with highly frequent regular words containing short vowel letters. Although high frequency words tend to have both long and short vowels, short regular CVC words are present in a large number of children's books. Perhaps being exposed to high frequency words containing short vowel letter-sounds would teach those letter-sound relations to children. Moreover, being exposed to short vowel high frequency words that are memorized on word walls – a very common experience in schools – may increase the likelihood that children learn vowel letter-sounds in those words.

The children in our sample were able to identify and recognize many high frequency words, even without being able to identify and recognize the short vowel letter-sounds present in the words. These findings support the idea that children initially acquire their knowledge of high frequency words through partial cue reading, and then proceed to learn more about the alphabetic system and the vowel system.

Ehri and Wilce (1987b) reported some interesting findings in a study to teach children in the partial alphabetic phase to become full alphabetic phase readers. Through training in phoneme identification in words, and blending and decoding, they were able to help children move from learning words by only paying attention to their initial or final letters to learning words by paying attention to all the grapheme-phoneme relations, which in fact made them full alphabetic readers. The training in this study did not focus much attention on the vowels. Rather, it was the consonants that were varied systematically to fit the objectives of the study. However, one unexpected gain, well documented in the children's pre and post-test differences, was the increase in children's knowledge of short vowel letter-sound relations. It is worth noticing that the training focused children's attention on all individual letters and sounds, so learning was more explicit than implicit.

Other researchers have proposed that grapho-phonemic frequency of occurrence impacts strongly in how children and adults acquire and use orthographic knowledge. Cassar and Treiman (1997) showed that children were sensitive quite early to orthographic knowledge. In one experiment, kindergarteners and first-graders were asked to choose which of two words with doubled consonants was more like a real English word. The children had been given a task where there were always two choices in similar pseudowords: one pseudoword with double letters in the beginning (eg. PPES), an illegal spelling in English, and another pseudoword with double letters in the end (e.g., PESS), a legal spelling in English. Children chose the legal spellings above the level of chance, demonstrating they were able to recognize certain orthographic characteristics of English that they were not taught, probably just by being exposed to the spelling of words.

Caravolas, Kessler, Hulme and Snowling (2005) looked at children's vowel spelling development. They assessed their vowel spelling ability at two points in time: the end of reception year in England (kindergarten) and six months later, in the middle of year 1. Children as young as 5 ½ year-olds, who had not been taught letter names nor had been explicitly taught any other vowel letter-sound relations at school besides short vowel letter sound relations, already showed the influence of how consistently certain letter-sound relations for vowels are represented in the language. Since children had not been explicitly taught about the probabilities with which certain vowel graphemes occur in English words, the authors concluded that children had learned implicitly about them through exposure to print.

However, these authors were studying influences on spelling, which tend to appear later than influences in reading. It is possible the effect of word frequency in implicit learning of short vowel letter-sound relations are stronger in reading than in spelling.

Children in the present study were tested for their knowledge of high frequency words containing short vowel letter-sounds at a certain date in time when the words were already part of their written lexicon, and not at the moment children first learned those words. Since that learning was not controlled in any way, any number of unaccounted factors may have influenced why some high frequency words were learned better than others.

The next sections will discuss data gathered through a more controlled word learning task where words varied in their short vowels. It may be informative in identifying factors present when learning occurred, letter-sound knowledge that existed prior to the learning, and possible influences of that learning in spelling.

High and low short vowel letter-sound knowledge and learning new words with and without vowels.

In our experimental task, the objective was to evaluate how children with different levels of vowel knowledge would perform when learning new words, both with vowel letters in their spellings, and without vowel letters in them. Various tasks of vowel letter-sound knowledge were given to children, and their scores in them were transformed into *z*-scores. The sum of all the individual tasks' *z*-scores became the total *Z*-score. This composite measure had a bimodal distribution, and so it was used to divide all the participant children into two groups, one with the higher scores in the total *z*-score continuum, and one with the lowest scores. Children were then randomly assigned to a learning condition, and each child was taught to read two sets of ten facilitated words, one with vowel letters in its spellings, and one without vowel letters.

Ehri's theory (1992, 1998, 2005) predicts that readers with a higher level of knowledge of the alphabetic system, especially the vowel system in English, would have an easier time making connections between more complete spellings and pronunciations in words, and would therefore, learn them better. It was expected, then, that children with greater vowel knowledge – full-alphabetic phase readers – should find it easier to learn new words that had vowel letters to disambiguate them.

The word learning task administered to the children was expected to facilitate learning when vowel letters were present inside words for the children who were knowledgeable about vowels. For children who did not know vowels, or had a limited knowledge of them, (i.e. the partial alphabetic readers), they were expected to have more difficulty in learning words containing vowels than words without them, since the extra vowel letters would increase the length of the word and hence the memory burden.

However, our hypotheses were not confirmed. High vowel knowledge children were able to learn significantly more words per trial and it took them fewer trials to reach criterion than children of low vowel knowledge, regardless of the presence or absence of vowels in the words to be learned. Having vowels in the words did not have any effect on those learners.

Adults who were given the same learning task in a pilot study reported experiencing a facilitative effect in the vowel present condition. According to them, the vowel letters helped them to disambiguate the many possible words that could be formed with the shown consonants. For them, if the set contained vowel letters, it was not even necessary to learn the words belonging to the set prior to identifying those words, since they did it just by decoding the consonant sounds and the correct vowel. If the word had no vowels, however, the many possibilities would sometimes slow them down and make the identification of words less straight forward. Both sets of words were learned quickly, but the adult readers felt that the presence of vowel letters facilitated their word reading.

Children with low vowel knowledge did not find it easier to learn three letter words with no vowels than four letter words containing a short vowel. Both forms were equally hard to learn for them, and the presence or absence of vowels in the spellings of the target words did not make any difference in their learning. This is not to say that the number of letters in words did not matter. Having fewer letters made high frequency words more likely to be read correctly in the short vowel word reading task, but word length did not make learning easier in the word learning task.

It is interesting that we found a significant difference between children of high and low vowel knowledge, which agrees with Ehri's view (1992, 1998, 2005). More vowel knowledge is associated with better word reading skill (as seen in the high correlations between vowel knowledge and word/pseudoword reading scores. However, the presence of significant differences in vowel knowledge between the groups was not accompanied by the finding of a significant difference in terms of their learning of words that had or did not have vowel letters in their spelling.

Why having vowel letters in word spellings did not make a difference in learning?

Various factors may explain the absence of effects. One possibility is that groups compared may not have been sufficiently different in their vowel knowledge. When the two groups differing in vowel knowledge were created, the participants ranged from low vowel knowledge to high vowel knowledge based on the sum of the *z*-scores across all vowel tasks. This distribution was bimodal, which provided the basis for dividing the groups by its mean. Although the high knowledge group included children at the high end of the spectrum, and the low knowledge group had children in the low end of the spectrum, both groups had many children in the middle, which reduced differences between the groups. Perhaps the two groups were not so different after all because children in the middle were still acquiring their short vowel letter-sound knowledge and hence were not knowledgeable enough to use the full vowel system. Some children in the high vowel knowledge group may have known as few as 50% of the vowels.

We found that children's use of vowel letters varied, especially if their knowledge was incomplete. They knew more about some vowel letter-sound relations than others and showed greater vowel knowledge in some tasks than others. Their knowledge was not all or none. Even those with more vowel knowledge still made mistakes, since their knowledge was not yet secure. The question raised by this findings is when can a child be said to possess enough vowel letter-sound knowledge to use it consistently in reading and spelling. Perhaps vowel knowledge has to be more secure in children's repertoire than it was in the present study in order to aid word learning.

According to Ehri (2005), children in the partial alphabetic phase have very limited knowledge of vowels, and tend not to represent them in words whereas children in the full alphabetic phase are quite adept at using them. Although we might be able to identify children who are clearly at the beginning of the partial alphabetic phase, or clearly at the end of the full alphabetic phase, it is harder to pinpoint when a child moves from one phase to the next. There is a gray area between those two points. Present findings revealed that children's short vowel letter-sound knowledge varied depending on the task used to measure it, so it was not possible to say that children either possessed this knowledge or they did not.

In the present study, when we looked at the best performers – children who learned the target words to criterion in fewer than 10 trials – seven children learned better in the vowel present condition, whereas 4 children learned better in the vowel absent condition, and one had similar performance in both sets. The small number of participants limits the value of any statistical comparison among this small group. However, it suggests that maybe the lack of a significant difference for learning words with vowels when compared with no vowels in the high vowel knowledge group might be more due to lack of power than to lack of a real effect. Perhaps in a group that is more homogeneous in terms of their level of mastery of short vowel letter-sound relations, stronger differences favoring words spelled with vowel letters might be evident, as reported by adults being pilot tested.

Another plausible explanation for the lack of effects, especially in the children with high vowel knowledge, is that children's sight word identification (through lexical retrieval) of the words learned may have been supplemented by children's level of decoding and their memory for the finite set of 10 words. Children with high vowel knowledge, who were also the best decoders, could use both lexical retrieval and partial decoding simultaneously to recall the words, using just the consonants as their guide. Inspection of the simplified spellings in Table 1 reveals that the consonants alone made each word in the set of 10 words somewhat distinctive. Vowels were not needed. However, there was substantial overlap in the occurrence of letters across the words. The high number of intra-list errors showed that letter overlap did create confusion for both groups of children, although the low vowel knowledge group had many more mistakes than the high vowel knowledge group. The use of these combined strategies may have diminished the possible facilitative effect of the vowels in words, since for the high vowel knowledge group the words without vowels would be equally accessible once they were familiar with the 10 words in the set.

One question remains, however: how was the disambiguation effect, when vowel letters were present, felt so clearly by adults but not by children? It is possible the difference felt by adults was happenstance, since only a few adults were tested. However, they were unanimous in describing facilitative effects. If we assume that the effects are real, perhaps the aid provided by vowel letters in words works more to improve speed in disambiguating words, and maybe only experienced readers would be able to use it to their advantage. It is possible that the influence of vowel letters may be stronger in terms of increasing precision in the identification of words, and thereby allowing faster access to the lexicon. Maybe the difference between words with vowels and words without vowels lies in processing speed. Since we did not measure latency in identifying words, this hypothesis awaits investigation. This is a question worth studying, and it could indeed be an additional reason why no effects were found.

