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ABSTRACT

A number of studies exploring how beginning readers acquire knowledge that enables them to spell words fairly accurately and to recognize words correctly and quickly as they are reading are described in this report. (The reported studies were designed to test hypotheses derived from a theory of printed word learning proposed by L. C. Ehri.) In the first chapter, various factors thought to be important in learning to read are described along with supporting evidence, and Ehri's theory of word identity amalgamation is summarized and contrasted to alternative views. The next eight chapters discuss the specific studies (with the results and conclusions drawn from the studies) on the following topics: the mnemonic value of orthography among beginning readers, the nature of orthographic images, the influence of orthography on readers' conceptualization of sound segments in words, the effects of image training on printed word learning in children and in beginning readers, whether beginning readers learn printed words better in sentences or in isolation, whether they learn printed words better in contexts or in isolation, and whether word training increases or decreases interference in a Stroop task. The final chapter presents a summary of the studies. (FL)

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FINAL REPORT

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ORTHOGRAPHY AND THE AMALGAMATION OF WORD IDENTITIES IN BEGINNING READERS

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ABSTRACT

This research explored how beginning readers acquire knowledge which enables them to spell words fairly accurately and to recognize words correctly and quickly as they are reading text. Results of several studies yielded various facts about printed word learning. Orthography functions as a mnemonic device among more successful readers to symbolize and preserve meaningless sounds in memory. The orthographic representations stored in memory for words include silent as well as pronounced letters. One way to preserve some silent letters in memory is to re-conceptualize the sound structure of words to include phonemes corresponding to the letters. Giving children instruction and practice in forming orthographic images of words improves their ability to spell the words but not to read them. Teaching children to read words in meaningful sentences improves knowledge of printed word meanings whereas teaching children words on flash cards improves knowledge of spellings. Accuracy and speed training with printed words exerts opposite effects on the extent to which the words distract in a Stroop picture naming task, with accuracy increasing and speed decreasing interference. In sum, these results confirm that learning to read entails learning a number of word identities and they clarify some aspects of the acquisition process.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF TABLES AND FIGURES (cont.)

Chapter 1: Introduction, Background, Theory and Overview

The present collection of studies was performed to explore processes involved in learning printed words. The studies were conducted with children who had achieved various levels of reading proficiency (first through fourth graders). The studies were designed to test hypotheses derived from a theory of printed word learning proposed by Ehri (1978) and elaborated during the course of these studies. The report of these studies is divided into several sections. In Chapter 1 various factors thought by others to be important in learning to read are described along with supporting evidence. Next, Ehri's theory of word identity amalgamation is summarized and contrasted to alternative views. Then an overview of the project is presentd. In Chapters 2 through 9, the specific studies are described along with a discussion of the results and conclusions drawn from each study. Most of these chapters have or will appear in scholarly journals or books. In the final chapter (10), the overview summary is presented (i.e., 6-8 page document in non-technical language for dissemination to the general public).

First Stage in Learning to Read

According to Gibson and Levin (1975), the first stage of reading acquisition involves mastery of the "mechanics of the process." The beginning reader learns decoding rules for transforming unfamiliar letter sequences into possible blends of sounds (Venezky, 1974), he learns the conventions for representing spoken language in terms of printed letter clusters for words, empty spaces to mark boundaries, capital letters and periods to mark sentences, etc., and he learns to distinguish legitimate from illigitimate orthographic sequences (Rosinski & Wheeler, 1972; Golinkoff, 1974). He learns to recognize basic high-frequency words from their orthographic forms and this capability moves from a level of accuracy to a level of automaticity (LaBerge & Samuels, 1974). In reading text, he uses his knowledge of language to form expectations about the words and sentences he reads and to make sensible guesses at unfamiliar printed units (Goodman, 1969; Weber, 1970). His accuracy in recognizing improves as his printed lexicon grows and as he learns to coordinate graphic cues with his syntactic and semantic expectations (Clay, 1969; Biemiller, 1970). In addition to reading, he also learns to write and to produce recognizable spellings for words, partly because he has memorized at least some letters in words, partly because he knows some phoneme-grapheme rules (Simon & Simon, 1973).

Which "Mechanics" Are Central?

There is substantial disagreement among investigators over the importance of word recognition in learning to read and comprehend text and over the issue of whether words should be analyzed into sounds and taught as separate printed units. Goodman (1971, 1972,

1973) and Smith (1971) argue that the beginner should practice reading text for meaning from the start, that word recognition capabilities will grow as a consequence, and that special instruction in phonics or word identification is not necessary and may in fact interfere by teaching children to "bark at print." In contrast, Shankweiler and Liberman (1972), Gleitman and Rozin (1973) among others assert that syllabic and phonemic analysis of words is critical and that little progress is possible without acquisition of these skills.

Results of various investigations appear to favor the latter view. Firth (cited by Gleitman, 1974) compared good and poor third grade readers. Holding IQ constant, he found correlations above .80 among the following abilities: pronunciation of nonsense syllables; pronunciation of words; identification of words embedded in meaningful sentences. In contrast, he found low correlations between these measures and the syntactic-semantic ability to guess at plausible endings of sentences. Gleitman concludes that the ability to relate printed words to their phonological identities constitutes the most important component to be mastered by beginners.

Clay (1969) compared the oral reading performances of 5-year olds differing in reading ability and found that the best of the four beginning-reader groups was far superior to the others in being able to recognize and read words accurately in a story. Ss in the next highest group were observed to self-correct almost all the words they read incorrectly, as did Ss in the high group; however, they read a far greater proportion of words incorrectly the first time, almost as many as the two poorer groups. Clay attributes superior beginning reading to the efficient processing of graphic, syntactic and semantic cues.

Shankweiler and Liberman (1972) examined the oral text reading and word list pronunciations of second and third graders and found correlations ranging between .53 and .77 on their measures. Among the poor readers, 75% of their errors on the word list entailed mispronunciations of vowels and consonants. These researchers propose that inability to segment and analyze the makeup of a word phonemically characterizes the deficiency of poor readers.

Other studies corroborate this pattern of difficulty in the linguistic analysis of printed words. Lucas (1972) examined the relationship between reading a list of words and reading achievement test scores in second graders and found that final-consonant pronunciation errors accounted for 10% of the variance, and vowel pronunciation errors accounted for 74% of the variance. Venezky (1974) reports that "one of the most important distinctions between good and poor readers at the second and fourth grade levels is their response to invariant consonant spellings." (p. 2091) Whereas both good and poor readers could pronounce initials consonants of nonsense syllables, the poor readers made many more errors than the good readers when these letters were in medial or final position of the syllable. Marchbanks and Levin (1965) report a similar lack of attention to non-initial word details among kindergarten and first grade readers.

In addition to being able to recognize and pronounce printed words accurately, LaBerge and Samuels (1974) suggest that readers must be able to recognize words automatically so that they can direct their attention to meanings rather than word forms. Automaticity refers to that point in word learning (occurring after the attainment of recognition accuracy) when attention to component letters is no longer required in order to decode a word. Research by Rosinski, Golinkoff and Kukish (1975), Golinkoff and Rosinski (1976), and Ehri (1976) indicates that even beginning readers (second graders) and poor readers (third graders) have achieved automaticity with some well practiced printed words.

A study by Perfetti and Hogaboam (1975) suggests that automaticity may be important for reading comprehension. They found that third and fifth graders who were less skilled in reading comprehension also took longer to recognize and say familiar words than more skilled comprehenders. Performance differences were even greater in the pronunciation of pseudowords and low-frequency English words.

Word Identity Amalgamation Theory[a]

From the above discussion, it is apparent that learning to read words is a multi-faceted process entailing several components. Ehri (1978) has attempted to integrate some of these components into a theory of printed word learning. Rather than singling out one skill or experience, this theory makes room for the importance of several. An updated version of the theory is presented below. It is important to recognize that the theory has been fashioned as a guide for the conduct of research and hence represents an explicit but very tentative statement about the word learning process. At this point, its only value is heuristic, as a means of raising questions, identifying hypotheses to be tested, directing observations and experimentation, and organizing information. It should not be construed as any final explanation or answer.

According to Ehri, the most important acquisition during beginning reading is learning to recognize printed words accurately, rapidly, and also completely in the sense that all the words' identities -- phonological, syntactic, and semantic -- are apparent when the printed word is seen. Children already possess substantial linguistic competence with speech when they start learning to read. The major task facing them is to learn how to assimilate printed language to this existing knowledge. In English, the most perceptible and dependable units of printed language are words, not letters or sentences, so it is at a lexical level that children work at assimilating print to their existing linguistic knowledge.

[a] This section is taken from the chapter by Ehri (in press-a) in Frith's book, Cognitive Processes in Spelling.

Following the suggestions of linguists (Chomsky & Halle, 1968; Langacker, 1973) the lexicon is conceptualized as consisting of abstract word units having several different facets or identities. Every word has a phonological identity which consists of information about acoustic, articulatory, and phonemic properties of the word. (In subsequent text, these properties are sometimes referred to as word "sounds." It is important to note that the term "sounds" is used in a loose sense to include articulatory gestures and abstract phonemes which are not really sounds but only correlates of sound.) In addition, every word has a syntactic identity specifying characteristic grammatical functions of the word in sentences (i.e., noun, verb, adjective, determiner, etc.). And most words have a semantic identity, that is, a "dictionary definition." All of the foregoing identities are thought to be acquired and known implicitly as a consequence of achieving competence with spoken language.

In the course of learning to read, another identity is added to the lexicon, the word's orthographic form. This written unit is thought to be incorporated not as a rotely memorized geometric figure but rather as a sequence of letters bearing systematic relationships to phonological properties of the word. The term "amalgamation" is used to denote the special way in which orthographic identities get established in lexical memory. Since beginners already know how words are pronounced, their task is to assimilate the word's printed form to its phonological structure. They do this by matching at least some of the letters to phonetic or phonemic segments detected in the word. These segments serve as "slots" in lexical memory which are filled by images of letters seen in the word's spelling. To process and remember letter-sound correspondences effectively, readers must already be familiar with those letters as symbols for the relevant phonological segments they map in the word. If at least some of these letter-sound relationships are known and recognized, then there will be enough "glue" to secure this visual symbol in lexical memory. Very likely, readers who possess more systematic knowledge about mapping relationships between letters and sounds will be better able to form a match between conventional spellings and word pronunciations and to store a complete amalgam in lexical memory.

General orthographic knowledge which is useful for setting up orthographic images includes not only information about single letter-sound relations but also information about more complex functional spelling patterns in which letters combine to map sounds within words (Venezky, 1970), about syllabic print-sound structure, and about common spelling patterns shared by sets of rhyming words (i.e., AIR, PAIR, CHAIR, HAIR, FAIR, STAIR). As the reader's repertoire of printed words grows, he becomes aware of new patterns for mapping print into speech, and these regularities are added to his knowledge of orthography as a system for mapping words. Very likely, much of this orthographic knowledge is induced as a consequence of the reader's experiences learning to read and to spell words, though some of it may result from explicit instruction about letter-sound mapping rules. However, simply being able to state a rule is not sufficient for the knowledge to become operational. The functional value of the rule must be incorporated into word learning processes. Such systematic knowledge serves the reader in several ways. It provides him with a means of decoding or spelling unfamiliar printed words. It may also speed up the process of pronouncing familiar, regularly spelled printed words (Baron & Strawson, 1976). Most importantly, it makes it easier for him to make sense of, store, and remember the spelling patterns of newly learned words.

When printed words are stored in lexical memory, the orthographic forms are amalgamated not just with phonological identities but also with syntactic and semantic identities. Amalgamation occurs as readers practice pronouncing and interpreting unfamiliar printed words while they are reading text for meaning (Ehri & Roberts, 1979). As printed words are successfully read, orthographic images come to represent information about how the words function in phrases and sentences (i.e., what classes of words are usually positioned next to them and how they combine to form larger units) and what the words mean in various contexts. In this way, orthographic images are synthesized with syntactic and semantic as well as phonological identities and they combine to form single representational units in lexical memory.

When identity amalgamation has been achieved for particular words, the quality of the word recognition process changes. The printed form is processed as a single unit rather than as a sequence of letters to be translated into sounds (LaBerge & Samuels, 1974), and letters in words are recognized simultaneously rather than sequentially (Doggett & Richards, 1975; Terry, Samuels, & LaBerge, 1976). The reader can glance at a word and recognize its meaning "silently" without needing pronunciation in order to identify it (Barron, 1978). This is because a fairly exact copy of the printed form has been stored in memory and this visual image functions as the symbol for meanings as well as sounds. When the word is seen and matched to its visual image, all of its other identities become apparent simultaneously. Once visual images are established in memory, they provide information useful for spelling as well as for reading words (Simon & Simon, 1973; Simon, 1975).

Notice how easy it is to recognize the pronunciations and meanings of the following similarly spelled words: comb, tomb; bear, dear; here, were, there; have, pave. Readers familiar with these forms do not make errors in pronouncing them and they can recognize their linguistic identities at a glance. In fact, they may be surprised to discover that the same spelling patterns are pronounced differently depending upon which word is represented. Such spelling-sound variations do not bother word identification processes because in learning each form, readers have amalgamated letter patterns to meanings as well as to sounds. A study by Mackworth and Mackworth (1974) provides evidence that good readers are more skilled than poor readers in sorting out the appropriate lexical identities for similarly spelled word forms.