Analysis of errors in word identification.

Analysis of children's errors in the learning task was conducted to examine how much vowel information children used when learning new words and what types of mistakes were more common for individuals with high versus low vowel knowledge. Their errors were expected to reveal their understanding of the vowel system, and their learning processes. It was also of interest to investigate whether knowledge of short vowels would prompt children to make use of qualitatively different strategies to learn new words.

The word spellings to be learned in the experimental task made use of few letters, but they were organized in a way to demand careful attention to letter detail. Different words shared the same letters in different positions in each set. Learning would be more difficult if children only made use of the first letter, since at least two words within a list shared the same initial letter or final letter.

During the first five trials, children in the high vowel knowledge group read words correctly more than 70% of the time in both vowel present and vowel absent condition, whereas children in the low vowel knowledge group were closer to 50% correct in their word reading. The most common mistake among all children was to confuse the target word with other words that shared the same first letter in the list. Independent of vowel knowledge and presence or absence of vowels, it accounted for from 38% to 48% of the total number of mistakes. The second most common mistake was producing an extra-list word that shared two or more letters with the target word. This occurred more often among children possessing higher vowel knowledge, indicating that these children paid attention to more than one letter when identifying the words, and that their letter-sound mapping skills were superior. This type of mistake tended to diminish as children became more familiar with the set of words.

High vowel knowledge children had similar percentages of intra-list and extra-list errors when vowel letters were present. When they were absent, however, they produced a larger number of extra-list mistakes. This suggests that the presence of vowel letters in words constrained their guessing. They were still guessing, but when there were no vowels they were freer to guess from outside the list. The majority of their extra-list mistakes shared two letters or more with the target spellings, showing their use of letter-sound mapping relations.

In contrast, children with low vowel knowledge produced twice as many intra-list errors as extra-list errors. Most of their intra-list errors shared the same initial letters with the target words, and their number of mistakes were similar, regardless of the presence of vowels in the target spellings. This indicates that they were having difficulty identifying the words inside the list well enough to read them accurately, and the presence of vowels did not have any effect, possibly because they were not looking beyond the first letter of the word anyway. In the vowel absent condition, when they made extra-list errors, they kept to their pattern of identifying words based on only one letter. However, in the vowel present condition, the majority of their mistakes shared two or more letters with the wrong word. This pattern of mistakes is different from their usual strategy of word identification, although the numbers were small. Perhaps words that were better known by the children were retrieved from their own lexicon by some personal and idiosyncratic trigger. Since this happened only in the vowel present condition, it is possible it could be related to the vowel letter or to the fact that more letters in a word offered more opportunity for confusion.

Memory for spellings after the learning task.

A question of interest in the spelling after task was how much the short word learning exercise would impact children's memory for vowels. According to Ehri's theory (1992, 1998, 2005), only children with some knowledge of the vowel system would be able to remember and spell short vowels, because they would only spell the word correctly if it was secure in memory when learned, bonded with the sounds heard in its pronunciation and meaning.

Results for this task showed that higher vowel knowledge children spelled more words correctly than low vowel knowledge children, independently of the presence or absence of vowel letters in the spellings.

Children with high vowel knowledge had a higher proportion of correct letters in each word than children with low vowel knowledge. Having no vowel letters in the words to be spelled significantly improved the proportion of correct spellings for both groups of children, but mainly for low vowel knowledge children, probably because remembering 3 letters correctly was much easier than remembering 4, if your memory is already being taxed. Note that the number of letters in the target word did not affect children's word learning, but only their word spelling.

Our results show that children were aware of the presence of vowels in the spellings, and they stored them in memory. Both groups of children represented vowel letters in the second position of words about 80% of the time after having seen vowel spellings in the words they learned, and about 44% of the time when they had not seen vowel spellings in the words. However, high vowel knowledge children wrote significantly more correct vowel spellings in words than low vowel knowledge children, which meant that either they remembered them better or they had better ability to spell the correct sounds.

Children with high vowel knowledge read and spelled more words correctly than children with lower vowel knowledge, independent of the presence of vowels in the models. High vowel knowledge children also spelled significantly more correct consonants than low vowel knowledge children, showing that their difference in vowel knowledge meant also a difference in their knowledge of how consonants are represented in words. Low vowel knowledge children's memory for letters in words was not as good, showing their more limited ability to keep and store letters in the proper order.

Children were asked to spell the words from the list they had just learned to read. We cannot be sure whether they were recalling spellings of the words, or whether they were just encoding sounds with letters, as the words were dictated. The fact that they spelled significantly more vowels in the vowel present than in the vowel absent condition may indicate that they had stored that information and were retrieving it from memory. Alternatively, the greater inclusion of vowels in one word set than the other may have occurred because the word sets were taught in blocks so children knew whether the words they were writing had contained vowel letters or not.

Learning words with different vowels: was there a difference?

One interesting finding of the learning task involved performance differences among the five short vowels. We discussed earlier that children's short vowel letter sound knowledge followed the order A > I > O > E > U, with significant differences detected only for A > O, E, U. Children's ability to read high frequency words containing short vowels followed a different pattern, reflecting the presence of particular short vowels in the words. Based on easiest to hardest words, the vowel pattern was : U > O > A > I > E, although significant differences among them were found only for U, O, A > I, E. Particularly interesting was the fact that the most well-known words contained the least known of the vowel letter-sound relations (short U). Children who could read words like ***up*** or ***sun*** still were not sure what sound or sounds the letter U produced, indicating that it was not necessary to explicitly know vowel letter-sounds to learn to recognize words containing them. This suggests that vowel letter-sound knowledge may emerge independently of specific word learning. Among beginning readers, word specific learning may be governed by exposure to words and practice reading them using partial cues, whereas vowel letter-sound learning may be governed by explicit instruction.

The experimental learning task offered results bearing on the same relationship. Performance was examined to investigate whether short vowels in words were learned differently one from one another. The number of correct responses for words sharing the same vowel was summed across the first five trials, and comparisons were made among the five vowels. Results showed that words from the two lists that were best learned followed the short vowel order U > E > I > O > A, with significant differences showing U > A only for the high vowel knowledge group. For the low vowel knowledge group, word learning followed the short vowel order U > O > E > A > I, but the differences among them did not reach significance.

Again the words with the highest rate of success in learning were not the words containing the best known short vowel letter-sound A, but words containing short U, the least known short vowel letter-sound relation. Words that had A in their spellings in the learning task were among the hardest to learn to read. The words learned with highest means contained short U vowel spellings.

The fact that words with short U were read more easily both in a more controlled experimental learning task and in everyday/school life (as seen in the knowledge of high frequency words with short U), suggests that there could be a facilitator at work helping children learn words with the letter U. That factor was not knowledge of the letter-sound relation, which many children did not know. It was not frequency of occurrence either, since regular words with short U letter and sound are less frequent than all the other short letter-sounds.

The facilitator may involve how children pronounce the sounds of the letters when they are trying to learn them. When children pronounce the isolated sound of consonants, they often add a schwa vowel to the phoneme, so that the letter B, for example, sounds more like a /b^/ – which is /b/ plus the sound of the short U sound – than the sound of the single phoneme, which would be just /b/. It may be that the phonological association between B and /b^/ when children looked at the word BUBL, for example, provided an extra phonemic cue in remembering how to read the word. The other words containing U might have benefited from this as well: /s^/ to begin to pronounce summer, /t^/ to begin tunnel, and /r^/ to begin rubber. By adding a schwa vowel to the first letter in these words, children got additional help in reading these words.

General discussion.

Results of the present study have shown that a higher level of short vowel letter-sound knowledge is associated with superior reading and spelling. Strong correlations were found between the composite vowel letter-sound score, and the high frequency short vowel word reading score ($r = .648$, $p <.01$). The two tasks that had the highest correlations with reading short vowel high frequency words were vowel spelling in words and pseudowords ($r = .710$, $p < .01$), and vowel reading in CVC pseudowords ($r = .599$, $p <.01$), both of them decoding measures. Another measure of decoding from the pseudoword reading task – number of correct pseudowords read – had a very high and significant correlation with the high frequency short vowel word reading task ($r =.834$, $p < .01$), showing that the children who knew more short vowels were also the ones who could read more high frequency words with short vowels, and were also the best decoders. Correlations between the Woodcock word identification test and most of the short vowel letter-sound knowledge tasks were significant, although somewhat lower. The Woodcock word ID contained at the beginning level not only regular high frequency words, but also high frequency irregular words, which probably caused the lower correlation. But a very high and significant correlation between the Woodcock word ID and the high frequency short vowel task shows that the children who could read more regular words containing short vowels were the same ones who also knew more words in general (both regular and irregular) and had a higher level of reading.

All this is evidence that children who know more short vowels are also the ones who are good decoders and good readers of regular and irregular words. Although explicit teaching may be the main source of their learning once children are in school, the source of children's knowledge of short vowels before school or when it is not explicitly taught is still to be determined. Word reading practice using partial cues may be a good candidate to explain implicit learning of short vowel letter-sounds.

Although knowledge of high frequency words was seen previously as correlated to vowel knowledge, learning of specific vowel words in the word learning task was not correlated with the specific vowel letter-sounds known. This means that learning a word like BUBL (*bubble*) was not dependent on a child knowing the sound that the letter U makes. Additionally, strong correlations do not imply causality. Other factors like memory, decoding ability, or decoding practice could be impacting both vowel letter-sound knowledge and word learning, by offering children better tools to identify words. This, in turn, could aid in their vowel letter-sound knowledge.

Results of the pseudoword reading task showed that children's performance reading short vowels was better in VC units, where the vowel began the word, than in CVC units, where the vowel was inside the word. Maybe if vowel letters were the first letters in word spellings to be learned, children would be more attentive to them and would implicitly learn short vowel letter-sounds relations faster and better. Vowel letters embedded in words tend to be much harder to notice and process, even if the child has some vowel knowledge.

However, just having the knowledge of letter-sound relations for vowels might not be enough to produce an effect in learning new words containing vowel spellings. It is hard to learn a new word if you cannot parse beyond the first letter in the spelling seen. Some decoding skill would probably be required to be able to recognize the various letter-sounds in words. And in order to be able to use the knowledge of vowels that you have, you need to be able to look and recognize letters fast, which means you probably need to have those letter-sound relations automatized. You cannot respond quickly if you have to consciously remember which sound a letter makes. According to Ehri (1986; 1994), children would not be able to use the knowledge of vowels to learn new words if they did not have at least a working knowledge of the vowel system, or how the system works.

The mastery of letter-sound representations for short vowels alone may not explain the learning of new words, but children's ability to differentiate those vowels may be an important part of it. Also, the value of a vowel letter as a place holder cannot be dismissed. Using vowel letters as place holders (even if children are not sure which vowel sounds those letters represent) may allow children to learn incomplete spellings of words made a little more informative due to the knowledge that a yet unknown vowel letter is supposed to be in that position in the spelling, and learn more about specific vowel letter-sound relations as they learn new words. This incomplete knowledge may well be how a child transitions from the partial alphabetic to the full alphabetic phase. When children start learning letter sound relations, consonants and vowels may not be seen as functionally different – they are all important for reading and spelling words. But as children start to learn more words, and they start to see how words are formed, it is possible they start to implicitly categorize letters by their function in words, as vowels and consonants emerge as separate entities.

In the present study, we found support for the idea that the children who learned the experimental words in fewer than ten trials seemed to have a better grasp of the vowel system, even if it was not totally secure, or even complete. It seems that, in order for a child to learn new words, full vowel knowledge is not necessary, and may even be insufficient if not accompanied by some other abilities, probably some level of decoding skill.

So, when a child knows one or two vowel letter-sound relations, he/she may still not have grasped the idea of a system where vowels represent the vocalic center of words, and all words are composed of them. Knowing three or more vowels may force children to at least implicitly perceive a system in place, even if they are not fully able to use it. Such knowledge may allow them to learn more words, which in turn might also benefit their vowel knowledge.

When vowels are not studied in isolation, but are combined with children's knowledge of high frequency words (words they probably know by sight), and their decoding ability, a more complete picture emerges. The analyses of the performance of two children in our group illustrate this point further. Child number 18, for example, possessed poor vowel knowledge (she reached 90% accuracy in reading short A words, but was below 30% in all the other vowels), but she was able to decode correctly two VC pseudowords, and one CVC pseudoword. This child was a slow reader, but all reading was done by decoding. Astonishingly, her high frequency word reading score (28 words) and her score on the Woodcock word identification (18) were even higher than some children in the 10 or fewer trials group. If we were to characterize her capacity for learning words based solely on her vowel knowledge, prior to the word learning task, we probably would have deemed her a strong candidate for not reaching criterion. She, however, learned both sets of words, requiring 12 trials when vowels were present (VP), and 10 trials when vowels were absent (VA). This child is the perfect candidate for a low vowel knowledge child. However, her decoding skill was pushing her ahead by helping her to identify each individual phoneme and connect it to the words' pronunciation that was then stored.

Another interesting performance was that of child number 19. This child was extraordinary in that he had mastered two vowels, with the third vowel in the 60% accuracy level. But the scores for reading high frequency words were some of the highest of all children, besides the fact that he learned both sets in the learning task in fewer than 5 trials each. How was it possible that a child, still transitioning from the partial alphabetic phase to the full alphabetic phase, was able to read words so well, if his vowel knowledge was incomplete? The answer, perhaps, lies in his high level of decoding skill. This child was able to decode correctly 3 out of 5 CVC pseudowords, with the mistakes caused by confusion among vowels. Somehow, this child was able to know how to connect letters to sounds, and connect their letters to pronunciations, even when his vowels were not yet secure.

According to Ehri (1992, 1998, 2005), in order for children to successfully learn new sight words they must have at least implicit knowledge of the vowel system, for otherwise the representations built will be only partial. But they also need to be able to fully analyze the spelling and be able to match it to the sounds in the pronunciation of the word that are then stored in memory. It seems that children who consistently try to decode new words instead of guessing them are carefully building representations in their memory for the spellings of those new words associated with their pronunciations. This would correspond to what Ehri calls the “amalgamation” process in its onset, where each phoneme identified is linked to its grapheme in the spelling being seen, which are also associated to the word’s meaning. After the child has seen that word a few times, seeing the spelling again will immediately bring forth the meaning of the word and its pronunciation. Even if vowels are not completely mastered, if a child knows that vowels as a category are a necessary part of spellings, the decoding and the reading process will probably guide the child in grasping the remainder of the short vowel system.

This study was designed to facilitate reading if children had good short vowel letter-sound knowledge. It was expected that children with low knowledge of vowels would have more difficulty learning new words, especially if the words had vowels in their spellings. However, the decoding process is also a strong teaching process, especially if the child tries to monitor the learning to match the finite number of words of the set being learned. Conversely, a child with some short vowel letter-sound knowledge – even if more than 3 vowels are known – , but with weak awareness to the constituent sounds of words, and with almost non-existing blending and segmentation skills to aid in the decoding process will probably not make much use of the letter-sound connections offered by the vowel letters in learning new words. This was what happened with children number 4, who reached 70% accuracy in the mastery of two vowels, and 60% in the mastery of two others. Although his level of vowel knowledge could be expected to help him in his learning, his decoding level was extremely low (zero in both tasks of pseudoword reading), and his score of only two high frequency words known, combined with his weak score on the Woodcock (4) , all show the difficulty this child had to learn new words.

In our particular sample, children who learned the target words to criterion in fewer than ten trials probably read the words by lexical retrieval (sight word reading). They had not seen those spellings before, but it was not difficult to identify them if one tried to decode the words by pronouncing the sounds of the letters in the spellings. There were those who had a mixed approach – reading more familiar target words by sight but using the sounds of the letters to guide their identification of words that they still had trouble with. Children who reached criterion in between 10 and 15 trials either decoded or guessed their words based mostly on the first letter, and all children who never learned guessed their words based on one letter in the word, usually the first. So although there were many children that seemed to be at a similar level of ability in terms of their phase, differences were enhanced just by the strategies they were using to learn those new words. It is quite possible that children who were sounding out words were closer to moving out of one phase and into the next.

In the word learning task of the present study, words could be recognized if children could identify all the consonant letters, perhaps even if children had no knowledge of vowels. Since initial and final consonant were not similar, if a child had enough consonantal knowledge, and a good enough memory for remembering the full set of words, he/she may not even have needed to use vowels. However, vowels are very helpful for disambiguation, and sight word identification is much faster if retrieval of words in memory is made based on all pieces of information available. If there are letters identifying all the possible phonemic segments, no decision making is required.

Identification should proceed quickly. Even if children are not sure about the actual sound a vowel letter represents, it is possible that knowing the general shape of a word- including the position of where should a vowel be - would aid in the identification of words, since it provides more information to preclude alternative words also stored in memory. This could explain why a child with apparently lower vowel knowledge could have a very large sight word vocabulary. If constraining alternative choices can speed up the process of word learning and word identification, it is possible that children with the highest vowel knowledge use vowels to increase their speed in encoding and decoding words. This study, however, was not designed to measure speed. Although the investigator wrote notes when children were particularly slow or fast, fine distinctions in time were not measured. Although this hypothesis cannot be tested at the moment, it is worth exploring in later studies.

Improving on this study and future studies.

Perhaps a clearer investigation of whether vowel knowledge impacts sight word learning would be to compare a group of children who had mastery of short vowels, and a group of children who had not mastered them yet. One possible way to clarify whether vowel knowledge impacts children's reading and spelling abilities and/or learning strategies is to compare only the two ends of the distribution, the strategies of children with high expertise on vowels (above 80^{th} percentile) to the strategies of students with very low scores on the vowel tasks (below 30^{th} percentile). Such a comparison would provide valuable information about how children with different levels of short vowel letter sound knowledge use their vowel knowledge when learning to read and spell new words. The difficulty when analyzing the performance in the learning tasks of two groups of children with such extreme scores is that not only their vowel knowledge differs, but also their consonant knowledge, as well as other literacy-related skills differ as well, so attributing cause is problematic.

A solution for this would be an experimental training study. This might involve randomly assigning children from matched pairs who have little or no knowledge of short vowel letter-sound relations into two groups, teach the experimental group the letter sound relations for the five short vowels and the control group an irrelevant learning task and later teach both groups to read new sight words differing only by their vowels. Perhaps the use and learning of vowels would be enhanced by teaching sets of words that can only be distinguished if learners are forming vowel letter-sound connections. (e.g., sing/song; ball/bull or sit/sat). It would be interesting to see whether learning of vowel letter-sound relations alone would help children learn new words, and how much training that would require.

Another interesting possibility would be an expansion of the present study, with a stronger correlational approach, with a larger sample: to categorize children's level of short vowel letter-sound mastery and observe whether different levels of short vowel knowledge would affect their learning of new words. Children could be divided by the number of vowels they had mastered, or by the strength of the association of their vowel letter-sound knowledge, and their performance in a word learning task and their ability to read high frequency short vowel words could be examined to determine which vowel knowledge sources explain variance in word reading. Perhaps the question of who uses what may be as important as the knowledge about what strategies children use to learn different words containing different letter-sound relations, or what type of errors they make when trying to learn to identify an unfamiliar word. It may allow us to understand why in the present research the presence or absence of vowels in words did not seem to aid them in learning, and whether an effect might have been missed because some participants were not fully proficient in their vowel knowledge and its use to read and spell words.

Limitations of this study.