ERIC

In order for these word learning processes to become operational, some preparation is essential to bring the reader to the point where the particular letters appearing in words are seen as belonging there and he can store them in memory. This preparation very likely includes some analytic capabilities: being familiar enough with the shapes and sounds of alphabet letters so that the shapes can be imagined and remembered accurately as symbols for sounds; being able to isolate relevant acoustic or articulatory segments in words and to detect systematic relationships between these sound segments and letters present in their spellings. Very likely these analytic skills must be known well enough so that the reader can coordinate and synthesize multiple letter-sound relations automatically without having to attend to each segment individually (LaBerge & Samuels, 1974).

Although some preparation is needed, this does not mean that printed word learning cannot begin until all the skills have been mastered. It is more likely that during acquisition, word learning ability and its relevant subskills interact with each other and are acquired simultaneously rather than sequentially (Goldstein, 1976; Ehri, 1979). Word reading begins but is a slow, laborious, rote process subject to forgetting initially while these skills are developing. Such practice, however, may be necessary in order to learn phonetic segmentation, letter-sound mapping relationships and how to coordinate them, and in order to develop visual memory for word forms. Once these prerequisite capabilities get established, words can be learned much more quickly, completely, and permanently.

Contrast to Other Theories

Before evidence for the theory is presented, it might be helpful to review how this approach contrasts with some other views of word learning. The word identity amalgamation view is distinctly different from E. J. Gibson's theory (Gibson & Levin, 1975) in that principles of memory rather than perception are invoked. The necessity of adopting memory constructs to explain how printed words are recognized is perhaps less obvious than to explain how words are spelled since the former but not the latter has the appearance of a perceptual process. However, perceptual principles such as differentiation, selective attention, detection and use of redundancy are simply ad hoc descriptions of the process. In contrast to memory constructs, they do not constitute a mechanism which explains or yields predictions about how readers' capabilities with words develop. Since printed words are conventional forms whose appearance deviates very little across instances and since they are seen and processed over and over again, it makes much sense to postulate the storage of specific visual information about those forms in lexical memory. Certainly, this offers a very powerful explanation. If readers know exactly how particular printed words should look, then the act of recognizing them on a printed page should occur rapidly and accurately and should require little effort. This appears to characterize the capabilities of readers shown familiar printed words.

ERIC

Word identity amalgamation theory resembles F. Smith's theory (1973) in that the visual forms of words are portrayed as being stored in memory together with meanings. However, the present view differs in that words are thought to be stored as alphabetic images rather than as non-alphabetic distinctive features. Furthermore, sounds play a central role in setting up these images, according to amalgamation theory, whereas Smith argues that sound has nothing to do with the storage of print-meaning relationships.

Word identity amalgamation theory differs from a phonemic recoding view (Rubenstein, Lewis, & Rubenstein, 1971) in that another mechanism besides letter-to-sound translation is offered to explain how printed words are recognized. In contrast to the decoding view, a distinction is drawn between processing familiar and unfamiliar printed words. If readers encounter words never seen before, they apply various sound translation strategies to discover the word's identity. However, if they have successfully read the word enough times previously, then the form is familiar and does not have to be sounded out or recognized anew each time it is seen. Decoding "strategies" are superceded by a very different process which takes much less time, one where the word is recognized in terms of its match to the form stored in memory.

A view similar to amalgamation theory is the information processing model of spelling performance proposed by D. Simon (1976). She offers some additional constructs which are compatible with and serve to elaborate the present view. Her model includes the notion of a word store containing auditory, visual, semantic, and also motor representations of familiar words. Another component of the model is knowledge of general mapping rules relating graphemes and phonemes. The building blocks of the system are alphabet letters which, like words, are units specified multi-modally, in terms of auditory, visual, and motoric representations. Correspondences among alternative alphabetic codes (i.e., upper and lower case letters) form part of the alphabetic store. Though the theories are similar, Simon does not discuss processes by which information about word spellings gets stored in memory.

Overview

The proposed research was intended to examine decoding and word recognition processes underlying comprehension in early reading. The processes examined were those suggested as important according to the psycholinguistically-based view of reading acquisition proposed by Ehri (1978). This theory suggests that the major hurdle facing beginning readers is learning to recognize printed words and that effective word recognition requires particular types of learning experiences. When the printed forms of words are encountered, their appropriate phonological, syntactic, and semantic identities must be activated in the learners' heads. In addition, they must pay enough attention to orthographic details so that written forms can be amalgamated with the words' other identities, and all of this information can be stored as one unit in the lexicon. The most efficient means of storing orthographic forms is to analyze words into those component sounds designated as "there" by letters comprising the printed form. To the extent that learners can justify at least some of the letters used to spell a word (justification comes from their growing systematic knowledge of the various possible letter-sound relationships and patterns), they will be able to amalgamate the word's printed form with its phonological identity. To the extent that they process appropriate syntactic functions and meanings when they pronounce printed forms, they will be able to recognize and interpret these words accurately while reading text. The purpose of work reported here was to obtain some evidence that these word identification processes are central to the emergence of word recognition and reading comprehension. An additional purpose was to examine how closely related reading and spelling skills might be and to what extent they develop together. Experimental rather than strictly correlational studies were conducted in order to permit inferences about cause-effect relationships underlying printed word learning.

Chapter 2: The Mnemonic Value of Orthography Among Beginning Readers. The mnemonic value of letters in a paired associate sound learning task was examined in four experiments. First and second graders were taught four CVC nonsense sounds as oral responses. The stimuli were geometric figures or numbers or alphabet letters corresponding to initial consonant sounds. Various types of adjunct aids or activities occurred during study and feedback periods as the learning trials progressed. Visual spellings or misspellings of the CVC sounds were shown. Or subjects imagined visual spellings. Or they listened to oral spellings or to sounds broken into phonetic segments. Or they rehearsed the sounds. Spellings were not present during test trials when sounds were recalled. In all experiments, sound learning was fastest when correct spellings were seen or imagined. The preferred interpretation is that spellings are effective because they provide readers with orthographic images useful for symbolizing and storing sounds in memory. Spelling-aided sound learning scores were highly correlated with subjects' knowledge of printed words, indicating that this representational process may be used by beginning readers to store printed words in lexical memory.

Chapter 3: Preliminary Investigations of the Nature of Orthographic Images. Several studies were conducted to explore the nature of orthographic images. Of special interest was the status of silent and unexpected letters in word spellings and how these might be established in memory. In the first series of studies, second and third graders imagined the spellings of familiar printed words and judged whether each contained a designated letter. Then they were surprised with a letter-prompted word recall task. Some letters were present, some not. Of the present letters, half corresponded to a phonetic segment, half were silent in the words. Results revealed that children had no trouble imagining the words. Letter judgments were close to perfect although errors favored silent letters. Surprisingly, more words were recalled for silent than pronounced letters. These findings suggest that silent letters are salient features of orthographic images. That silent letters are as clearly represented in orthographic images as pronounced letters was indicated in another study. First graders shown misspellings of familiar words in which single silent or pronounced letters had been deleted were equally successful at detecting both types of errors. In a study designed to explore memory for unusual pseudoword spellings, second graders were found to retain in memory the original orthographic patterns they had learned to read rather than to substitute more straightforward phonetic versions in their spellings. This demonstrates that much about spelling and unexpected letters is acquired by reading words. In a second study with pseudowords, the behavior of learners suggested a strategy for remembering non-distinctively pronounced letters in spellings. Subjects were observed to modify pronunciations of words to include the appropriate sounds symbolized by the letters (i.e., schwa letters transformed into appropriate short vowel sounds). The value of this technique awaits further study. These findings when added to the results of other studies lend much credence to the claims that orthographic images are acquired and retained in memory as children learn to read and that they create a close relationship between reading and spelling skills.

Chapter 4: The Influence of Orthography on Readers' Conceptualization of Sound Segments in Words. Derived from a theory of printed word learning, the hypothesis tested was that children's conceptualization of the sound structure of words is influenced by their knowledge of the words' orthographic forms. Selected for study were words whose spellings suggest the presence of extra sounds in their pronunciations (e.g., interesting, catch). Fourth graders' sound conceptualizations were assessed with a syllabic and a phonemic segmentation task. Their knowledge of orthography was determined by a spelling task. In Experiment 1, performance was examined with real words already familiar in print. In Experiment 2, performance was examined with nonsense words which the children were taught to read. Results supported expectations. When children knew that the orthographic forms of the words included the extra letters, they were more likely to conceptualize the extra segments in sound. Results are interpreted to suggest an interactive relationship between print and sound analysis as it contributes to the process of storing printed words in lexical memory.

Chapter 5: Effects of Image Training on Printed Word Learning in Children. The purpose of this study was to determine whether explicit instruction and practice in the formation and storage of orthographic images for words might enhance children's ability to read and to spell those words, particulary among poorer readers. Matched pairs of second graders were divided into three reader ability levels--high, middle and low. Members of the pairs were randomly assigned to an image formation (experimental) condition or to a control condition. In a preliminary training session, all children were taught to pronounce and to recognize the meanings of

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ten printed pseudowords. Experimental subjects then performed three tasks designed to improve their visual images of the pseudowords. Control subjects performed comparable tasks but received no image instructions. Rather than consult their memories, they were provided with printed spellings to use in performing the tasks. Delayed posttests were administered to assess subjects knowledge of word spellings, word pronunciation accuracy and speed, and word meanings. Results revealed that image-trained subjects were significantly superior to control subjects on all tests of spelling production. However, despite this difference, performances of the two groups on measures on spelling recognition, pronunciation accuracy and latency, and knowledge of word meanings were approximately equal. Apparently, image training boosted spelling production, but this superior knowledge of letter details did not benefit word reading. Effects of reading ability were obvious, with better readers performing consistently higher than poorer readers on most tasks. Contrary to expectations, training influenced good and poor readers similarly. Analysis of skills clearly distinguishing good from poor readers revealed differences involving the phonetic processing of printed forms and memory for letter details. Differences were minimal in memory for meanings, and word reading speed. The greater importance of individual skills than learning experiences in accountng for reading ability differences was suggested by the finding that whereas differences in spelling knowledge resulting from learning experiences did not influence word reading accuracy or speed, individual differences in spelling knowledge did correlate significantly with word reading measures. Consistent with the claim that printed word learning entails multiple aspects, correlations between tasks revealed stronger interrelationships among word reading accuracy and spelling measures than between these measures and reading speed or word meaning measures. The importance of distinguishing between partial and complete knowledge of word spellings was suggested by the fact that whereas children were able to recall most of the letters in words, they were quite poor at reproducing spellings perfectly. Regarding classroom practice, results suggest that instructional methods which require learners to store letters in memory will be more beneficial in teaching spelling than word copying methods.

Chapter 6: Effects of Image Training on Printed Word Learning in Beginning Readers. A second study was conducted to determine whether explicit training in the formation of complete orthographic images would enable beginning readers to identify the words more accurately and rapidly as well as to produce more complete spellings. Following pretests, first graders studied two sets of real words. They formed images for 6 experimental words. They read 6 control words several times. Posttests given a week later revealed that image training boosted subjects' ability to spell the words but not their ability to read the words. These results are consistent with those reported in Chapter 5.

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Chapter 7: Do Beginners Learn Printed Words Better in Contexts or in Isolation? First graders were taught to read 16 words. Half of the subjects studied the words in printed sentence contexts. Half learned the words printed singly on flash cards and listened to sentences containing the words. Posttest scores indicated that context-trained children learned more about the semantic identities of printed words whereas flash-card trained children could read the words faster and learned more about orthographic forms. Knowledge of letter-sound mapping relationships at the lexical level was more highly correlated with word learning performance than knowledge of single letter-sound relations. Results are interpreted in terms of word identity amalgamation theory. Findings demonstrate that there is value in exploring multiple aspects of printed word learning and the experiences which contribute to each aspect.

Chapter 8: Do Beginners Learn to Read Function Words Better in Sentences or in Lists? First graders practiced reading 10 unfamiliar function words (i.e., might, which, enough). Half of the children studied the words embedded in printed sentences. Half studied the words embedded in unstructured lists of words and then listened to sentences comprised of the words. Posttest measures revealed that sentence readers learned more about the syntactic/semantic identities of function words whereas list readers remembered their orthographic identities better and could pronounce the words faster and more accurately in isolation. Findings show that there are multiple aspects of printed words to be learned by beginning readers. Which aspect gets learned depends upon how the words are practiced. Results are interpreted to support word identity amalgamation theory.

Chapter 9: Does Word Training Increase or Decrease Interference in a Stroop Task? First and second graders (6- and 7-year olds) practiced reading 20 words. Before and after word training, they named pictures printed with and without these words as distractors. Of interest was whether training would enhance or diminish the interference created by these words in the picture-naming task. Results indicated that children who learned to recognize unfamiliar distractor words more accurately suffered more interference after training. In contrast, children who were already familiar with the words and learned to recognize them faster experienced less interference following training. Results are interpreted as supporting LaBerge and Samuels's model of automatic word processing. Effects of accuracy training are attributed to the elmination of attention as a requirement for processing distractor words. Effects of speed training are attributed to a reduction in the time consumed by distractor words in the central processor.