One shortcoming of the study was the absence of a large enough number of participants who had mastered short vowel letter-sound relations. Even those with very high vowel letter-sound scores showed inconsistencies across tasks. The small size of the sample was an additional limitation. Had we had a larger number of participants, we could have compared the performance of children at the extremes of the vowel knowledge continuum. Additionally, a larger sample would have allowed us more power, which would certainly have increased the sensitivity of our analyses to individual differences.

In the present research there was no measure of general verbal memory such as a vocabulary measure. This presumably would help children in learning to read high frequency words, which in turn may help them learn vowel spellings. Memory may help children remember letter-sounds better, which would help with automatization and speed in reading words. It probably would help them learn new spellings faster. Some children were strong readers and learners, although their vowel knowledge was still not very secure. Perhaps having a measure for general verbal memory would have helped us address alternative explanations better.

Educational implications .

Short vowel knowledge is just a tiny piece of what is necessary when learning to read. Besides knowing the differences between short and long vowels and their representation both in reading and spelling, you also have to have knowledge of the consonantal spelling system, how to blend one sound into another, how one letter can represent various sounds and one sound can be represented by various letters.

Vowel knowledge is one of many hurdles to be overcome by beginning readers. It is, however, one of the hardest. Many theories (Ehri,1992,2005; Beers & Henderson,1977) use it to distinguish between different developmental levels in both reading and spelling.

Complementing what has been discussed in other studies, our findings show that knowledge of short vowel letter-sound relations may appear earlier than children are able to demonstrate in productive tasks of reading and spelling. At the outset of development in literacy, children's knowledge of letter-sound relations is detected only in multiple choice recognition tasks, but not production tasks. Multiple choice tasks offer the opportunity for researchers and teachers to investigate incipient knowledge children may not even be aware that they possess.

Confirming the findings of other researchers, children use their letter-name strategies to derive the sounds of letters they do not know, even when it is counter-productive, as in the case of short vowel sounds and their letter names. If teachers are aware of the sources of children's common mistakes, both the simpler letter-name strategies and the more elaborate phonological confusions involving acoustically similar sounds, they will be more prepared to identify the different levels of development and offer more precise intervention when needed.

In our study, children with higher vowel knowledge learned to read more words and in fewer trials than children with low vowel knowledge. Although an increase in vowel knowledge is desirable, vowel knowledge per se may not be enough to ensure learning of new words. Some decoding skills may also be necessary for children to be able to use them efficiently.

Short vowels are the regular counterpart to the complex English vowel spelling system. For early readers, practicing reading and spelling in a more regular grapheme-phoneme environment should ensure trust in the system, which in turn should help decoding improve and aid in the development of word reading and spelling. However, as we have seen in our study, the fact that children may be able to read high frequency regular words containing short vowels does not automatically inform children that those vowel letters always produce those short sounds in regular environments. Explicitly calling attention to those regular letter-sound relations and how they can be applied elsewhere in reading and writing may be necessary to ensure that children benefit the most from their experience reading and writing regular and simple words. Helping children identify short vowel spellings in words on their word wall or bank of flash cards may be a way of making sure that children benefit from the frequent encounters with high frequency words in more productive ways than just learning words without explicit attention and analysis.

Children with higher levels of short vowel letter-sound knowledge tend to be better decoders and have more word knowledge in general. Their knowledge of individual letter sound-relations, however, does not seem to aid them in learning words containing those vowel letter-sound relations. For example, short U was the least known of the short vowel letter-sound relations yet it was present in words that were the most easily read by children. Perhaps when teachers are teaching children the short vowel letter-sound relations, they need to provide time for children to learn to read and spell target vowel sounds in words containing those letter sounds.

Research has shown that children and adolescents with reading difficulties have much more difficulties identifying and holding a category of sound in their minds than making a decision when there is a model for comparison, as in a discrimination task (Post et al., 1999).

Although many classrooms display letters and sounds on their walls, it is not so common to have a mnemonic picture to remind children of each letter and their sounds, as in Letterland (Wendon, 1992), for example. In Letterland, Uppy, the umbrella, and Eddy Elephant are pictured with their bodies shaped as the letters U and E respectively. Their names start with the target vowel sound. Perhaps teaching such mnemonics provides a scaffold: children with difficulties in learning to identify short vowels can initially look at the pictures and remember the sounds associated to them. Having a model to compare other sounds to may facilitate identification and categorization of sounds. That, combined with explicit practices of showing which high frequency words have similar vowel letter-sound relations should help children acquire short vowel letter-sound knowledge much faster.

The most important suggestion perhaps is that children need to acquire an expectation that there is a writing system, with letters representing sounds in a consistent systematic way. Present findings suggest that around the time when children are able to identify and classify at least 3 different vowels, that they start realizing the benefits of being a full alphabetic learner. Although this hypothesis needs further investigation, the idea of discovering a system by successfully learning to identify individual letter-sounds sounds is a very interesting one. Therefore, it is necessary to continue to help children build those successful individual experiences with short vowel letter-sound relations.

Final Thoughts

Summary

In designing this study, our objective was to understand beginning readers' knowledge about short vowel letter-sound relations across various tasks, and to investigate the extent to which short vowel knowledge influenced reading and spelling words. A related objective was to discover whether the use of vowel letters to represent short vowels in spellings would aid children in learning to read new words and in remembering their spellings.

Ehri´s theory, portraying the development of sight word reading (Ehri, 1991, 1994, 1995, 2005) claims that when children learn to read new words they store them in memory as amalgams of spellings, pronunciations and meanings. Their storage is dependent upon the type of connections that form the access route into memory. Immature learners in the partial alphabetic phase process few links between sounds heard in speech and letters seen in spellings, mainly beginning letters and sounds. As they develop their awareness of letter-sound relations and phonemic awareness, they start to match each sound heard in speech to the letters that represent them, and their repertoire of sight words grows. They become full alphabetic readers. They process more letter-sound mappings in words, they store more links between speech and sound, the words are stored with more complete information in them, and their written lexicon increases. When they read, their word retrieval process is faster, since more letters stored means less confusion between words that share similar letters.

One of the most fundamental acquisitions that moves children from the partial alphabetic to the full alphabetic phase, is how to use the vowel system to learn new words and remember them. According to Ehri (1991, 1994), children in the partial alphabetic phase have difficulty in remembering the vowels, especially the short ones. They may be able to perceive vowels inside stressed syllables, especially if they say their own names, but most of the times partial alphabetic children are not able to include vowels in the mental representations formed in memory. Full alphabetic readers, on the other hand, are better able to read words by sight and to spell words because they have a more complete representation that includes the letter-sound vowel system.

In the present research we found support for the idea that a difference in vowel knowledge leads to differential learning in spelling and reading words, although we could not find support for the presence of vowel letters aiding children in the full alphabetic phase, or hindering learning for partial alphabetic phase children in a word learning task. Vowel letters are a necessary ingredient in English spellings, and they can aid in disambiguating words if children know them well enough to use them. Unfortunately, that was not the case for children in the present study. The presence of vowel letters in the word spellings to be learned did not make a difference in children's learning. Both sets of words(with and without vowel letters) were learned at a similar level by each group, although high vowel knowledge children learned significant more words than the lower vowel knowledge group, and that advantaged was maintained throughout the task. Children with low vowel knowledge had difficulty learning and distinguishing words that shared similar letters. They identified words based on their initial letter, and this led to confusion among similarly spelled words. They were not able to use the short vowel letter-sound relations they knew to help them learn the target words, probably because those vowels were embedded inside the words. They dismissed the vowels when learning new words, and rather paid attention mostly to the initial and final consonants.

As pointed out in the literature review, children in the partial alphabetic phase have very limited knowledge of vowels, and are not very skilled at matching all the sounds they hear in words with their spellings, which makes their representations incomplete. Incomplete representations of spellings in memory leads to confusion between similar words, as was evident in the learning task. Children's mistakes in learning words reflected their difficulty in being able to identify the proper words, since they focused mostly on the first letter of their target spellings. Letters in the middle were largely ignored, and that was what happened to the vowel letters.

Although children with high vowel learned the target words significantly faster and better than low vowel knowledge children, still they did not show the expected advantage of vowel letters in facilitating their word learning. Various reasons can be proposed for that. Consonant letter cues in both sets of words (with and without vowel letters) may have been sufficient to support lexical access - reading words from memory- which was the primary means of reading the words, making vowel letters expendable and unnecessary. Also, the high vowel knowledge group had not fully mastered the vowel spelling system, so this may have limited the effect of vowel knowledge on their word learning.

In regard to the letter-sound knowledge possessed by our sample, this study found evidence for incipient short vowel knowledge, which was only displayed through recognition tasks, but not through production tasks. Children who were more knowledgeable in short vowel letter-sound relations performed at ceiling in the recognition tasks, whereas they still displayed uncertainty and lack of knowledge in the harder production tasks.

The sound-letter writing task was found to be the best predictor of overall short vowel letter-sound knowledge. It was a simple enough task to apply, and its accuracy was higher than other tasks with similar predictive ability.

The vowel knowledge pattern found for high frequency words containing short vowel letters was not the same as the pattern found for vowel letter-sound relations measured in vowel tasks. Whereas in individual letter tasks short A letter-sound relations were the best known, and short U the least, in the high frequency word reading task words containing short U were the most well-known. Short E letter-sound relations were either at the bottom (for high frequency words) or near bottom (for vowel letter-sound tasks), and never as well-known as most well-known vowels. The singular position of short E could be linked to its specificity – it was the only short vowel to which a large number of children gave the letter name instead of the correct sound. It was the only name having no glide. In the experimental word learning task, the only significant difference found was that words with the vowel U were learned more easily than words with A. This was unexpected, since A was a vowel that most children had mastered. Children's mispronunciation of the initial consonants of the words in the word learning as the consonant plus a schwa vowel, which sounds just like the short U sound, may have provided cues to their learning and may explain why words with U were easier to learn.

The significant correlations found between measures of decoding, word identification and short vowel knowledge show that the more vowel knowledge children have, the more words they are able to read. However, such correlational data do not allow us to say whether children decode and read better because they have more vowel knowledge or whether they know more short vowels because they read or decode better.