General Remarks. One claim of amalgamation theory is that printed word learning entails acquisition and amalgamation of several different identities of words. Results of the above studies support this view and suggest some elaborations of it. Regarding knowledge of the orthographic identities of words, learners appear to possess substantial orthographic knowledge despite imperfect spelling production ability. It is much easier for them to recognize whether letters are present or absent in spellings, to recall most of the present letters, and to distinguish correct from incorrect spellings than it is to write out entirely correct spellings. Apparently, orthographic images are informative but incomplete in their specification of all the details needed for perfect reproduction of printed words. Comparison of memory for silent and pronounced letters indicated that silent letters may be harder to store but that they are a particularly salient feature of spellings and their omission from words is as easily detected as pronounced letters. This indicates that both types of letters are prominent in orthographic images. In acquiring orthographic identities of words, readers notice and retain more information about letters when they read the words in isolation on flash cards than when they read the words embedded in meaningful sentences. Whereas in the former case, attention to letters is required to identify the word, in the latter case, the word's identity can often be guessed with minimal attention to letters.

Regarding the process of amalgamating orthographic to phonological identities, results show that letters can be stored in memory as symbols for sounds. This accounts for their capacity to enhance subjects' memory for sounds in a learning task. Furthermore, letters in spellings can influence and modify one's conceptualization of the sound structure of words by symbolizing and thereby clarifying the separate phonemes and by pointing out additional phonemes not apparent in pronunciations. Although the sound-symbolizing value of letters appears central in learning to read words, it does not appear that once the words become familiar a more thorough knowledge of letters results in more accurate or rapid identification of words in a reading task. Apparently partial orthographic knowledge is sufficient to support maximum word reading performance.

Regarding the amalgamation of meanings to printed words, it appears that in learning homographs and function words whose meanings are not readily apparent from their pronunciations, readers acquire these meanings better by reading the words in meaningful sentences than by listening to meanings after they have decoded the words on flash cards. According to amalgamation theory, because meanings are active at the time the words are seen, their attachment to printed forms is thereby secured.

It is interesting to note that in two studies, those reported in Chapters 5 and 6 where instruction or practice rehearsing word spellings was manipulated, we failed to observe any differential effect upon word reading ability. This was despite differences in word spelling ability produced by training conditions. Effects were absent on measures of word reading speed as well as accuracy even after several days had intervened between training and testing. In contrast, in two studies where word reading experiences were manipulated (i.e., Chapters 7 and 8 where words were read in sentence contexts or in isolation), differences in spelling ability with the words were detected. Combined, these results show that the nature of reading experiences with words affects how well children can spell the words whereas the reverse is not true. The nature of spelling practice does not influence how well the practiced words can be read.

The present research project was successful in showing how printed word learning entails several separable aspects and how various conditions of learning contribute to the acquisition of one or another of these aspects. However, the project was not successful in demonstrating how printed word learning contributes to the process of reading sentences and comprehending text. Attempts to determine whether words learned under varying circumstances made a difference in the ease of comprehending sentences containing those words failed to reveal any differences. This was attributed to the inadequacy of comprehension tasks designed to reflect such difference. However, even if the tasks had worked, results might have been negative. Other studies employing more adequate techniques (Fleisher, Jenkins, and Pany, 1979) have been unsuccessful in demonstrating that superior skill in recognizing printed words leads to improved comprehension of text comprised of those words. It may be that since comprehension processes [illegible] top-down as well as bottom-up processing (Rummelhart, 1977), they are not differentially influenced by the quality of one's word knowledge but rather by whether or not the words are familiar at some minimum level or can be quessed easily. In our studies, children were quite familiar with most of the target words when they completed the comprehension tests.

Chapter 2: The Mnemonic Value of Orthography Among Beginning Readers[a]

The purpose of this study was to explore the beginning reader's ability to use orthography as a representational system for storing speech sounds in memory. An additional purpose was to assess how important such an ability might be in learning to read. From previous studies, it is clear that more successful beginning readers know how orthography maps speech (Gibson & Levin, 1975; Guthrie & Siefert, 1977; Mason, 1976). However, it remains unclear how this knowledge is used during reading and how it contributes to the process of identifying and remembering the printed forms of words. One possibility is that orthographic knowledge supplies translation routines for converting print to a phonemic code which is then used to access words in the lexicon (Rubenstein, Lewis, & Rubenstein, 1971). Another possibility is that the print itself is stored as an alphabetic image which has been mapped onto the word's sounds in lexical memory. The present study was intended to gather some evidence for the latter possibility.

The view that alphabet letters provide a visual code for representing and storing words in lexical memory arises from a theory proposed by Ehri (1978), referred to as the word identity amalgamation view. The focus of the present study was upon the process by which orthographic forms are amalgamated to sounds and established as images symbolizing the sounds in memory. A series of experiments was performed in order to observe the operation of this orthographic mnemonic system among beginning readers and to assess its relationship to other reading skills. A paired associate sound learning task was designed to tap children's ability to make use of spelling study aids in remembering sounds. Various types of mnemonic aids or sound-elaborative activities in addition to spellings were provided in one or another experiment in order to compare their effects upon sound memory.

In the first experiment, first and second graders were given four paired-associated tasks. The important features distinguishing the tasks are summarized in Table 2-1. In all tasks, the responses to be learned were four oral CVC nonsense syllables. The tasks differed in terms of the test cues employed and the type of mnemonic aids provided during study and feedback periods. The test cues were either meaningless but visually distinctive line drawings called squiggles,

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Insert Table 2-1 about here.

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[a]Referred to in the other chapters as Ehri and Wilce (1979). Published in the Journal of Educational Psychology, 71, 26-40.

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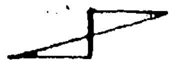
Table 2-1

Stimuli Employed in the Four

Paired Associate Learning Tasks

Task	Test Cues	Oral Responses[a]	Study Aid
		"jad"	(none)
Squiggles		"wek"	(none)
		"sim"	(none)
		"lut"	(none)
	V	"vap"	(none)
Initial	B	"bem"	(none)
Letters	T	"tib"	(none)
	H	"huk"	(none)
Initial	M	"mav"	Mav
Letters	R	"rel"	Rel
Plus Correct	K	"kip"	Kip
Spellings	G	"guz"	Guz
Initial	P	"pab"	Pes
Letters	D	"des"	Dif
Plus	N	"nif"	Nug
Misspellings	F	"fug"	Fab

[a]The four sets of oral responses listed here were employed in all four tasks with assignments counterbalanced across subjects.

or single alphabet letters representing the first consonant in each nonsense response. The mnemonic aids shown to subjects were either correct spellings or misspellings of the CVC responses. The anticipation method of presentaton was used. Each test cue was shown to children, they responded, and then the experimenter pronounced the correct response and showed them any spelling aids. It is important to note that theoretically subjects did not have to be able to read in order to perform the task. All they had to do was remember the CVC sounds and match them up with the appropriate test cue (squiggle or printed letter). The CVC spellings were extra and were not present at the time of the test.

In order to assess whether children's tendency to make use of spellings in the PA task was related at all to their ability to read, various measures of basic reading skills were taken in Experiments 1 and 2: familiarity with some high frequency printed words, ability to sound out and spell nonsense trigrams, speed and accuracy in naming alphabet letters, and phonemic segmentation ability.

Based on orthographic amalgamation theory, several predictions were formed. It was expected that if beginning readers acquire an orthographic-speech mapping system which they apply automatically to form alphabetic images standing for sounds in memory, then the presence of spellings should exert a strong impact upon learning. The sight of correct spellings should make it easy to store and remember the sounds being associated with stimuli, whereas the sight of misspellings should interfere and retard learning. Also, memory for the sounds should be better when letters mapping initial phonetic segments of CVC units serve as test prompts than when unrelated squiggles are the prompts. Furthermore, if an orthographic mnemonic system is used to store printed words in lexical memory, then subjects who benefit from spelling aids in the sound learning task should possess a sizeable repertoire of familiar printed words whereas subjects who do not find the spellings helpful should have much smaller printed repertoires.

Experiment 1

Method

Subjects. The subjects were 24 first graders (mean age, 77.2 months) and 24 second graders (mean age, 93.4 months), half male, half female. They were tested in the winter.

Materials. Four paired associate sound learning tasks were given to each child. The important features characterizing and distinguishing these tasks are depicted in Table 2-1. Orally pronounced CVC nonsense syllables served as the responses in all tasks. The stimuli paired with these responses in one task were aribitrary symbols (i.e., meaningless but highly distinctive figures called squiggles) and in three tasks were single alphabet letters corresponding to initial sounds of the CVC blends. In two of the letter cue tasks, adjunct stimuli were presented alongside the test

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cues during study and feedback periods: either correct spellings for the CVC sounds, or misspellings in which case the final two letters misrepresented the sounds. These cues were never present at the time of the test.

Four sets of response sounds were created so that a different set could be employed in each learning task with a single subject. The particular set assigned to each task was counterbalanced across subjects. The response sets are listed in Table 2-1. Within each set, phonemes in each position were unique. Across sets, the same four short vowel sounds were repeated. For each set, materials for the four types of paired associate tasks illustrated in Table 2-1 were prepared. Stimulus-response pairs were ordered randomly in each condition. This order was repeated on each learning trial. Repetition was preferred to variable ordering only for reasons of convenience.

Procedure. In the paired associate sound learning tasks, the anticipation method of presentation was employed. During the first trial, subjects were exposed to the four stimulus-response pairs. During subsequent trials, their memory for the responses was tested. After each test, they were given the correct answer for that item.

Before beginning, the task was explained along with an example. Children were told that each squiggle or letter stood for a sound, and that they would be shown the same squiggle or letter later on and they were to remember the sound that went with it. On the first trial, they were shown each of four stimulus cards printed with either squiggles or letters. The cards were shown one at a time, each sound was pronounced, and children repeated it. In the spelling and misspelling aided tasks, the stimulus cards displayed the adjunct cues printed next to the stimulus letters (e.g., F - Fab). However, no attention was drawn to these cues. The test trials then began. Each squiggle or printed letter cue was presented without CVC spelling aids, and children were given 5 seconds to recall the sound. The correct answer was then identified. In the squiggle condition, the experimenter pointed and said, "This squiggle stands for (sound) ." In the initial letter alone condition, the experimenter said, "The letter (name) stands for (sound) ." In the letter plus spelling and misspellings conditions, stimulus cards printed with the letters plus the spellings or misspellings were shown, and the experimenter pointed and said, "The letter (name) stands for (sound) ." If children had responded incorrectly, they were asked to repeat the sound.

In each learning task, a maximum of 15 trials was provided to learn the sounds. If children recalled all four sounds correctly on two successive trials, then learning for that task was terminated. Children were exposed to the four tasks in one of four orders: Sq, Let, Spel, Mis; Let, Spel, Mis, Sq; Spel, Mis, Sq, Let; Mis, Sq, Let, Spel. Thus, across subjects, each task was presented in each position (1st, 2nd, 3rd, 4th); however, all possible orders were not tested.

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The children's knowledge of printed language was assessed in the following tasks. (1) Spelling Production. Subjects wrote out the 16 CVC sounds employed in the PA tasks. (2) Sounding Out. Eight new CVC trigrams were printed on cards and children were told to read these "names." (3) Misspelling Recognition. Twelve new CVC sounds were represented on cards as either 2, 3, or 4 printed letters. In three cases, the letters correctly represented the phonemes, and in nine cases, there were single errors. Either initial, medial, or final phonemes were omitted or misrepresented. Children judged whether each had been spelled correctly and if not how it could be corrected. (4) Word Recognition. Children were shown 27 high frequency printed nouns and were asked to read each word.

Testing was conducted with individual children over a period of two days. On the first day, children were given two paired associate learning tasks and also the printed word recognition test. On the next day, they completed two more learning tasks, followed by the spelling production, sounding out, and misspelling recognition tasks.

Results

An analysis of variance was conducted to assess effects of several variables on performance in the paired associate sound learning task. The dependent measure was number of trials to criterion or termination of the task (maximum = 15). The independent variables were: Grade (first vs. second), Sex, Order of Tasks (four different orders of completion), Type of Learning Task (squiggles vs. initial letters vs. spellings vs. misspellings). The latter was a within-subject variable.

Results revealed a main effect of learning task, $F(3, 96) = 45.43$, $p < .01$. None of the other factors exerted any significant effects on performance ($p > .05$). The effect of grade was not significant, $F(1, 32) = 2.72$, $p > .05$, though second graders took slightly fewer trials than first graders. Mean values are presented in Table 2-2. Post hoc pairwise comparisons among learning task means using Tukey's method

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Insert Table 2-2 about here.

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revealed that sounds accompaniedby adjunct spelling aids were learned significantly faster than sounds prompted by initial letters without spellings, and these in turn were recalled significantly better than sounds with squiggle prompts or with misspelling study aids. The difference between the squiggle and misspelling means was not significant. Included in Table 2 is also the number of subjects failing to learn the sounds to criterion in each of the conditions. These values are consistent with patterns evident for trial means.

Analysis of the errors characterizing subjects' responses in the learning tasks revealed that response learning was the central

Table 2-2

Mean Number of Trials to Criterion or Termination and Number of Subjects Failing to Reach Criterion As a Function of Grade and Learning Condition

Grade	Squiggle	Letter	Spell	Misspell	Mean
			TRIALS		
1st	12.7	11.5	[illegible]	13.6	11.4
2nd	12.4	10.1	5.2	11.9	9.9
Mean[a]	12.6	10.8	6.4	12.8	10.6
			CHILDREN FAILING		
1st (N-24)	15	12	6	16	12.2
2nd (N=24)	14	9	2	11	9.0
Total	29	21	8	27	

[a]MSE (96) = 9.19, $T\sqrt{MSE} = 1.619$, $p < .05$

difficulty. Errors in which the correct response was produced but matched with the wrong stimulus were evident only in the condition where a squiggle rather than a letter served as the stimulus cue. However, even in this condition, mismatches accounted for few of the errors. For example, among second graders, only 6% of the errors in learning squiggle-sound pairs were mismatches while 94% involved either a failure to respond or production of the wrong blend of sounds. This indicates that the benefit provided by spellings in this task was to improve subjects' memory for the specific responses.

In order to assess the relationship between performance on the sound learning tasks and the children's knowledge of printed language, Pearson product-moment correlation coefficients were calculated. Three extra subjects had been tested. Since they differed in no discernible way from other subjects, their responses were included in order to maximize the number of observations contributing to the correlational analyses. Results revealed significant correlations between all of the pairs of measures ($p < .05$). These values are reported in Table 2-3.

Insert Table 2-3 about here.

Of particular interest is the fact that the correlations between spelling-aided sound learning scores and the various measures of printed language (i.e., correlations between Variable No. 3 and Nos. 5-8) were all substantially higher than the correlations between scores in the other PA tasks and the printed language measures (i.e., Nos. 1, 2, 4; with Nos. 5-8). Hotelling's test (Walker & Lev, 1953, p. 257) was employed to determine whether the spelling-aided correlations were significantly greater than the other correlations. Results were all positive ($p < .025$). This indicates that the ability to make use of spellings in remembering oral sounds contributes as an independent factor over and above general learning-memory ability in explaining the variability in beginning readers' knowledge of printed language.

The relationship between learning with spellings and printed word knowledge was particularly high, as expected ($r = -.75$). This relationship was examined in another way. Scores of only the first graders were considered since second graders recognized most of the printed words. A histogram of the distribution of word recognition scores is presented in Figure 2-1. Subjects were divided into two groups. Those who learned the sounds in fewer than 10 trials are

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Insert Figure 2-1 about here.

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represented in white, those who took 10 or more trials in black. From

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Table 2-3

Intercorrelations Among Measures for

First and Second Graders (N = 51 Subjects)

	LEARNING				PRINTED LANDUAGE					
LEARNING TRAILS	Squig.	Init. L.	Spell	Missp.	Spell	So. Out	Missp.	Means	Max. Score	S.D.
1. Squiggles								12.4	(15)	3.7
2. Initial Letters	.45**							10.7	(15)	4.6
3. Spelling Aids	.46**	.50**						6.3	(15)	4.6
4. Misspellings	.42**	.41**	.42**					12.6	(15)	3.4
PRINTED LANGUAGE										
5. Spelling production	.29*	-.34*	-.74**	-.32*				12.5	(16)	4.9
6. Sounding out	-.32*	-.43**	-.69**	-.39**	.91**			6.2	(8)	2.5
7. Misspelling recognition	-.32*	-.41**	-.64**	-.35*	.89**	.88**		7.6	(9)	2.3
8. Word recognition	-.43**	-.56**	-.75**	-.41**	.84**	.83**	.74**	19.9	(27)	9.2

*$p < .05$ **$p < .01$

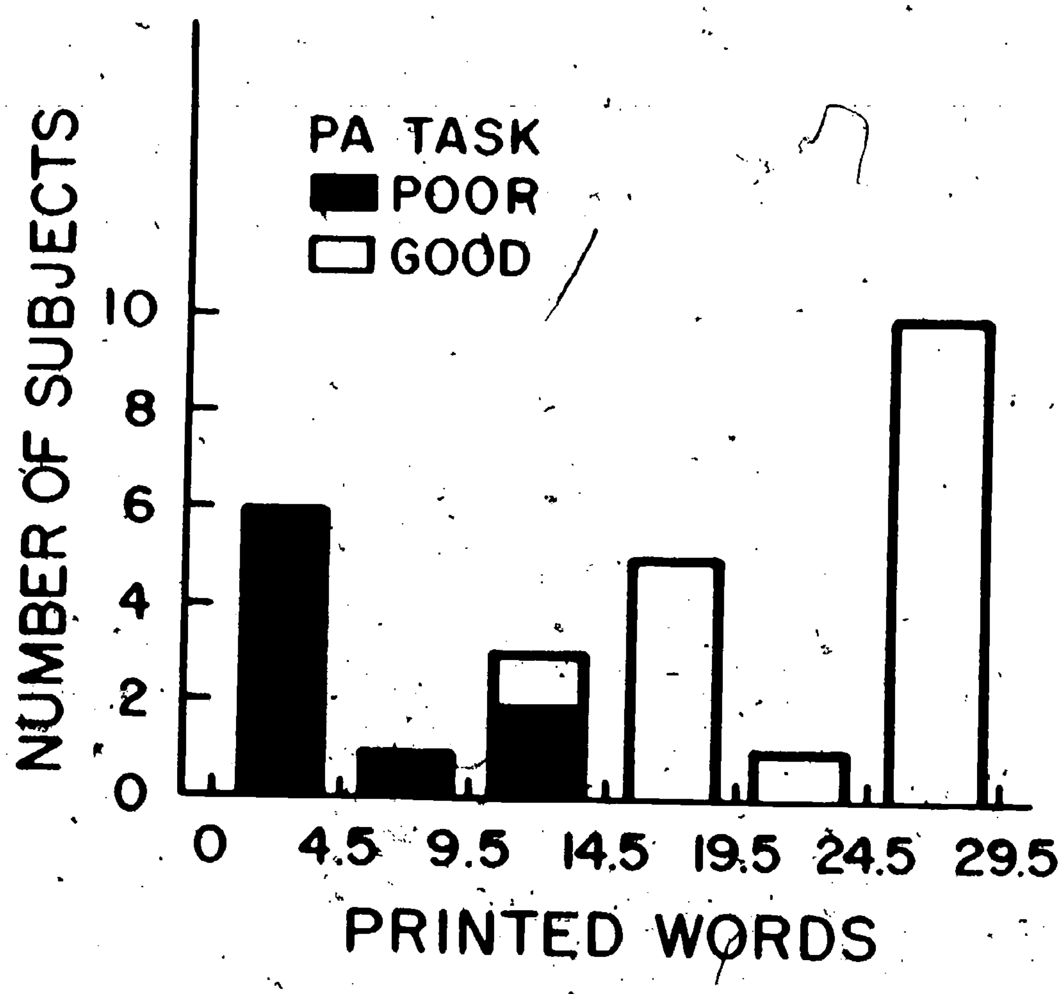

Figure 2-1. Distribution of good and poor sound learners on the printed word identification task in Experiment 1.

this figure, it is clear that there is very little overlap between the two groups of subjects. Those with large printed word repertoires learned the sounds easily. Those with small repertoires did not.

In conclusion, results of Experiment 1 offer support for the view that when children learn to read, they acquire an orthographic mnemonic system. This system is activated spontaneously when word sounds are seen mapped in print, and it serves as a means of gluing print to sound and storing word forms in lexical memory.

Experiment 2

Experiment 2 was conducted to replicate results of the first experiment. The design was modified somewhat. In the paired associate task, the misspelling condition was dropped. Only first graders were tested. Two additional measures of reading related capabilities were included: alphabet letter naming accuracy and speed; phonemic segmentation. The reading skills of children able to learn sounds with spelling aids were compared to the reading skills of children unable to benefit from spellings. This was to test the prediction that orthographic mnemonic capabilities distinguish more from less advanced beginning readers.

Method

The subjects were 30 first graders, 15 males and 15 females, mean age 6.9 years. Subjects were drawn from the same school as in Experiment 1 though none of the same children was included. Subjects were tested in the spring.

In the paired associate sound learning task, three sets of CVC nonsense syllables were employed: PAB, WEK, SIM, FUG; NAF, BEM, KIP, LUT; MAV, HES, TIB, RUK. The test cues for responses were either squiggles or single letters as before. Materials for three types of learning tasks were prepared: learning with squiggles; learning with initial letters; learning with initial letters plus spellings as study aids. The procedures employed in Experiment 1 were repeated except that all possible orders of the learning tasks were employed across subjects.

The same materials and procedures used in Experiment 1 were repeated for the Sounding Out task (i.e., 8 CVC trigrams). The Misspelling Recognition task (i.e., 12 CVC trigrams) was the same except that 12 longer nonsense forms were added for judgment (i.e., misspellings of sounds such as "bipper," "lemase," "seproom"). The Printed Word Recognition task was changed slightly. To the set of 27 nouns, 30 words were added. These included irregularly spelled, context-dependent words taken from the Dolch list of basic sight vocabulary words (e.g., WHEN, EVERY, COULD, MIGHT, ONCE). The Spelling Production task was altered. New trigrams rather than those used in the PA task were given for spelling.

Two new tests were created. In the letter identification task, subjects were shown a sheet printed with 25 randomly ordered lower case alphabet letters and were asked to name each as quickly as possible and to skip over any they did not know. Performance was timed with a stopwatch from the first to the final letter response.

In the phonemic segmentation task, children were first given practice and feedback in the analysis of two sets of related sounds (i.e., $\overline{oo}$, boo; boot; a, as, has). When children were able to analyze both sets correctly, the task commenced. The experimenter pronounced 18 blends, 9 real words, 9 nonsense sounds comprised of 2, 3, or 4 phonemes. The child repeated each syllable, then identified how many sounds he heard, then pronounced the syllable slowly to separate each sound, then laid down a poker chip as each sound was pronounced. If this last analysis was incorrect, the experimenter gave the child a second chance. Segmentations depicted with poker chips on this second attempt were the responses scored as correct or incorrect in this task.

All children were tested on two and in a few cases three separate days. On the first day, they were given two paired associate learning tasks. On the second day, the third PA task was given followed by the letter identification, word recognition, spelling production, phonemic segmentation, sounding out, and misspelling recognition tasks.

Results

To assess effects in the paired associate sound learning task, an analysis of variance was conducted. The dependent measure was number of trials to criterion or termination (maximum = 15). The independent variables were Sex and Stimulus Condition (Squiggle vs. Initial letter vs. Letter plus spelling aids). Only children who were able to learn the sounds to criterion within 15 trials in at least one of the three PA tasks were included in the ANOVA. It was necessary to test 30 first graders in order to find 9 males and 9 females who achieved this degree of success. The 12 children who were tested and replaced completed the maximum number of trials in all three tasks without learning the sounds. Their replacement was considered justified since their performances lacked variability and hence contributed little to treatment comparisons.

In the ANOVA, a main effect of stimulus condition emerged, $\underline{F}(2, 32) = 44.85$, $\underline{p} < .01$. Results are given in Table 2-4. Post hoc analyses using Tukey's method indicated that learning was significantly faster with spelling

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Insert Table 2-4 about here.

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aids than without spelling aids, and it was faster with initial letters than with squiggles. These findings confirm those observed in Experiment 1.

Table 2-4

Mean Number of Trials to Criterion or Termination

in The Paired Associate Sound Learning Task

as a Function of Stimulus Condition and Sex

	Squiggle	Letter	Spelling	Mean
Boys	12.0	6.7	5.1	7.9
Girls	13.4	12.0	6.3	10.6
Mean[a]	12.7	9.3	5.7	9.3

[a]For the main effect of condidton, MSE (32) = 9.836, $T\sqrt{MSE}$ = 2.47, $p < .05$.

Two other effects were evident though only at $p < .05$. A main effect of sex, $F(1, 16) = 5.64$, $p < .05$, as well as an interaction between sex and condition, $F(2, 32) = 4.89$, $p < .05$. From mean values in Table 2-4, it is evident that males learned sounds in fewer trials than females. In addition, among boys, the major improvement in performance resulted when initial letters replaced squiggles as stimuli, and spelling aids provided only a moderate boost. In contrast, among girls, the major improvement was afforded by spelling aids, and initial letters boosted performance only slightly more than squiggles. What accounts for these sex differences is unknown.

Although the criterion for inclusion in the ANOVA was the ability to recall the sounds twice perfectly in any one of the three PA tasks, it turned out that only one of the tasks served to select subjects for the ANOVA, the spelling-aided sound learning task. All 18 ANOVA subjects took no more than 12 trials to reach criterion here. In contrast, several of these children were not able to learn the sounds in the other two tasks. In the initial letter condition, 6 or 33% failed to learn the sounds; in the squiggle condition, 12 or 67% failed. These results indicate that remembering meaningless sounds is not an easy task for beginning readers, and hence they have need for a device such as spellings which will represent and preserve the sounds in memory.

The difficulty of a sound memory task was most apparent in the responses of the 12 subjects who failed to reach criterion in any of the sound learning conditions. In order to determine just how successful they were in the three tasks, the numbers of responses correct per trial were counted. The same pattern of recall favoring spelling aids was not expected to be evident among these children. It was reasoned that since they possess inadequate orthographic mnemonic capabilities, they should not benefit from seeing spelling aids and their memory for the sounds should be quite poor in all conditions. These predictions were confirmed. In a three-way analysis of variance with sex, stimulus condition, and trials as the independent variables, the main effect of stimulus condition was not significant, $F < 1$. To illustrate their low level of performance, these subjects were recalling on the 15th trial means of 1.1 sounds with squiggles, 1.2 sounds with initial letters, and 1.2 sounds with spellings out of a maximum of 4 sounds possible. Except for a main effect of trials, none of the other effects was significant in this analysis.