Analyses of children's performance in the word learning task showed that the best performers – the ones who reached criterion in under than ten trials – were also the best decoders and the ones with higher knowledge of high frequency words, both regular and irregular. Those analyses also showed that children who were able to reach criterion in fewer than 10 trials had at least 70 % mastery of close to three vowel letter-sound relations. It raises an interesting possibility. In order to learn to read words, vowel knowledge is not essential. However, if children do not have a certain amount of vowel knowledge, their progress is limited. Full knowledge and use of consonant and vowel spellings is an important part of learning to read and spell in an alphabetic language. Even if children are not completely sure of the vowel sounds of particular vowel letters, if they know at least a few vowel sounds, they can use vowel letters as place holders, while they work towards acquiring knowledge of additional letter-sound relations through word learning and decoding.

The hypothesis above needs additional evidence. Perhaps better experiments that also measure speed and automatization of word reading might generate more definite findings. New comparison groups should perhaps be used, with level of vowel mastery specified at the outset of the study to avoid lack of differentiation of the participants. Perhaps a future study should include measures of reaction time for a more complete investigation of the roles of short vowel letters in word identification.

Appendixes

Appendix 1 - The English vowels – International Phonetic Alphabet symbols

IPA symbols used	Words with that sound	In Educational Literature
æ	**a**pple	Short A
ɛ	**e**lephant	Short E
I	**i**t	Short I
a or ɑ	**o**ff	Short O
ʌ	**u**p	Short U
e	m**a**ke	Long A
i	s**ee**k	Long E
aɪ (diphthong)	b**i**ke	Long I
o	h**o**pe	Long O
yu	c**u**te	Long U
ʊ	b**oo**k	
u	b**oo**t	
ə (schwa)	**a**bout	
ɔ	c**au**se	In some American dialects, this vowel has merged with /ɑ/
aʊ (diphthong)	c**ow**	
ɔI (diphthong)	b**oy**	

Appendix 2 - The English letter-name sounds used – International Phonetic Alphabet symbols

Letter	IPA symbols used	Letter-name sounds like	Words with that sound	In Educational Literature
A	æ		**a**pple	Short A
	e	ay	m**a**ke	Long A
E	ɛ		**e**lephant	Short E
	i	ee	s**ee**k	Long E
I	I		**i**t	Short I
	aI (diphthong)	I	b**i**ke	Long I
O	a or ɑ		**o**ff	Short O
	o	oe	h**o**pe	Long O
U	ʌ		**u**p	Short U
	yu	you	c**u**te	Long U
B	bi	bee	banana	
C	si	cee	Seek - cd	
D	di	dee	detail	
F	ɛf	eff	effort	
J	dʒeI	jay	jail	
K	keI	kay	Kate	
L	ɛl	el	Elmo	
M	ɛm	em	Emily	
N	ɛn	en	men	
P	pi	pee	pea	
R	aɹ or ɑɹ	are	arm	
S	ɛs	ess	mess	
T	ti	tee	tea	
V	vi	vee	visual	

To: Parent/ guardian of an elementary student at P.S.

From: Simone Nunes/Linnea Ehri, Ph.D. Program in Educational Psychology at CUNY Graduate School

Re: Conduct of Project on reading/spelling development.

My name is Simone Nunes, and I am a Ph.D. student in the Educational Psychology program at the Graduate School and University Center of the City University of New York (CUNY). I study literacy acquisition. I am the principal investigator of the research project "Understanding vowel knowledge in the process of learning to read and spell".

This project studies children's knowledge about vowels in English. I want to study how children use their vowel knowledge to identify words, and learn to read and spell new words. We received permission from the Dept. of Education of the City of New York, from your child's principal and teacher to conduct this research project. We will develop this project with pupils in your child's classroom.

Each child will be seen individually from 1 to 5 occasions. The research will take place in or near the classroom, during school hours. Depending on the child's knowledge, and speed, each session may last between 15 to 30 minutes. We only take children from the classroom with the permission of the teacher. Children will not miss class time when new materials are presented.

Children will be asked to identify letters, sounds and simple words in cards or in a computer screen. They will be asked to spell some simple words and nonwords. Children who know letter names and letter sounds but are not yet readers will learn to identify new words using facilitated spellings. They may receive training to help them focus on letters they know to identify words. The activities will be similar to those used by teachers in classrooms to teach reading and spelling.

In participating in this research project, children will face no more risks than in normal school activities. They will benefit by an improved knowledge about letters and sounds. They will also gain practice using those letters and sounds to read and spell words.

Results of this study should advance our understanding about how children learn to read and spell. This in turn may help to improve literacy instruction in schools.

In order for your child to participate in our project, your written permission is required. Only after we have your permission your child will be asked to participate. If you are agreeable, please complete and sign the attached permission form. Return it signed to your child's teacher as soon as possible. Keep the second copy for your files.

You should know that participation in this project is completely voluntary. Any child who participates is free to withdraw from the study at any time for any reason without any consequence. Information about your child's reading and spelling skills may help your child's teacher understand the needs of your child better. If you have no objection, this information may be shared with the teacher. Otherwise, your child's performance will be kept confidential. Only I and my advisor will have access to it.

Any further information can be obtained by contacting Simone Nunes (718-932-0963 or Snunes@gc.cuny.edu) or Prof. Linnea Ehri (212- 817-8294 or Lehri@gc.cuny.edu). If you have any questions about your child's rights as a participant in this study, you can call Ms. Hilry Fisher. She is at the CUNY Graduate School, Office of Sponsored Research (212-817-7523 or Hfisher@gc.cuny.edu).

Please, if agreeable, sign and return this sheet to your child's teacher as soon as possible.

CONSENT TO PARTICIPATE IN THIS RESEARCH STUDY

Title of Study: Understanding vowel knowledge in the process of learning to read and spell

Principal Investigator: Simone R. Nunes

Ph. D. Program in Educational Psychology
CUNY Graduate Center
Phone: (212) 817-8301

I grant permission for ________________________________ to participate in this research project.

(name of the child)

I have read the description of the study. I understand the activities to be given to my child. The letter answers all the questions I have to my satisfaction. The researchers have given me a copy of this form. I consent to allow my child to participate in this study.

Signature of parent ________________________________ date__________________

Birth date of child ________________________________

Please check:

______I would like any information about my child's reading and spelling to be shared with my child's teacher.

______I don't want any information about my child's reading and spelling to be shared with my child's teacher.

Signature of researcher ________________________________ date__________________

Appendix 4 – List of Tasks

LETTERS

- Letter name knowledge – 18 items (range from 8 to 26)
- Letter sound production (21 consonants + 5 short vowels)
- Short vowel sound letter writing – 5 vowels
- Short vowel sound letter recognition – 10 items (3-item multiple choice)

READING WORDS

High frequency short vowel word identification task – 54 words

- Pseudoword reading – 10 nonwords with short vowels (5 CVs, 5 CVCs):

  Score: Correct nonwords read (10), Correct vowels in CVs (5), Correct vowels in CVCs (5)

Woodcock word identification

SPELLING WORDS

- Spelling test of real words with short vowels – 10 words (CVCs and multisyllabic words)

  Score: Spelled with correct initial vowel (5); Spelled with correct medial vowel (5 in CVCs)

- Pseudoword spelling – spell 10 short vowels explained as parts of real words

  Score: Correct vowels in pseudowords (10)

WORD LEARNING FOLLOWED BY SPELLING TASKS

One set of 10 words learned with short vowel letters

One set of 10 words learned without vowel letters

Measures: # words read correctly over trials

words and #short vowels spelled correctly at end of learning trials (10 items)

- Word learning
- Spelling of words learned

Appendix 5- Pre-test forms

Name________________________Grade_____ Teacher___________Date___________
School: PS_______ Gender: F M Ethnic Group: H – AA – W – A

Mother's name___________ Father's name__________other sig.Caregiver___________

Birth date_______________ siblings_______________________________

1. Questions:

a. Can you speak another language besides English?

b. What language do you speak at home with your family?

c. Do your parents speak English?

LETTER NAMING PRETEST		LETTER SOUND PRETEST	
B	C	B	C
N	E	N	E
T	X	T	X
i	G	i	G
M	V	M	V
K	J	K	J
P	Z	P	Z
A	Q	A	Q
S	H	S	H
L	W	L	W
D	F	D	F
R	Y	R	Y
U	O	U	O

SPELLING OF INDIVIDUAL VOWEL LETTERS

i ______ O______ A _______ U _______ E ________

CHOOSING THE LETTER THAT REPRESENTS THE CORRECT VOWEL SOUND

1 - [short O] - i, O, A
2 - [short U] - U, i, O,
3 - [short E] - O, U, E
4 - [short A] - U, A, E
5 - [short i] - E, A, i
6 - [short A] - U, E , A
7 - [short i] - i, O, A
8 - [short E] - i, E, A
9 - [short O] - i, O, U
10 - [short U] - U, O, E

☐ SPELLING OF WORDS:

1. SACK	6. ACTOR	11. LAB	16. LAP
2. FIT	7. ITCH	12. LIP	17. SICK
3. MUG	8. UPPER	13. LUCK	18. NUT
4. DECK	9. ECHO	14. NET	19. NECK
5. KNOCK	10. OFFICER	15. MOP	20. DOT

☐ High Frequency Word Recognition

1. ___and	15. ___fun	29. ___am	43. ___back
2. ___at	16. ___ask	30. ___bed	44. ___never
3. ___up	17. ___let	31. ___bring	45. ___miss
4. ___help	18. ___fish	32. ___drop	46. ___off
5. ___dog	19. ___on	33. ___cut	47. ___step
6. ___ran	20. ___jump	34. ___an	48. ___picture
7. ___is	21. ___fast	35. ___dress	49. ___cat
8. ___little	22. ___pet	36. ___if	50. ___pig
9. ___can	23. ___him	37. ___got	51. ___fat
10. ___it	24. ___us	38. ___duck	52. ___hand
11. ___with	25. ___man	39. ___as	53. ___hat
12. ___daddy	26. ___yellow	40. ___kitten	54. ___rabbit
13. ___in	27. ___his	41. ___lost	
14. ___stop	28. ___sit	42. ___sun	