The 12 children who failed to learn the sounds and the 18 successful learners were given the battery of reading skills pretests. A comparison of mean performances of the two groups revealed several differences, all of which were statistically significant according to t-tests. These results are reported in Table 2-5. The unsuccessful sound learners were only slightly poorer

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Insert Table 2-5 about here.

Table 2-5

Mean Scores on the Various Measures of Printed Language for Children Succeeding and Failing to Learn the Sounds in the Spelling-Aided Task[a]

Measure	Successful (N = 18)	Unsuccessful (N = 12)	Difference
Letters - Accuracy	24.4	22.6	1.8**
(Max = 25)	(1.2)	(2.0)	
Letters - Latency	23.1	40.9	-17.8**
(Seconds)	(8.9)	(14.9)	
Word Recog. - Nouns	21.5	2.8	19.7**
(Max = 27)	(7.5)	(3.7)	
Word Recogn. - Sight	17.8	1.2	16.6**
Words (Max = 30)	(11.0)	(1.8)	
Phonetic Segment.	16.1	12.2	3.9**
(Max = 18)	(1.9)	(2.3)	
CVC Spelling Prod.	11.1	5.3	5.8**
(Max = 12)	(0.6)	(4.5)	
CVC Sounding Out	7.4	3.2	4.2**
(Max = 8)	(1.0)	(2.6)	
CVC Misspell. Recog.	8.8	5.5	3.3**
(Max = 12)	(0.7)	(2.9)	
Nons. Misspell. Recog.	7.6	1.7	5.9**
(Max = 12)	(3.3)	(1.4)	

[a]Standard Deviations are given in parentheses.

**$p < .01$

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in naming alphabet letters accurately and in segmenting words into phonemes. However, they were severely deficient in naming letters rapidly, in reading words, and in detecting and correcting misspellings of longer nonsense syllables. The fact that successful spelling-aided sound learners were distinctly superior to unsuccessful sound learners in several basic reading skills confirms that a strong relationship does exist between orthographic memory and learning to read.

As in Experiment 1, a histogram was drawn depicting the relationship between subjects' spelling-aided sound learning scores and their printed word repertoires. Despite the fact that a larger set of printed words was sampled in the second experiment, Figure 2-2 reveals the same pattern as Figure 2-1: a

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Insert Figure 2-2 about here.

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bimodal distribution with little overlap between the two groups of subjects. Children who were familiar with only a small number of printed words found spellings of little help whereas children who knew a large number of printed words could make use of spellings to store the sounds in memory. Though these results are correlational and hence preclude any causal claims, they are at least consistent with the hypothesis that when children learn to read, they acquire an orthographic mnemonic system and this capability enables them to build up a repertoire of printed words in lexical memory.

The errors observed in the phonemic segmentation task were of special interest because they offered some additional evidence for the operation of orthographic images in the thinking of beginning readers. The majority of mistakes occurred on words or sounds containing four phonemes (i.e., dulp, brin, milk, horn, kest, grass). Even poorer readers were successful on units with three or fewer phonemes. Explanations for the segmentations produced by some better readers provided a glimpse of the influence that knowledge of orthography was exerting in this task. For example, when asked how many sounds they heard in the word "boat," some readers estimated that they heard four. However, when asked subsequently to mark each sound with a counter, only three counters were matched to sound segments. Children then reconciled the discrepancy by explaining that one letter was silent. A few performed a similar analysis on the nonsense sounds "sot" and "an" containing long vowels pronouncing their own names. Subjects overestimated the number of sounds because they imagined a silent E at the end of spellings. Subjects were never shown the printed forms of these sounds, so these letters came from their heads. These observations confirm the claim being made here that readers spontaneously create alphabetic images to represent sounds. In a phonemic segmentation task, these images are useful because the letters provide concrete symbols which make it easier to think about.

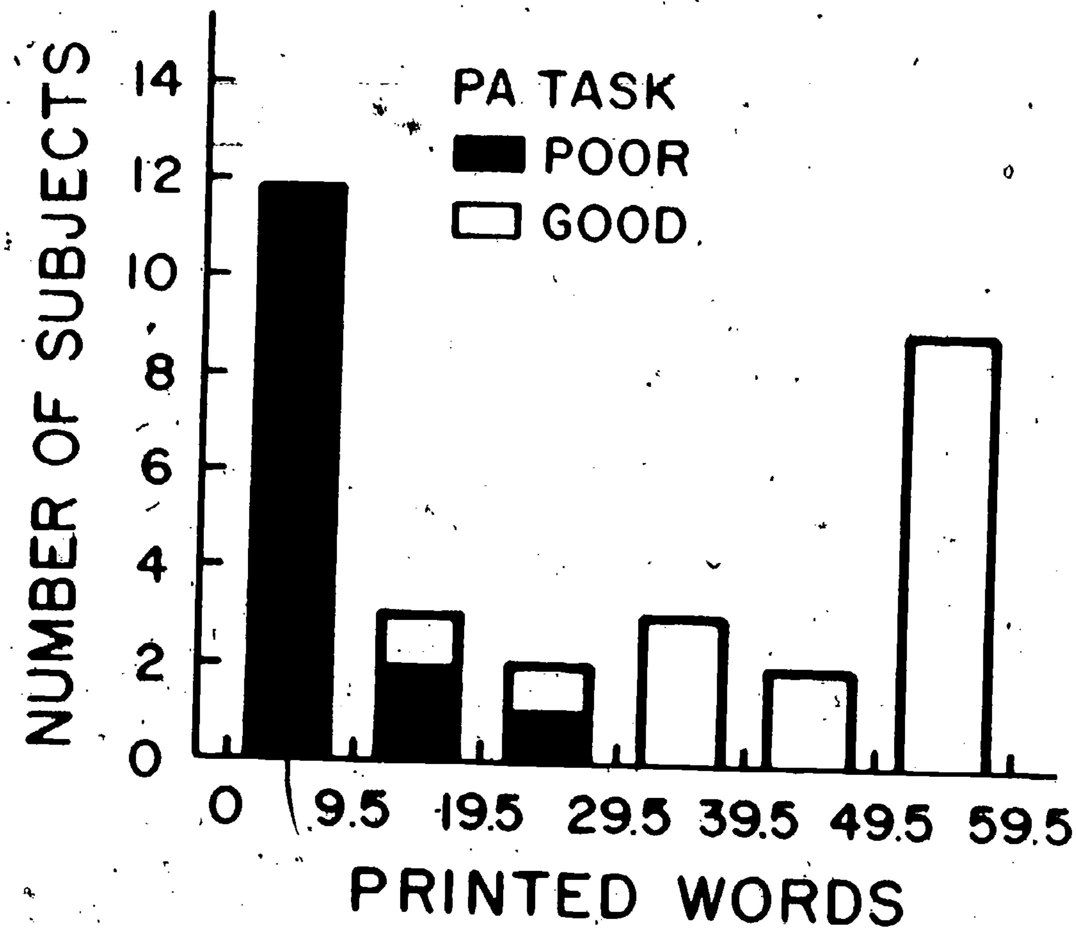

Figure 2-2: Distribution of good and poor sound learners on the printed word identification task in Experiment 2.

separate phoneme segments. In speech, the phonemes fold into each other and have no independent status.

Experiment 3

Results of the first two experiments suggest that spellings do facilitate beginning readers' memory for sounds when they map the sounds accurately. The preferred interpretation is that spellings provide the children with orthographic images they can use to symbolize and store the sounds in memory. However, some alternative explanations for the facilitative effects of spellings must be considered and ruled out. Spellings may have caused subjects to repeat and rehearse the sounds one additional time. Or spellings may have clarified the separate segments in the nonsense sounds more than simple pronunciation. Or some non-visual aspect of the letters may have helped.

To eliminate these possibilities, a third experiment was conducted in which four variations of the PA task were employed. Rather than using squiggles or letters as test cues, the numbers 1 through 4 were used to prompt recall of each of the four CVC nonsense responses in each task. The four tasks differed in terms of the activity occurring during study and feedback periods. Either a visual spelling was shown, or the experimenter gave the spelling orally by naming the letters, or the experimenter articulated each phonetic segment separately, or the child repeated the nonsense sound one additional time. It was reasoned that if spellings are helpful because they provide a visual image which subjects can use to remember sounds, then recall in the visual spelling condition should still be superior.

Method

The subjects were 24 second graders, 11 males and 13 females, mean age 93.6 months. Subjects were drawn from a different school from those above. They were tested in the winter.

In the paired associate sound learning task, four sets of orally pronounced CVC nonsense syllables were employed as the responses. The test cues paired with responses in all four conditions were the numbers 1 through 4. Four types of adjunct stimuli were included on the first study trial and during corrective feedback periods on test trials: (1) Visual Spellings, where subjects were shown a correct spelling for the CVC sound; (2) Oral Spellings, where subjects heard the experimenter pronounce the letter names; (3) Phonetic Segments, where subjects heard the experimenter pronounce each of the three sounds separately (i.e., for "Pab," "puh," "a," "buh"); (4) Repetition, where subjects repeated the correct response one additional time. After the experimenter pronounced each sound and had the subject say it, she presented the adjunct stimulus, saying either "Look at this" or "Listen to this."

The four PA tasks were given to all subjects in counterbalanced order. Also, the particular set of CVC responses was counterbalanced across subjects and tasks. Children were given a maximum of 7 trials to learn the sounds in each task. Learning was terminated early if subjects reached a criterion of two perfect trials. All testing was completed in one session.

Results

The dependent measure was number of correct sounds recalled on each trial. The independent variables were Condition (visual spellings vs. oral spellings vs. phonetic segmentation vs. repetition), and Trials (1-7). Both factors were within-subject variables. An analysis of variance revealed main effects of Conditions, $F(3, 69) = 10.13$, $p < .01$, and Trials, $F(6, 138) = 76.21$, $p < .01$. Also, the interaction was significant, $F(18, 414) = 2.33$, $p < .01$. Post hoc comparisons using Tukey's method revealed that recall was significantly superior with visual spelling aids than with each of the other three aids, none of which differed from the other. Mean values were: VS = 2.24, OS = 1.53, PS = 1.55, Rep. = 1.43, T MSE = .438, $p < .05$. Inspection of performances over trials revealed that recall with visual spellings became increasingly greater than recall in the other three conditions as learning progressed. These findings serve to eliminate three alternative explanations for the facilitative effects of spelling aids, and they suggest that the visual properties of spellings are central to their capacity to improve sound memory.

Experiment 3 differed from Experiments 1 and 2 in that arbitrary rather than related stimulus cues (i.e., numbers rather than first letters of CVC spellings) were used to prompt recall in the spelling-aided condition. The fact that spellings still boosted recall even when no inherent relationship existed between stimuli and responses confirms that what is important about spellings is not their ability to connect responses to stimuli (i.e., to facilitate the associative phase of learning) but rather their capacity to improve response learning.

Subjects were given all four tasks in counterbalanced order. Of interest was whether performance in each task was influenced by its position of presentation (i.e., whether subjects completed that task first, second, third or fourth). Analyses of variance were conducted on performances for each task separately as a function of presentation order and trials. The only significant effect emerged in the analysis of visual spelling scores, $F(3, 20) = 4.11$, $p < .05$. Post hoc Tukey comparisons revealed that recall was signficantly poorer when this task followed all of the others than when it was presented first or second. None of the other pairwise differences was significant. Why this occurred is unknown. No such pattern was apparent for the other three sound learning tasks ($p > .05$).

Experiment 4

The preferred interpretation for results of the above experiments is that spellings facilitate sound memory because they prompt learners to form orthographic images of the sounds and store these in memory. However, in the previous studies, this image-forming process was inferred rather than directly induced. Children were simply shown spellings and no mention was made of images. A further experiment was performed to demonstrate this effect directly. Sound learning was compared under two conditions: when children listened to oral spellings and imaged what they looked like, and when children rehearsed the sounds several times. It was reasoned that if spellings facilitate recall because they provide orthographic images of sounds which can be stored in memory, then performances should be better when children are told to imagine spellings than when they merely repeat the sounds.

Method

The subjects were 18 second graders, 10 males and 8 females, mean age 97.7 months. Children were tested in the spring and early summer.

Two versions of the PA sound learning task were designed. Two sets of four orally pronounced CVC nonsense syllables were selected as responses. The numbers 1 through 4 were paired with each and served as recall prompts for the sounds. Two types of adjunct activities were included on the first study trial and on test trials during feedback periods. In the Image Formation condition, subjects were first given practice imagining the spellings of four familiar printed words (i.e., girl, boy, book, tree). The experimenter pronounced each word, the subjects said it, the experimenter spelled it orally, had the subjects close their eyes, imagine the letters in their heads, and indicate when they could see the word. The sound learning task followed. The experimenter presented each number stimulus, pronounced the CVC sound, had children repeat it, close their eyes, the experimenter named the letters, and had children indicate when they could "see" the spelling. During test trials, this activity followed each attempt to recall the CVC sound. In the Repetition condition, the experimenter presented each stimulus number, pronounced the sound, had children say it, then pronounced the sound again and had children say it again. During test trials, this activity followed each recall attempt. The two tasks and response sets were given to subjects in counterbalanced order. Children were given 7 trials to learn the sounds. Learning was terminated early if they achieved two perfect performances. Testing was completed in one session.

Results

The dependent measure was number of correct sounds recalled on each trial. The independent variables were: Task Order (image task before vs. after repetition task); Task (image vs. repetition); Trials (1-7). An analysis of variance revealed main effects of Task, $\underline{F}$(1,

16) = 4.73, $p < .05$, and Trials, $F(6, 96) = 39.51$, $p < .01$. None of the other effects was significant ($p > .05$). As expected, recall of CVC sounds was superior when subjects imagined spellings than when they rehearsed the sounds (i.e., mean recall per trial = 2.05 vs. 1.70, $MSE(16) = 1.626$). These findings provide direct evidence for the claim that orthographic images improve children's memory for meaningless sounds.

Discussion

Results of all four experiments are interpreted as providing evidence for one or another hypothesis derived from orthographic amalgamation theory. These hypotheses together with supportive evidence are reviewed below. (1) Results confirm that orthography has mnemonic value among beginning readers. In all four experiments, sounds were learned faster when spelling aids were seen or imagined during study periods. (2) The visual property of spellings is central to their facilitative effect. In Experiment 3, seeing letters was more effective than simply hearing the letters named. In Experiment 4, hearing letters improved sound memory when subjects were told to form visual images of the letters. (3) Visual spellings must map sounds accurately in order to facilitate sound memory. In Experiment 1, misspellings were found to interfere with recall. (4) Spellings contribute by helping subjects store and remember the response sounds. Analysis of the errors committed by subjects in Experiment 1 indicated that the majority involved response failures rather than stimulus-response mismatches. (5) Spellings improve response memory because they induce learners to preserve letters as visual images symbolizing sounds in memory. In the first three experiments, visual spellings were not present on test trials yet they boosted recall. In order to have this effect, subjects must have stored them in memory. In Experiment 4, the same effect was demonstrated when subjects "saw" spellings by forming visual images in their heads. (6) The capability of creating alphabetic images to map sounds is possessed by beginning readers, and they use this capability spontaneously when the need arises. In Experiment 4, all the subjects were able to form and report the presence of images during the sound learning task, and their confirmations were immediate following the experimenter's oral spellings. Nobody expressed confusion over the image formation instructions. In the first three spelling-aided sound learning experiments, children were not taught or told how to benefit from spellings in remembering sounds. The experimenter simply showed the spellings during or after she pronounced the sounds. Nevertheless, subjects made use of the spellings to remember the sounds. In the phonetic segmentation task, although no mention was made of letters, some subjects appeared to form and consult alphabetic images as they estimated the number of sounds in real and nonsense words. Very likely spellings were imagined because they helped subjects identify the separate sound segments which are otherwise difficult to detect since the sounds fold into each other and are not discretely represented in speech (Liberman & Shankweiler, 1977). (7) In order to benefit from spellings in remembering sounds, children must be able to decode those spellings to sounds accurately. In Experiment 2, successful sound learners were able to sound out and blend most of the trigrams in the CVC Sounding Out task (mean = 7.4 correct out of 8) whereas unsuccessful learners were not (mean = 3.2 correct). (8) The ability to use spellings in remembering sounds is centrally involved in learning to read. Results of Experiments 1 and 2 indicate that this capability emerges during the first year of reading instruction, it is highly correlated with beginning reading skills, and it distinguishes between more and less advanced beginners. (9) Orthographic mnemonic capabilities contribute to reading acquisition by enabling readers to represent, store, and retain the printed forms of words as orthographic images in lexical memory. In Experiment 1, scores on the spelling-aided sound learning task were highly correlated with measures of children's printed word repertoires, significantly higher than correlations between the other PA tasks and this measure. As the histograms in Figures 2-1 and 2-2 show, differences in the size of print lexicons between good and poor sound learners at the first grade level were extreme and there were no exceptions to this relationship.

Although the evidence collected is perhaps impressive, the claims of orthographic amalgamation theory are still very tentative in need for further study. For example, before Hypothesis 9 is accepted, an experiment is needed to show that orthographic memory actually participates in the process of recognizing and remembering printed words. Present findings are correlational and so fall short of demonstrating a causal relationship.

The orthographic mnemonic explanation for the facilitative effects of spelling aids is the one favored by present findings. Two other explanations were considered. One was that spellings served to clarify the constituents of the acoustic stimulus, just as seeing a strange name spelled often enables the listener to distinguish the separate sounds being pronounced. Two facts make this interpretation unlikely. First, the sounds taught in the PA tasks were comprised of blends of only three familiar phonemes, and they were pronounced correctly and easily by all subjects during the learning trials. Second, in Experiment 3, subjects did not benefit from non-visual types of sound-elaborative experiences such as hearing the letters named, or hearing the sounds segmented, or rehearsing the sounds. The other explanation considered was that spellings boosted performance because they enhanced subjects' awareness of the relationships between test stimuli and nonsense responses. Without seeing trigrams spelled out next to letters serving as text cues, subjects failed to recognize that the letters represented initial sounds in the CVCs. This explanation was ruled out by Experiments 3 and 4 where stimulus cues were arbitrary numbers rather than the initial letters of CVCs yet subjects still benefitted from spellings in learning the sounds. As explained above, spellings improved the response learning phase, not the associate phase of the learning task.

Although results of the present study do not provide any direct evidence against the phonemic recoding view of printed word processing, they do contribute negative evidence for one assumption connected with this view, namely, that beginning readers possess an effective phonemic coding system for storing and remembering sounds. In the present study, children had a hard time remembering sounds in the absence of letters. Several beginning readers could not learn the four sounds in 15 trials under any circumstances, and others never learned the sounds unless they were shown spellings. In a previous study, Ehri (1976) examined children's memory for real words in a PA task where the stimuli were squiggles and the responses were five spoken words, a noun, adjective, past-tense verb, preposition, and function word. (No spellings were shown.) She found that prereaders could remember the meaningful words easily but they had much trouble learning the latter three types (e.g., words such as helped, came, from, and, could, were) which are essentially meaningless without sentence contexts. Results of these two studies suggest that in order to be memorable, sounds must have meaning or must be symbolized by letters. Otherwise there is no coding system available for preserving the sounds in memory.

Present theory and findings can be interpreted as bearing on an issue which has been prominent in the literature on word processing. The issue is whether readers go directly from print to meaning when they process words or whether readers translate print to sound and then retrieve meaning (Barron, 1978; Bradshaw, 1975). Most recently, Barron and Baron (1977) offer some evidence that sound plays a minimum role even among beginning readers as they process familiar printed words. The theory proposed here offers an explanation how this might be possible. The proposal is that readers store orthographic images of words, that these images are amalgamated with the words' other identities (i.e., phonological, syntactic, and semantic), and that these identities are stored and retrieved as single units in lexical memory. Readers are able to move directly from print to meaning because the visual properties of a familiar word match the reader's stored image, and sight of this triggers retrieval of the entire unit, with sounds and meanings becoming apparent simultaneously. Note that this proposal does not suggest that sound is absent from the recognition process, only that it is not central to recognition once the orthographic form of the word has been placed in lexical memory. Present findings offer some evidence for a part of this view by indicating that orthography does have mnemonic value for beginning readers and that the ability to benefit from orthography is highly correlated with the size of the reader's print vocabulary. However, the bulk of the evidence has yet to be gathered.

Present findings are related to another issue. Although most researchers agree that children become sensitive to orthographic regularities as they learn to read, there is some disagreement over when this sensitivity develops. Some findings indicate that it begins to emerge as early as the first year of reading instruction. Niles

ERIC

and Taylor (1977) presented children with triplets of 8-letter pseudowords bearing zero-order, second-order, and fourth-order approximations to English words, and they found that toward the end of first grade subjects were able to identify at better than chance which word was more like a real English word. Other researchers place development at a later point (Guttentag & Haith, 1978; McCaughey, Schadler, & Juola, 1977). Gibson and Levin (1975) cite several studies in which first graders did not perform better with pronounceable than with unpronounceable nonsense words. Findings of the present study appear to side with the "learned earlier" position. First graders were observed to benefit from nonsense word spellings in remembering the nonsense sounds. However, the task was quite different from those used in the other studies. Very likely resolution of this issue rests with the definition of orthographic sensitivity and the tasks used to study it. What it means to be sensitive to orthographic regularities is not clear and varies among researchers. Also, some types of tasks may be more sensitive to earlier forms of structural knowledge than others.

Several aspects of the beginning reader's knowledge of printed language were measured in the present study. One or another of these has been studied by other researchers, and evidence has been offered to suggest its importance in learning to read. Richek (1978) looked at the relationship between various skills and kindergarteners' ability to learn printed words. The general factor predicting success was the ability to name alphabet letters. Speer and Lamb (1976) found that among more advanced beginners (i.e., end of the year first graders), letter naming speed was correlated with reading ability. Liberman and her colleagues (Liberman, 1973; Liberman & Shankweiler, 1977; Liberman, Shankweiler, Liberman, Fowler, & Fischer, 1977) and also Fox and Routh (1975, 1976) have found that young children's ability to analyze spoken words into phoneme segments is correlated with beginning reading skill. From the high intercorrelations obtained among these and other measures of reading capabilities in the present study, it becomes clear that no single capability can be regarded as the key to reading acquisition. More likely, all are involved. Guthrie (1973) refers to this as a system model in which various components are acquired and function interdependently to permit progress in learning to read. He provides evidence that the difference between good and poor beginning readers is not that the poor readers are deficient in a particular skill but rather that the skills they possess have not been sufficiently organized into one system. The observation of a bimodal distribution of first graders in the present study supports this system model by suggesting that progress is limited in the absence of such integration but rapid once the various capabilities are mastered and work together. In the present paper, a particular mechanism is proposed in which all of these capabilities participate. The mechanism involves knowledge of orthography as a mapping system for sound and as a representational device for storing words in lexical memory. Whether this or some other mechanism proves most accurate as a description of how the capabilities are integrated, this approach illustrates what researchers need to do, that is to develop theory and research which clarifies the nature of the cognitive equipment involved in learning to read and how each capability participates.

Although processes important for beginning reading are the focus of the present study, it is not really clear how results translate into instructional practice. Though findings indicate the importance of several capabilities (i.e., the ability to form and retain orthographic images in memory, knowledge of orthography as a mapping system for speech, phonetic segmentation), it is not known how these capabilities are acquired or how they might be taught so as to facilitate learning to read. Answers to these questions cannot be inferred from present findings but must themselves be explored experimentally.

One implication of present findings for reading readiness instruction might be mentioned. The younger children in the present study found it very difficult to learn meaningless sounds, particularly when they were related arbitrarily to stimuli (i.e., squiggles). This was despite the fact that sounds were simple and there were only four to remember. Thus, teachers should not be surprised to find that it takes youngsters a long time to learn the names of all 52 upper and lower case alphabet letters, particularly when the children come to school knowing few of these already. If knowledge of alphabet letters is a prerequisite for learning to read, as some evidence suggests (cf. Venezky, 1975), then it is particularly important for teachers to develop an effective instructional program which takes account of the memory burden inherent in learning meaningless sounds and their associations with arbitrary printed figures.

Chapter 3: Preliminary Investigations of the Nature of Orthographic Images[a]

STUDIES

Comparison of Silent and Pronounced Letters in Orthographic Memory.

In the sound learning experiments reported in Chapter 2, the role of orthography in printed word learning was indicated only indirectly by correlational data. Some other studies were designed to collect more direct evidence that beginning readers store words as orthographic images. In the first study, a series of tasks was designed to show that children possess visual images of real words which are alphabetic and include all of the letters in a word's spelling, not just boundary letters or phonetically salient letters. Children were first shown some words to verify that they could read them. Then they were told to imagine the printed forms of each word and to decide whether it contained a particular letter. Some of the letters were constituents, some were not. Some of the constituent letters mapped single sounds in the words and some were silent. After this, subjects were surprised with a word memory task. Recall of each word was prompted with the letter given in the judgment task. It was reasoned that if beginning readers have stored familiar words as orthographic images, then they should be able to consult these images to answer questions about constitutent letters, and they should have information about silent as well as pronounced constituents. Furthermore, they should be able to remember words prompted by constitutent letters far better than words prompted by nonpresent letters.

To verify these hypotheses, 20 second graders were tested individually. A preparatory phase came first in which 15 high frequency adjectives and verbs were presented on cards for the children to identify. If subjects were unsuccessful, they were taught to read the words by re-presenting the cards until all were correctly pronounced. Most of the words proved already familiar to the children. The mean number correct on the first presentation was 13.5 words out of 15. Eleven children required some training (i.e., a mean of 1.6 additional trials) to learn the words. After this, the subjects spent 10-15 minutes performing two filler tasks which assessed their ability to identify a set of 84 printed words and to sound out and blend some nonsense words. The letter judgment task came next. The experimenter pronounced each of the 15 words the child had recognized or been taught earlier. The child was told to form an image of the word's spelling and to indicate when he/she could see it. Then the experimenter presented a card printed with a lower case letter and told the subject to decide whether the word being imagined contained that

[a]This chapter will appear as part of an article for a book. It is referred to in other chapters as Ehri (in press-a). The reference is: Ehri, L.C. Reading and spelling in beginners: The development of orthographic images. In U. Frith (Ed.), Cognitive Processes in Spelling. London, Eng: Academic Press, 1980, in press.

letter. Different letters were judged for each word. Among the 15 words judged, five words contained a letter which mapped into a sound in that word (i.e., n - kind, o - brown, r - strong, i - sick, w - sweet), five words contained a letter which was silent in the word (i.e., a - dead, c - black, l - talk, g - bright, e - come), and five words did not contain the letter at all (i.e., u - drink, z - jump, y - fast, m - hard, p - short). All of the contained letters were in non-initial positions. The experimenter presented the words for judgment twice, each time in a different order. Then she surprised the subject with a recall task. Each letter was shown again and the child was told to remember the word he had imagined for that letter.