☐ Pseudoword reading

AP	TAF
IB	FIP
EK	PEB
OP	VOT
UT	NUK

Appendix 6 – Protocols for the Word Learning Task

Name:________________________ Teacher:_______________________
Date:___________________
C1 – word learning – set K vowels + set L no vowels

Vowels			No Vowels		
KASL	KASL	KASL	LDR	LDR	LDR
MESJ	MESJ	MESJ	DVL	DVL	DVL
KITN	KITN	KITN	SPL	SPL	SPL
MODL	MODL	MODL	BMR	BMR	BMR
TUNL	TUNL	TUNL	FSN	FSN	FSN
RATL	RATL	RATL	LTC	LTC	LTC
PESL	PESL	PESL	BBL	BBL	BBL
TIKT	TIKT	TIKT	FDL	FDL	FDL
POSM	POSM	POSM	DLR	DLR	DLR
RUBR	RUBR	RUBR	SMR	SMR	SMR
MESJ	MESJ	MESJ	BMR	BMR	BMR
TIKT	TIKT	TIKT	FDL	FDL	FDL
MODL	MODL	MODL	SPL	SPL	SPL
RATL	RATL	RATL	BBL	BBL	BBL
KASL	KASL	KASL	SMR	SMR	SMR
POSM	POSM	POSM	DVL	DVL	DVL
KITN	KITN	KITN	LTC	LTC	LTC
TUNL	TUNL	TUNL	FSN	FSN	FSN
PESL	PESL	PESL	LDR	LDR	LDR
RUBR	RUBR	RUBR	DLR	DLR	DLR
RATL	RATL	RATL	BBL	BBL	BBL
TUNL	TUNL	TUNL	FSN	FSN	FSN
MODL	MODL	MODL	SMR	SMR	SMR
KITN	KITN	KITN	DLR	DLR	DLR
MESJ	MESJ	MESJ	SPL	SPL	SPL
KASL	KASL	KASL	LDR	LDR	LDR
POSM	POSM	POSM	FDL	FDL	FDL
RUBR	RUBR	RUBR	LTC	LTC	LTC
TIKT	TIKT	TIKT	DVL	DVL	DVL
PESL	PESL	PESL	BMR	BMR	BMR
MODL	MODL	MODL	SPL	SPL	SPL
POSM	POSM	POSM	FDL	FDL	FDL
RUBR	RUBR	RUBR	BMR	BMR	BMR
TUNL	TUNL	TUNL	DLR	DLR	DLR
KASL	KASL	KASL	FSN	FSN	FSN
RATL	RATL	RATL	LDR	LDR	LDR
MESJ	MESJ	MESJ	SMR	SMR	SMR
PESL	PESL	PESL	LTC	LTC	LTC
KITN	KITN	KITN	DVL	DVL	DVL
TIKT	TIKT	TIKT	BBL	BBL	BBL
RUBR	RUBR	RUBR	DVL	DVL	DVL
TUNL	TUNL	TUNL	BMR	BMR	BMR
PESL	PESL	PESL	LTC	LTC	LTC
KASL	KASL	KASL	FDL	FDL	FDL
POSM	POSM	POSM	SMR	SMR	SMR
MESJ	MESJ	MESJ	LDR	LDR	LDR
TIKT	TIKT	TIKT	SPL	SPL	SPL
RATL	RATL	RATL	FSN	FSN	FSN
MODL	MODL	MODL	BBL	BBL	BBL
KITN	KITN	KITN	DLR	DLR	DLR

Name:________________________ Teacher:_______________________
Date:___________________
C2 – word learning – set K no vowels + set L vowels

No Vowels			Vowels		
KSL	KSL	KSL	LADR	LADR	LADR
MSJ	MSJ	MSJ	DEVL	DEVL	DEVL
KTN	KTN	KTN	SIPL	SIPL	SIPL
MDL	MDL	MDL	BOMR	BOMR	BOMR
TNL	TNL	TNL	FASN	FASN	FASN
RTL	RTL	RTL	LETC	LETC	LETC
PSL	PSL	PSL	BUBL	BUBL	BUBL
TKT	TKT	TKT	FIDL	FIDL	FIDL
PSM	PSM	PSM	DOLR	DOLR	DOLR
RBR	RBR	RBR	SUMR	SUMR	SUMR
MSJ	MSJ	MSJ	BOMR	BOMR	BOMR
TKT	TKT	TKT	FIDL	FIDL	FIDL
MDL	MDL	MDL	SIPL	SIPL	SIPL
RTL	RTL	RTL	BUBL	BUBL	BUBL
KSL	KSL	KSL	SUMR	SUMR	SUMR
PSM	PSM	PSM	DEVL	DEVL	DEVL
KTN	KTN	KTN	LETC	LETC	LETC
TNL	TNL	TNL	FASN	FASN	FASN
PSL	PSL	PSL	LADR	LADR	LADR
RBR	RBR	RBR	DOLR	DOLR	DOLR
RTL	RTL	RTL	BUBL	BUBL	BUBL
TNL	TNL	TNL	FASN	FASN	FASN
MDL	MDL	MDL	SUMR	SUMR	SUMR
KTN	KTN	KTN	DOLR	DOLR	DOLR
MSJ	MSJ	MSJ	SIPL	SIPL	SIPL
KSL	KSL	KSL	LADR	LADR	LADR
PSM	PSM	PSM	FIDL	FIDL	FIDL
RBR	RBR	RBR	LETC	LETC	LETC
TKT	TKT	TKT	DEVL	DEVL	DEVL
PSL	PSL	PSL	BOMR	BOMR	BOMR
MDL	MDL	MDL	SIPL	SIPL	SIPL
PSM	PSM	PSM	FIDL	FIDL	FIDL
RBR	RBR	RBR	BOMR	BOMR	BOMR
TNL	TNL	TNL	DOLR	DOLR	DOLR
KSL	KSL	KSL	FASN	FASN	FASN
RTL	RTL	RTL	LADR	LADR	LADR
MSJ	MSJ	MSJ	SUMR	SUMR	SUMR
PSL	PSL	PSL	LETC	LETC	LETC
KTN	KTN	KTN	DEVL	DEVL	DEVL
TKT	TKT	TKT	BUBL	BUBL	BUBL
RBR	RBR	RBR	DEVL	DEVL	DEVL
TNL	TNL	TNL	BOMR	BOMR	BOMR
PSL	PSL	PSL	LETC	LETC	LETC
KSL	KSL	KSL	FIDL	FIDL	FIDL
PSM	PSM	PSM	SUMR	SUMR	SUMR
MSJ	MSJ	MSJ	LADR	LADR	LADR
TKT	TKT	TKT	SIPL	SIPL	SIPL
RTL	RTL	RTL	FASN	FASN	FASN
MDL	MDL	MDL	BUBL	BUBL	BUBL
KTN	KTN	KTN	DOLR	DOLR	DOLR

Name:________________________ Teacher:_______________________
Date:___________________
C3 – word learning – set L vowels + set K no vowels

Vowels			No Vowels		
LADR	LADR	LADR	KSL	KSL	KSL
DEVL	DEVL	DEVL	MSJ	MSJ	MSJ
SIPL	SIPL	SIPL	KTN	KTN	KTN
BOMR	BOMR	BOMR	MDL	MDL	MDL
FASN	FASN	FASN	TNL	TNL	TNL
LETC	LETC	LETC	RTL	RTL	RTL
BUBL	BUBL	BUBL	PSL	PSL	PSL
FIDL	FIDL	FIDL	TKT	TKT	TKT
DOLR	DOLR	DOLR	PSM	PSM	PSM
SUMR	SUMR	SUMR	RBR	RBR	RBR
BOMR	BOMR	BOMR	MSJ	MSJ	MSJ
FIDL	FIDL	FIDL	TKT	TKT	TKT
SIPL	SIPL	SIPL	MDL	MDL	MDL
BUBL	BUBL	BUBL	RTL	RTL	RTL
SUMR	SUMR	SUMR	KSL	KSL	KSL
DEVL	DEVL	DEVL	PSM	PSM	PSM
LETC	LETC	LETC	KTN	KTN	KTN
FASN	FASN	FASN	TNL	TNL	TNL
LADR	LADR	LADR	PSL	PSL	PSL
DOLR	DOLR	DOLR	RBR	RBR	RBR
BUBL	BUBL	BUBL	RTL	RTL	RTL
FASN	FASN	FASN	TNL	TNL	TNL
SUMR	SUMR	SUMR	MDL	MDL	MDL
DOLR	DOLR	DOLR	KTN	KTN	KTN
SIPL	SIPL	SIPL	MSJ	MSJ	MSJ
LADR	LADR	LADR	KSL	KSL	KSL
FIDL	FIDL	FIDL	PSM	PSM	PSM
LETC	LETC	LETC	RBR	RBR	RBR
DEVL	DEVL	DEVL	TKT	TKT	TKT
BOMR	BOMR	BOMR	PSL	PSL	PSL
SIPL	SIPL	SIPL	MDL	MDL	MDL
FIDL	FIDL	FIDL	PSM	PSM	PSM
BOMR	BOMR	BOMR	RBR	RBR	RBR
DOLR	DOLR	DOLR	TNL	TNL	TNL
FASN	FASN	FASN	KSL	KSL	KSL
LADR	LADR	LADR	RTL	RTL	RTL
SUMR	SUMR	SUMR	MSJ	MSJ	MSJ
LETC	LETC	LETC	PSL	PSL	PSL
DEVL	DEVL	DEVL	KTN	KTN	KTN
BUBL	BUBL	BUBL	TKT	TKT	TKT
DEVL	DEVL	DEVL	RBR	RBR	RBR
BOMR	BOMR	BOMR	TNL	TNL	TNL
LETC	LETC	LETC	PSL	PSL	PSL
FIDL	FIDL	FIDL	KSL	KSL	KSL
SUMR	SUMR	SUMR	PSM	PSM	PSM
LADR	LADR	LADR	MSJ	MSJ	MSJ
SIPL	SIPL	SIPL	TKT	TKT	TKT
FASN	FASN	FASN	RTL	RTL	RTL
BUBL	BUBL	BUBL	MDL	MDL	MDL
DOLR	DOLR	DOLR	KTN	KTN	KTN

Name:________________________ Teacher:_______________________
Date:___________________
C4 – word learning – set L no vowels + set K vowels

No Vowels			Vowels		
LDR	LDR	LDR	KASL	KASL	KASL
DVL	DVL	DVL	MESJ	MESJ	MESJ
SPL	SPL	SPL	KITN	KITN	KITN
BMR	BMR	BMR	MODL	MODL	MODL
FSN	FSN	FSN	TUNL	TUNL	TUNL
LTC	LTC	LTC	RATL	RATL	RATL
BBL	BBL	BBL	PESL	PESL	PESL
FDL	FDL	FDL	TIKT	TIKT	TIKT
DLR	DLR	DLR	POSM	POSM	POSM
SMR	SMR	SMR	RUBR	RUBR	RUBR
BMR	BMR	BMR	MESJ	MESJ	MESJ
FDL	FDL	FDL	TIKT	TIKT	TIKT
SPL	SPL	SPL	MODL	MODL	MODL
BBL	BBL	BBL	RATL	RATL	RATL
SMR	SMR	SMR	KASL	KASL	KASL
DVL	DVL	DVL	POSM	POSM	POSM
LTC	LTC	LTC	KITN	KITN	KITN
FSN	FSN	FSN	TUNL	TUNL	TUNL
LDR	LDR	LDR	PESL	PESL	PESL
DLR	DLR	DLR	RUBR	RUBR	RUBR
BBL	BBL	BBL	RATL	RATL	RATL
FSN	FSN	FSN	TUNL	TUNL	TUNL
SMR	SMR	SMR	MODL	MODL	MODL
DLR	DLR	DLR	KITN	KITN	KITN
SPL	SPL	SPL	MESJ	MESJ	MESJ
LDR	LDR	LDR	KASL	KASL	KASL
FDL	FDL	FDL	POSM	POSM	POSM
LTC	LTC	LTC	RUBR	RUBR	RUBR
DVL	DVL	DVL	TIKT	TIKT	TIKT
BMR	BMR	BMR	PESL	PESL	PESL
SPL	SPL	SPL	MODL	MODL	MODL
FDL	FDL	FDL	POSM	POSM	POSM
BMR	BMR	BMR	RUBR	RUBR	RUBR
DLR	DLR	DLR	TUNL	TUNL	TUNL
FSN	FSN	FSN	KASL	KASL	KASL
LDR	LDR	LDR	RATL	RATL	RATL
SMR	SMR	SMR	MESJ	MESJ	MESJ
LTC	LTC	LTC	PESL	PESL	PESL
DVL	DVL	DVL	KITN	KITN	KITN
BBL	BBL	BBL	TIKT	TIKT	TIKT
DVL	DVL	DVL	RUBR	RUBR	RUBR
BMR	BMR	BMR	TUNL	TUNL	TUNL
LTC	LTC	LTC	PESL	PESL	PESL
FDL	FDL	FDL	KASL	KASL	KASL
SMR	SMR	SMR	POSM	POSM	POSM
LDR	LDR	LDR	MESJ	MESJ	MESJ
SPL	SPL	SPL	TIKT	TIKT	TIKT
FSN	FSN	FSN	RATL	RATL	RATL
BBL	BBL	BBL	MODL	MODL	MODL
DLR	DLR	DLR	KITN	KITN	KITN

Appendix 7 - Script used

	Description	Materials	Script
Introduction	Introduce yourself and ask for verbal assent from child		*"Hi __________.* *My name is Simone Nunes, and I will be working with some children at your school to help them read better.* *We will learn and practice the names and sounds of some letters. That will help children learn to read better.* *We will also learn to read and spell some words. We can stop at any time, if you feel tired. You just tell me, OK?* *Would you like to work with me in learning those things?"* Response___________
Letter name accuracy	Children will be asked to name all the letters included in cards (all 26 letters of the alphabet) in the fastest way possible.	4 card boards with letters written in there. Recording sheet.	*"Now I want you to tell me all the letters in this card. Name them carefully without making a mistake. You can start."*
Letter sound production	Children will be asked to give the sounds of all letters in a card (all sounds).	Cardboard with all letters written. Recording sheet.	*"Now I want you to give me the sounds that these letters make when they spell words."* **Prompt:** *"Can you tell me the sound that this letter makes?"* **If the child says the name of the letter:** *"Yes, that is the name of this letter. But do you know what sound the letter "?" makes?"* **If the child only says the long vowel sounds**: *"Do you know any other sound that this letter makes?"* If any consonant is wrong, mark it for use in the identification task.
Sound letter dictation	Children will be asked to spell letters that represent some short vowel sounds	Paper Pencil	*"Let's play a game of spelling letters. I'm going to say some letter sounds, and I want you to write them on this paper, the best way you can. Are you ready?"* I – O – A – U - E
Letter sound recognition	Children will be asked to find/point to some letters that represent sounds dictated by the researcher. These sounds will be the short vowel sounds, plus any consonant sound that the child may have missed in the sound production task.	Triple Letter Cards (each card containing 3 letters) Recording sheet	*"Now I want you to find some letters in this group of letters.* *Point to the letter that says "? " .* __________ *(Very good!)"* [short O] - I , O, A [short U] - U, I, O [short E] - O, U, E [short A] - U, A, E [short I] - E, A, I [short A] - U, E , A [short I] - I, O, A [short E] - I, E, A [short O] - I, O, U [short U] - U, O, E plus any consonant letter missed previously

Spelling test Real words	Children will be asked to do a spelling test to be classified in terms of their ability in phonologically represent words. This task will especially focus in their ability to represent short vowels, both at the beginning and middle of words .	Paper Pencil	*"Now I want you to spell some words for me. I want you to listen to the separate sounds you hear in those words, and write down the letters that represent the sounds you hear."* **Routine:** *"The word is ______."* Sentence . *"Say ______."* (child says word. Correct if wrong). *"Write _____."* Sack – I bought a sack of potatoes. Fit – My clothes do not fit me anymore. Mug – I drink coffee in a mug. Deck –I bought a deck of Yougiu cards. Knock – It is polite to knock before opening doors. Actor – My brother wants to be an actor in movies. Itch – I have an itch here. Upper – I live in the upper floor Echo – If you go in a cave and shout, you can hear the echo. Officer – The police officer arrested the thief
Pseudoword Spelling	Children will be asked to spell parts of words	Paper Pencil Recording sheet	*"Now I want you to spell only parts of words. I want you to spell AB as in LAB. Say LAB. __________. Say AB. _________. Spell AB."* Say the words: LAB LIP LUCK NET MOP LAP SICK NUT NECK DOT *"You did a very good job writing those words!!!"* **If child fails to write a vowel letter:** *"Can you write the first sound in ___ ?"*
High-Frequency Word Recognition Task	Children will be asked to read a set of words coming from Harris and Jacobson (1972) pre-primer, primer and first reader high frequency words.	Cards with frequent words and pictures. Recording sheet pencil	*"I'm going to show you some pictures and some words on cards. I want you to identify and read them as best you can. If you can't read a word, that's Ok. Some are hard. You can guess or tell me you don't know."* *"Tell me each word or picture you see in each page. Be sure to read each word correctly, and say it quickly as soon as you know it."* *"Begin at the first page"* *(RECORD)* (give about 7 s. to respond) **If no response after that, say:** *"Try the next one"*

<u>Woodcock Word Reading Identification</u>	Children will be asked to read the Woodcock-Reading Mastery test of word identification. This will assess their level of word identification at pre-test. Children read woodcock words until they fail to read at least 6 consecutive words in the same set.	Woodcock List Recording Sheet Card to slide.	*"You did such a nice job that I want you to keep reading. The words are listed down the page. Here is a card to slide under each word as you read it. This will help you keep your place. Be sure to read each word correctly, and say it quickly as soon as you know it."* (discontinue after 6 consecutive wrong words in the same set) *"Begin at the first page"* *(RECORD)* (give about 7 s. to respond) If no response after that, say: *"Try the next one"* **If sounding out for more than 10 s, say:** *"Try the next one"*. **Stop the task if child fails to read at least 6 consecutive words in the same set.**
<u>Pseudoword Reading Task</u>	The child will be asked to read 10 nonwords (5 VC and 5 CVC), two with each vowel. This will be done to detect the productive knowledge of the child in using short vowels to decode words.	Cards with words Recording sheet	*"You did a very good job so far! Those were hard words. Now I'm going to show you some crazy words. These are words that do not exist, but you can read them by saying the sounds their letters make. You can start."* AP - IB - EK – OP – UT TAF – FIP – PEB – VOT – NUK

<table>
<tr>
<td><u>Word Learning Task</u> –
FIRST set</td>
<td>Children are taught to read a set of words.