Results for the most part confirmed expectations. On the letter judgment task, scores were close to perfect. Mean values are given in Table 3-1. Though errors were few, the majority occurred with the silent letters. Scores improved slightly on the second trial. Some children commented that it was easier to

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Insert Table 3-1 about here.

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judge the second time around, and response latencies appeared to be shorter. With one exception (i.e., a child who missed five), no child judged more than two letters incorrectly on the second trial.

Informal observation of behaviors accompanying the image judgments further confirmed that it was easy for children to imagine the spellings of familiar printed words. They had no difficulty following instructions. When asked to report when they had the image, all complied, and no one claimed not to understand what he/she was supposed to do. Everyone was able to form images for most of the words, these images seemed to be formed readily, and the letter judgments were immediate. A few words required more time. For these, children would close their eyes tightly or whisper spellings to themselves. They appeared to be engaged in constructing rather than simply retrieving an image. When asked about the presence of a letter in these words, some were observed to stretch out the word as they pronounced it, either in order to find the letter or to confirm its presence in the word. Only three children reported lacking an image, and this occurred for only 1 or 2 words. As the children examined their images, some were observed to roll their eyes upward and nod their heads. If a letter was not present, they seemed to respond immediately, one child claiming "No way!" If present, their "yes" responses were slightly delayed as they appeared to be locating the letter in the image before answering. Eye movements and head nodding often accompanied confirming responses. These observations make it hard to doubt that the children were indeed working with images of words in their heads.

Recalling the words was somewhat more difficult than imagining spellings. Out of five words per letter category (i.e., sounded, silent, absent), the mean number of words recalled ranged between 0.5

Table 3-1

Mean Correct in the Letter Judgment and

Incidental Recall Tasks (Maximum per cell = 5)

	Letter Cue			
	Sounded	Silent	Absent	Mean
Letter Judgment Task				
First trial	4.85	4.30	4.80	4.65
Second trial	4.95	4.35	4.80	4.70
Word Recall Task				
All Subjects	1.70[a]	2.55[a]	0.45[a]	1.57
Subjects with Perfect Letter Judgment Scores (N = 9)	1.90	2.90	0.40	1.73

[a]MSE (32) = 0.75, Tukey pair-wise comparison value = .58, $p < .05$.

and 2.5 words (see Table 3-1). Recall was very poor for words whose spellings did not include the letter prompt. Out of 20 children, 12 failed to remember any of these five words. In contrast, there were no children who failed to recall at least one word prompted by a constituent letter. These results indicate that letters comprise a relevant part of beginning readers' memory for words.

In this study, silent and pronounced letters were compared in terms of their capacity to prompt recall. This was done in order to verify that orthographic images rather than phonetic translations underlie performance. It was reasoned that if familiar printed words are stored as visual images, then all of the letters should be represented, regardless of whether they map into sound. Thus, silent letters should be as effective as sounded letters in prompting recall. An alternative possibility is that when children learn words, they translate letters into sounds and use sound to access word meanings. Those letters which correspond to sounds become the critical cues for identifying words, and they are the letters which get represented in lexical memory. If this is true, then sounded letters should serve as better retrieval cues than silent letters.

Analysis of performances in the recall task disclosed a difference, but it was the opposite of any effect expected. As displayed in Table 3-1, the mean number of words retrieved by silent letters was signficantly greater than the mean number retrieved by pronounced letters. When the recall performance of only the best subjects was considered, that is, those who performed perfectly in judging silent and pronounced letters, the difference between silent and pronounced letter recall was even larger (see Table 3-1). The fact that recall was not poorer with silent letters is interpreted as support for the claim that alphabetic images of word spellings are represented in lexical memory as visual forms whose component letters do not have to map sound to be included and remembered.

Why recall should be superior with silent letters is puzzling. Several possibilities can be identified. It may be that the children spent more time or effort thinking about the silent-letter words during the letter judgment task since the presence of these letters was harder to detect. Or it may be that, unlike pronounced letters which could be verified by consulting the word's sound, silent-letter prompts forced subjects to access and examine an image of the word. Since orthographic images appear to be better mnemonics than sounds (see above discussion), word recall was superior when subjects consulted images. Another possibility is that silent-letter words were more memorable than pronounced-letter words. This could have happened since a different set of words was used in each case. A fourth possibility is that pronounced letters may have produced more intrusion errors than silent letters by causing children to think of other words containing that letter sound. Inspection of the errors, however, revealed an equal number of intrusions with each letter type, thus discounting this hypothesis. A fifth possibility is that the effect reflects a real difference. Silent letters may in fact be more salient in the images of familiar printed words. The presence of these letters is not predicted by any sound in the word and so there exists less redundancy for that letter slot in the image. As a result, these letters may have received a disproportionate amount of attention during the learning phase when the words were being stored in lexical memory.

To check on some of these explanations, another similarly designed experiment was performed. This time, a set of 10 words thought to be familiar to second graders was selected, and the same words were presented for letter judgment to two different groups of children, one group given pronounced letters to judge, the other given silent letters. Since the same words were given to both groups, we eliminated the possibility that recall differences might result from differences in our word choices. In order to make subjects in the two groups comparable in reading skill, we used their scores on a printed word reading task to form matched pairs. Members were randomly assigned to the pronounced and silent letter judgment groups. As in the previous experiment, an incidental letter judgment task was followed by a surprise letter-prompted recall task. The same sequence of tasks and task procedures were used. The new set of words plus the silent and pronounced letter prompts are listed in Table 3-2. Initially, the experiment was conducted with second graders.

Insert Table 3-2 about here.

However, several of the subjects were not sufficiently familiar with the words and so their judgment and recall performances were too poor to consider. Additional pairs were recruited from the third grade to yield a total of 19 pairs, 13 third graders and 6 second graders.

Analysis of performances revealed that these children were already familiar with most of the 10 target words and so did not require much training. The mean number correctly read on the first word recognition trial was 8.1 words for second graders, 9.8 words for third graders. In the letter judgment task, all second graders and 5 pairs of third graders went through the task twice while eight pairs of third graders performed the judgments just once. As in the previous experiment, children judged the letters almost perfectly, with a mean of 9.8 correct for pronounced letters, and a mean of 9.4 correct for silent letters.

In the recall task, the mean number of words prompted by silent letters was again superior, 6.6 words, as contrasted to 4.9 words prompted by pronounced letters. A matched pair t-test confirmed that this difference was significant ($p < .05$). These findings replicate the pattern found in the previous experiment.

To further verify the superiority of silent letters as recall prompts, the number of subjects recalling each word successfully with each letter prompt was calculated. These values are reported in Table 3-2. Comparison of silent and pronounced letter recall for individual

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Table 3-2

List of Words and Letter Prompts Employed

and Number of Subjects Recalling Each Word

Words	Silent Letter	Subjects (Max=19)	Pronounced Letter	Subjects (Max=19)	Difference
school	h	14	c	17	-3
straw	w	10	t	5	5
wide	e	15	i	9	6
laugh	u	7	a	5	2
listen	t	14	s	4	10
friend	i	9	n	1[illegible]	-1
dead	a	12	e	10	2
young	o	13	u	9	4
comb	b	18	m	12	6
bright	g	14	r	13	1
Mean		12.6		9.4	

words revealed that the pattern favoring silent letters held for 8 out of 10 words. Thus, results appear to generalize across words as well as across subjects.

As in the previous study, it was not the case that pronounced letters elicited more word intrusions. Inspection of the number of errors in which subjects matched the wrong words to letters revealed about the same number occurring for pronounced and silent letters. Thus, greater response interference does not account for the poorer recall occurring with pronounced letters.

Another explanation for the effect was suggested by Uta Frith (personal communication). In analyzing the locations of letter cues in the words in Table 3-2, she noticed that silent letters occurred in later positions than pronounced letters in 8 out of 10 cases. The exceptions were "friend" and "young." It may be that subjects scanned more of the orthographic image in locating silent letters than in locating pronounced letters, and that words whose images were more completely processed were better remembered. This explanation would attribute recall differences not to any special role of silent letters in images but rather to processing differences resulting from the choice of early or late letters. This possibility merits further investigation. If found to be true, it would clarify how orthographic images operate in this task, and it would suggest that silent and pronounced letters have equal status in these images.

Results of another study using a different task to compare memory for silent and pronounced letters provided support for the equal status hypothesis. Included as part of a larger experiment (Ehri & Roberts, 1979) was a spelling task which required first graders to detect misspellings in 18 words thought to be in their reading vocabularies. In each misspelling, one non-initial letter had been deleted. For nine words, the omitted letter was silent; for nine words, a phonetic segment for the missing letter could be found in the word's sound. The child's task was to detect and correct the misspellings. It was reasoned that if the importance of letters in words is determined by whether they map sounds, and if word spellings are generated or remembered in terms of sound-salient letters, then missing silent letters should not be as easily identified as sounded letters. However, if orthographic images of words are stored in memory, then silent letter omissions should be as obvious as sounded letter omissions. Comparison of the mean number of misspellings detected and corrected revealed equivalent means for the two sets of 9 words: $\underline{X} = 6.0$ for silent letters, 6.1 for pronounced letters, matched-pair $\underline{t}$-tests statistic $\underline{t} < 1$. A tally of performances with the more easily detected misspellings illustrates what errors were obvious. Most children (i.e., between 25 and 36 out of 37 subjects) detected letter omissions in the following words: for pronounced letters, HELP, WORK, AWAY, THERE; for silent letters, LIKE, TREE, YOUR, PLAY, TELL. More than half of the children detected the following errors: for pronounced letters, FIND, SMILE, AFTER, FISH; for silent letters, HOUSE, WALK.

There are some sources of concern about these data. More of the silent than pronounced letters were located at word ends which tend to be a more salient position. Also, different words comprised the two sets, opening up the possibility that the sets were not equally familiar to subjects. Regardless of these shortcomings, the fact that beginning readers detected and corrected a majority of the silent letter omissions indicates that the visual forms of these words and not simply the pronounced letters were known. These results are consistent with the hypothesis that silent and pronounced letters are equally prominent in the visual images of words stored in memory.

Memory for Visual Forms of Pseudowords.

If it is true that when children learn to read words, these words are stored as orthographic images, then one would expect beginning readers to be able to read off their images and to produce correct or approximately correct spellings for familiar printed words. Acquiring the ability to spell words should develop hand in hand with learning to read words, even under circumstances where no opportunity is provided for spelling practice. Some preliminary studies were conducted to see just how closely related reading and spelling capabilities might be.

One experiment was designed to find out how accurately second graders would be able to spell made-up words they had been taught to read but had never written. Eight nonsense word sounds were invented. For each word, two alternative spellings were created, the spellings were printed on drawings of animals, and these were described to the children as names of the animals. Each child was shown only one of the two spellings for each picture. First, subjects practiced reading the eight names until they could perform perfectly with the pictures present, then without the pictures. Also, they practiced recalling the names of the pictures. Following a delay of 3-4 minutes during which they completed some math problems, they were shown the pictures and asked to write out each name. Of interest was whether original spellings would be recalled or whether children would create their own phonetic versions. It was reasoned that if, when subjects learned to read the words, they spontaneously stored orthographic forms as visual images, then their spellings should resemble the original forms. If, however, when they learned the words, they recoded the print to speech and stored the sounds in memory, their spellings should be phonetic and not terribly faithful to the original form, particularly if it was irregular.

The words used are listed in Table 3-3. For each word, one of the spellings was thought to be more conventional than the other. Each of 14 children read four of the more conventional

Insert Table 3-3 about here.

Table 3-3

List of Nonsense Names and Misspellings

Original Spellings	No. of Errors	Misspellings*
Wheople	6	wheaple (3), whopore, whepole, weeple
Weepel	4	weeple (2), weepl, wepol
Bistion	4	bistoin, bishtin, bshistun, bitson
Bischun	4	bischtun, bistchin, bischen, buchden
Crantz	4	cantz, cranttz, crants, crand
Crans	1	crane
Ghirp	4	ghrip (2), grirp, girp
Gurp	1	grup
Juild	2	juiled, jild
Jilled	0	
Proat	2	poat (2)
Prote	0	
Lutter	1	luter
Ludder	1	lutter
Knopped	1	knoped
Nopt	0	
Total	35	
(Max.)	(112)	

*Parentheses indicate that more than one child produced this misspelling.

and four of the less conventional spellings. The names were pronounced identically for both spellings. In cases where different pronunciations might be possible, the one used was the one suggested by the first more deviant spelling listed in Table 3-3.