Half of children (group 1) learn set 1 with no vowels, and the other half (group2) learns set 1 with vowels.</td>
<td>Recording sheet
Book 1</td>
<td>“I’m going to teach you to read some words. Pay attention and try to remember its spelling, OK?”
Routine:
KASL(CASTLE)
The king and the queen live in a castle.
This word says <u>castle</u>.
You say it.__________
LDR(ladder)
We use a ladder to reach high places
This word says <u>ladder</u>.
You say it.__________
KASL - The king and the queen live in a castle
MESJ – I left a message for my mother in the answering machine.
KITN – My cat has a new kitten.
MODL – My friend wants to be a model for clothes.
TUNL – Have you ever gone in the Lincoln Tunnel?
RATL – Babies sometimes play with a rattle.
PESL – I have brought my pencil with me.
TIKT – I bought a ticket for a Mets game.
PSM – A possum looks like a big rat.
RUBR – The soles of my shoes are made of rubber.
<table>
<tr><th>C1</th><th></th><th>C2</th><th>C3</th><th></th><th>C4</th></tr>
<tr><td>KASL</td><td>castle</td><td>KSL</td><td>LADR</td><td>ladder</td><td>LDR</td></tr>
<tr><td>MESJ</td><td>message</td><td>MSJ</td><td>DEVL</td><td>devil</td><td>DVL</td></tr>
<tr><td>KITN</td><td>kitten</td><td>KTN</td><td>SIPL</td><td>simple</td><td>SPL</td></tr>
<tr><td>MODL</td><td>model</td><td>MDL</td><td>BOMR</td><td>bomber</td><td>BMR</td></tr>
<tr><td>TUNL</td><td>tunnel</td><td>TNL</td><td>BUBL</td><td>bubble</td><td>BBL</td></tr>
<tr><td>RATL</td><td>rattle</td><td>RTL</td><td>FASN</td><td>fasten</td><td>FSN</td></tr>
<tr><td>PESL</td><td>pencil</td><td>PSL</td><td>LETC</td><td>lettuce</td><td>LTC</td></tr>
<tr><td>TIKT</td><td>ticket</td><td>TKT</td><td>FIDL</td><td>fiddle</td><td>FDL</td></tr>
<tr><td>POSM</td><td>possum</td><td>PSM</td><td>DOLR</td><td>dollar</td><td>DLR</td></tr>
<tr><td>RUBR</td><td>rubber</td><td>RBR</td><td>SUMR</td><td>summer</td><td>SMR</td></tr>
<tr><td>LDR</td><td>ladder</td><td>LADR</td><td>KSL</td><td>castle</td><td>KASL</td></tr>
<tr><td>DVL</td><td>devil</td><td>DEVL</td><td>MSJ</td><td>message</td><td>MESJ</td></tr>
<tr><td>SPL</td><td>simple</td><td>SIPL</td><td>KTN</td><td>kitten</td><td>KITN</td></tr>
<tr><td>BMR</td><td>bomber</td><td>BOMR</td><td>MDL</td><td>model</td><td>MODL</td></tr>
<tr><td>BBL</td><td>bubble</td><td>BUBL</td><td>TNL</td><td>tunnel</td><td>TUNL</td></tr>
<tr><td>FSN</td><td>fasten</td><td>FASN</td><td>RTL</td><td>rattle</td><td>RATL</td></tr>
<tr><td>LTC</td><td>lettuce</td><td>LETC</td><td>PSL</td><td>pencil</td><td>PESL</td></tr>
<tr><td>FDL</td><td>fiddle</td><td>FIDL</td><td>TKT</td><td>ticket</td><td>TIKT</td></tr>
<tr><td>DLR</td><td>dollar</td><td>DOLR</td><td>PSM</td><td>possum</td><td>POSM</td></tr>
<tr><td>SMR</td><td>summer</td><td>SUMR</td><td>RBR</td><td>rubber</td><td>RUBR</td></tr>
</table>
</td>
</tr>
</table>

			(The child reads it. If there is a mistake, we correct the child, and register in the recording sheet) *"This word says __________(stretching the sounds). ________(repeat it again, but not stretching it the second time).* When the child can read them all to criterion of 2 successful trials, we test spelling of that set.(maximum of 15 trials). After that, we start the next set.
Spelling words learned (first set)	Children are asked to spell the words they learned.		*"Now I want you to spell the words you just learned. I will say the words and you spell, OK?"*

<table>
<tr>
<td>Word Learning Task – SECOND set</td>
<td>Children learn to read words.

Half of children (group 1) learn set 1 with vowels, and the other half (group2) learns set 1 with no vowels.</td>
<td></td>
<td>"I'm going to teach you to read some words. Pay attention and try to remember its spelling, OK?
Routine:
LDR(ladder)
We use a ladder to reach high places
This word says ladder.
You say it.__________
KASL(CASTLE)
The king and the queen live in a castle.
This word says castle.
You say it.__________
LADR – We use a ladder to reach high places
DEVL – This is a picture of a devil.
SIPL – Simple things are easy to do.
BOMR – A bomber is a fight jet that drops bombs.
BUBL – I love doing a bubble from soapy water.,
FASN – Fasten you seat belt when you are in a car.
LETC – Usually I have lettuce in my salad.
FIDL – A fiddle is a musical instrument.
DOLR – Do you have a new dollar bill?
SUMR – In the Summer, children like to go to the beach.
<table>
<tr><th>C1</th><th></th><th>C2</th><th>C3</th><th></th><th>C4</th></tr>
<tr><td>KASL
MESJ
KITN
MODL
TUNL
RATL
PESL
TIKT
POSM
RUBR</td><td>castle
message
kitten
model
tunnel
rattle
pencil
ticket
possum
rubber</td><td>KSL
MSJ
KTN
MDL
TNL
RTL
PSL
TKT
PSM
RBR</td><td>LADR
DEVL
SIPL
BOMR
BUBL
FASN
LETC
FIDL
DOLR
SUMR</td><td>ladder
devil
simple
bomber
bubble
fasten
lettuce
fiddle
dollar
summer</td><td>LDR
DVL
SPL
BMR
BBL
FSN
LTC
FDL
DLR
SMR</td></tr>
<tr><td>LDR
DVL
SPL
BMR
BBL
FSN
LTC
FDL
DLR
SMR</td><td>ladder
devil
simple
bomber
bubble
fasten
lettuce
fiddle
dollar
summer</td><td>LADR
DEVL
SIPL
BOMR
BUBL
FASN
LETC
FIDL
DOLR
SUMR</td><td>KSL
MSJ
KTN
MDL
TNL
RTL
PSL
TKT
PSM
RBR</td><td>castle
message
kitten
model
tunnel
rattle
pencil
ticket
possum
rubber</td><td>KASL
MESJ
KITN
MODL
TUNL
RATL
PESL
TIKT
POSM
RUBR</td></tr>
</table>
(The child reads it. If there is a mistake, we correct the child, and register in the recording sheet)
"This word says __________(stretching the sounds). ________(repeat it again, but not stretching it the second time).
When the child can read them all to criterion of 2 successful trials, we test spelling of that set. (maximum of 15 trials)</td>
</tr>
<tr>
<td>Spelling words learned (SECOND set)</td>
<td>Children are asked to spell the same words they learned in the second set</td>
<td></td>
<td>"Now I want you to spell the words you just learned. I will say the words and you spell, OK?"</td>
</tr>
</table>

Appendix 8

Comparisons Between Children Who Reached Criterion In The Learning Task In Fewer Than Ten Trials, Children Who Reached Criterion Between Ten And Fifteen Trials, And Children Who Never Reached Criterion.

Children who reach criterion in less than 10 trials (in at least one set)

Par. #	VP	VA	HFWI	WWI	Phase	PW VC	PW CVC	A	E	I	O	U
3	2	7	54	75	Cons.	5	5	10	9	10	10	10
19	5	4	54	47	Part./Full	3	3	9	2	8	6	2
22	3	5	53	50	Full	5	5	10	10	10	10	9
16	5	13	51	34	Full	3	3	7	6	9	7	6
8	3	5	50	46	Full	5	5	10	10	10	10	7
13	5	6	40	32	Full	2	2	8	2	8	7	1
5	2	5	45	34	Part./Full	3	1	9	7	5	7	4
10	9	7	37	28	Full	2	4	10	7	8	10	3
9	-	6	34	25	Full	3	4	10	3	10	6	3
11	6	6	28	23	Full	5	1	9	7	10	7	8
1	3	4	28	9	Full	4	4	10	10	9	3	7
20	5	4	20	21	Full	3	0	9	6	3	9	8
15	9	11	20	7	Full	4	4	10	4	8	10	4
M	4.8	6.4	39.5	33.2		3.6	3.2	9.3	6.4	8.3	7.8	5.6

(*Table continues*)

Table continued

Children who reach criterion between 10 and 15 trials (in at least one set)												
Par. #	VP	VA	HF WI	WWI	Phase	PW VC	PW CVC	A	E	I	O	U
18	12	10	28	18	Full	2	1	9	2	2	3	3
12	15	13	21	18	Full	3	1	9	7	7	7	10
14	13	**15**	9	15	Partial	0	0	6	2	5	0	1
M	13.3	12.7	19.3	17		1.7	.7	8	3.7	4.7	3.3	4.7

Children who never reached criterion												
Par. #	VP	VA	HF WI	WW I	Phase	PW VC	PW CVC	A	E	I	O	U
24	**15**	**15**	17	22	Part./Full	3	0	10	1	6	3	3
2	**15**	**15**	11	18	Partial	0	0	4	2	0	1	2
23	**15**	**15**	8	3	Partial	1	0	8	4	2	1	4
21	**15**	-	7	8	Pre/Part	0	0	1	2	2	1	0
17	**15**	**15**	4	3	Partial	0	0	7	1	2	8	1
4	**15**	**15**	2	4	Partial	0	0	6	7	7	6	4
6	-	-	4	7	Pre/Part	0	0	5	2	4	3	2
7	-	-	1	1	Partial	0	0	9	0	3	3	1
M	15	15	6.8	8.2		0.5	0.0	0.7	0.4	0.4	0.4	0.2

Note. Pre/Part=Moving from pre-alphabetic to partial alphabetic phase; Part. =Partial-alphabetic phase; Part. /Full = Moving from partial-alphabetic to full alphabetic phase;

*Full= Full alphabetic phase; Par=participant; VP= vowel present set; VA=vowel absent set; HFWI= High Frequency Word Identification task; WWI=Woodcock Word Identification subtest; PW VC= Pseudoword reading task Vowel-Consonant; PW CVC = Pseudoword reading task Consonant-Vowel-Consonant;**15**=Children who did not learn the target words in 15 trials; - = children who did not perform the learning tasks.*

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