Results revealed that children were quite accurate in their spellings: 69% of the productions were perfect. Their errors are listed in Table 3-3. Fewer of the deviant spellings were recalled correctly than the phonetic versions: 59% versus 80%. This suggests a greater tendency to forget more irregular forms. Inspection of the misspellings revealed that phonetic factors did play a role in distorting recall of original spellings though they did not account for all misspellings. Out of 35 errors, 60% could be considered phonetically acceptable maps while 40% failed to represent sounds in the pseudowords accurately. Further inspection of the particular letters retained in misspellings revealed that subjects did not completely abandon original spellings in favor of a straightforward phonetic version. This is apparent from the fact that subjects tended to preserve a salient letter pattern from the original form, and these patterns were produced only by subjects who had seen that version of the spelling. They never occurred with the other version. Whereas every misspelling of WHEOPLE began with WH, every misspelling of WEEPEL began with WE. Every misspelling of BISTION contained ST whereas every misspelling of BISCHUN had CH. CH was not produced at all in the former case. Every misspelling of GHIRP had an I and two included the H as well, whereas these letters never occurred with GURP. From these findings, it can be concluded that both visual and phonetic factors participate in the storage and production of word spellings with neither dominating to the exclusion of the other. This is consistent with amalgamation theory suggesting that the two sources of information work together in setting up orthographic images in memory.

One other study was conducted to explore subjects' visual memory for letters in pseudowords. Some better first grade readers were selected and taught to read 16 tri-syllabic nonsense words such as PETRAVAMP, ROSTENLUST, NULLIBLE, TERMOLENT, MUSTURAL, pronounced with primary stress on the first syllable. The second syllable of each word was pronounced with an unstressed schwa which theoretically can be spelled with any of the five vowels. In the spellings created for these 16 words, the schwa sound was represented by each of the vowel letters in one or another word (i.e., each vowel occurred 4 times except the letter O which appeared 5 times). Of interest was how accurately children might be able to remember these letters. It was reasoned that if sound alone determines which letters get stored, then accuracy should be poor. However, if visual properties of words are stored, then these letters might be remembered better than chance.

The 16 words were taught on a memory drum using a study-test procedure. During the study trial, the child pronounced each word correctly. During the test, he or she had 3 seconds to recognize and say each word. Four training trials were given to 19 children who had demonstrated that they could read single-syllable nonsense words easily (i.e., words such as rin, clus, grak, keb). After each subject completed the four training trials, his memory for spellings was tested. For each word, he was shown a card with all but the schwa letter printed. In place of the schwa, there was a hole behind which was a sliding row of vowels. Each of the vowels could be positioned in the hole to fill in the slot. The child was told to pick the letter which made the word look right.

Though subjects learned to read many of the words, most did not remember the schwa letters very well. The mean number of nonsense words read correctly during the fourth test trial was 10.5 (maximum = 16 words). The mean number of schwa letters correctly identified on the spelling test was 6.1. By chance, one would expect about half this many, or 3.2 letters to be correct if children were selecting randomly from the set of 5 vowels. However, not all choices may have been random. A few words were correct much more often than the others (i.e., 12 or more out of 19 children were correct on PIMMICAN, SALSIFY, WEXELBAN, LIMMERPOP, whereas 9 or fewer children were correct on the other words). Thus, some of the letters may have been easy to guess based on knowledge of orthographic patterns. When the four easy words were excluded, there were only 8 subjects out of 19 who performed above a chance level, recognizing between 4 and 9 out of 12 letters correctly. These results suggest that visual memory for spellings was relatively weak in this experiment, perhaps not surprisingly since the words were long and there were several to remember.

The study was designed to assess subjects' visual memory for letters which did not map into distinctive sounds. However, observation of the children's learning strategies revealed that this was in one sense a false characterization of the task. When required to learn multisyllabic forms, some children were observed to adopt a printed word learning strategy which <u>created</u> relevant sounds for the schwa letters. During learning trials, as children were pronouncing the printed words, they sometimes separated the forms into component syllables. In doing so, they transformed unstressed into stressed syllables, and schwa letters were given appropriate sound values. For example, when SALSIFY was broken into syllables and pronounced slowly, /sə/ was pronounced /si/. This strategy is noteworthy because it reveals one way that word learners might improve their memory for letters mapping into nondistinctive sounds, and it may explain how some of the children in the present study were able to remember spellings for schwa sounds. By pronouncing each syllable separately with stress, they created relevant phonetic slots for the letters to fill in memory.

These observations illustrate how visual and phonetic properties of words might work together to set up and retain more accurate orthographic images in memory. As such, they are consistent with the WHEOPLE pseudoword learning study whose results pointed to an interactive view of the process. One conclusion ~~which~~ might be drawn from these two studies is that when both the visual and the phonological identities of words are being established in the lexicon and when the load on memory is increased beyond its capacity, the phonological representation is implanted first and the visual representation is assimilated to this form. This would account for the superior recall of phonetic spellings in Experiment 1 and also the greater success of subjects in remembering visual characteristics of words in the first than the second experiment. This possibility awaits further investigation.

DISCUSSION

Nature of Orthographic Images.

Results of the studies reported here all contribute to the claim that orthographic images of words exist and that they are acquired by beginners as they learn to read. Orthographic images are thought to arise from visual experiences with words. They are not special constructions of the mind made out of something not actually seen. Evidence for a purely visual component in word memory comes from the work of McClelland (1976, 1977), Kirsner (1973), and Hintzman and Summers (1973). These studies show that visual properties of words (i.e., whether the print seen is in lower case, upper case, mixed case, or script letters) are stored in memory independent of their phonemic properties.

Rayner and Posnansky (1978) and Posnansky and Rayner (1977) have conducted some tachistoscopic word processing studies with children and adults, and their evidence also supports a visual word storage view. They found that subjects who were shown drawings of common objects or animals printed with word or nonword stimuli were able to name the pictures faster when correct labels were printed on the pictures and also when nonwords were printed which preserved many of the alphabetic visual features of the correct labels (i.e., horse - honre) though facilitation was not as great as with correctly spelled labels.

A very different type of evidence for the existence of orthographic images comes from a study by Brown and McNeill (1966). They induced a "tip of the tongue" state in which adult subjects felt a particular word in mind but were unable to identify the word's pronunciation. Brown and McNeill found that subjects in this state were often able to identify many of the letters in the word (i.e., initial letters were guessed correctly 57% of the time). Sometimes letter identifications prompted retrieval of the word's pronunciation. The fact that letter information was available despite the absence of phonological information suggests that visual forms of words constitute a separate representation in lexical memory. The fact that letter information was connected with semantic information in the absence of pronunciations suggests that the word's phonological form is not an essential mediator of semantic information when a link between print and meaning has been established in memory.

Research reported in this chapter indicates that orthographic images provide beginning readers with fairly complete knowledge of the printed forms of words. Silent as well as pronounced letters in non-initial positions are firmly entrenched in the representations. It is interesting to note that in the picture-word facilitation study by Posnansky and Rayner (1977), the only type of printed label which facilitated picture-naming among their youngest readers (first graders) was the correctly spelled form of the word, not the forms which resembled the shape or boundary letters of the correct label (i.e., apple vs. aggte vs. azzme). In contrast, older readers did display some facilitation with boundary letters and shape cues. This finding for beginning readers appears to conflict with results of some previous studies suggesting that beginning readers process and remember words in terms of boundary letters (Marchbanks & Levin, 1965; Mason & Woodcock, 1973; Rayner & Hagelberg, 1975; Timko, 1970; Williams, Blumberg, & Williams, 1970). In these studies, a delayed recognition task was employed. Subjects were shown a single sequence of letters (e.g., "cug") and then were shown a card with several alternative letter sequences resembling the original form (e.g., cwg, owg, oug, cqn, jun, jqg). They were told to select the one most like the original. Since the correct form was never included on the card, subjects were prevented from displaying accurate memory for visual forms. Thus, it is not clear from these latter studies that beginning readers' memory is limited only to boundary letters.

One rather surprising result obtained in the present studies indicated that silent letters may be more salient than pronounced letters in children's memory for words. A similar result with a proofreading task was found by Frith (1978) and hence this finding cannot be dismissed as a task specific artifact, even though it is difficult to explain.

One reason why some silent letters may be remembered easily is that learners recognize them as an instance of a general lexical pattern characterizing a number of printed words they have already acquired as orthographic images (i.e., long vowel-silent E pattern; short vowel-double consonant patterns; member of a family of words such as light, night, bright, fight). Though the letters themselves do not map into single sounds, in combination with other letters, their relationship to sound is recognized as regular and predictable (Venezky, 1970). Thus, they are easily remembered as an integral part of word spellings.

Another explanation for silent letter memory is that the process of storing visual word forms may be semi-autonomous in the sense that only some of the letters need to be rooted in sound in order for the entire word to enter memory. A few novel letters may be easy to learn when embedded in a familiar or predictable context. As the visual forms of words are seen repeatedly, their shape and length are stored and these characteristics create visual spaces in memory for letters to fill.

A third possibility is that children who are learning new word forms adjust their representation of the sounds in words so as to take account of as many letters as possible in word spellings. This process was suggested in the tri-syllabic study where learners were observed to convert unstressed to stressed syllables so as to create appropriate vowel sounds for the letters. Also, Blumberg and Block (1975) note this strategy in the behavior of their spelling learners who tended to segment graphemes into separate syllable units and to pronounce words as they were spelled rather than spoken even though they could read the words correctly (e.g., "discipline" pronounced /dis/-/ki/-/ plin/). In learning to read words like "February" and "often," learners might even modify the words' pronounciation in their normal speech to legitimize the silent letters.

Functions of Orthographic Images

1. Reading and Spelling

From previous as well as present research, it is apparent that orthographic images are not mere epiphenomena but perform several important cogitive functions. Their main function is to insure correct identification and production of printed words. They thus provide a close link between reading and spelling skills. In place of sound-letter principles which are utilized to generate unknown spellings, visual images can be consulted when the words are familiar printed forms. In the WHEOPLE study, children's spellings resembled the particular orthographic forms they had learned to read. The possession of alphabetic images insures that silent letters are included in spellings and also that the correct orthographic pattern is selected when a number of options are available (e.g., pair, bear, dare, prayer, ere, err). In the case of homonyms, orthographic images which have been amalgamated to word meanings enable readers and writers to distinguish which spelling goes with which meaning (Ehri & Roberts, 1979; Mackworth & Mackworth, 1974; Mackworth, 1975).

2. Verbal Memory

The contribution of orthographic images to verbal memory is indicated by the sound learning studies of Ehri and Wilce (1979). Also, Sales, Haber and Cole (1969) found that adults' short-term memory for six words displaying vowel variations (i.e., hick, heck, hack, hook, hoak, hawk) was better when the words were seen than when they were heard. The mnemonic advantage provided by letters may be twofold. They may offer a more memorable code than sound for preserving unfamiliar words in memory. They may serve to clarify which phonemes are being pronounced if there is any uncertainty.

The mechanism by which spellings may clarify phonemes is that they provide a means of conceptualizing and symbolizing words as sequences of separate sound segments. This function was apparent in the performances of beginning readers observed in a phonetic segmentation task (Ehri & Wilce, 1979). First graders listened to various words and nonwords (e.g., red, grass, pag, kest), estimated how many phonetic segments each contained, then identified the separate segments by pronouncing and marking each with a poker chip. To aid their analyses, several children spontaneously created or thought of word spellings and used these to estimate the number of segments. This strategy was verbalized when children recognized they had overestimated the segments due to the presence of silent letters in their images. Not only "boat" with a silent A but also two nonsense words (/an/and/sot) which subjects imagined as having silent E's at the end were misjudged. The reason why children might find letters helpful is that in speech, phonemes do not exist as separate units but rather fold into each other, with properties of one often determined by the properties of adjacent sounds (Liberman & Shankweiler, 1977; Liberman, Shankweiler, Liberman, Fowler, & Fischer, 1977). By operating with concrete symbols for the sounds, it is easier to think of them as independent units. This conceptualization is very likely essential in learning orthography as a speech mapping system.

3. Pronunciation

Another function of orthographic images, one not commonly recognized, is suggested by Kerek (1976) who shows that orthography can influence the pronunciation of words. Kerek proposes that when people learn how spoken words are spelled, and when spellings are not iconic with sounds (as is the case with many words in English), there is pressure to change pronunciations to enhance the iconic relationship between letter and sound (e.g., "victuals," previously pronounced "vittels"). Of course, the pressure works its effects slowly over time across groups of individuals due to the resistance offered by oral traditions with words. Kerek refers to this as the iconic principle of "one graphic form - one phonetic form" (p. 326). Spellings may serve to block vowel reductions so that letters mapping unstressed schwa sounds become pronounced (i.e., registrar, mentor, thorough, processes, bases, juvenile, genuine). Words which are less common in speech than in print are particularly susceptible to change. For example, H is not pronounced in commonly spoken words such as "hour" and "honest" but is pronounced in words such as "humble" and "homage." Geographical names are pronounced more like spellings by outsiders than by natives, as in Oregon pronounced with unstressed schwa by local folk.

Pressure to change pronunciations may arise when new orthographic images are being formed for words whose spoken forms are less familiar and whose spellings suggest an additional or alternative phoneme. Some evidence for the iconic tendency was detected above in the spelling studies where children were observed to distort pronunciations so as to create relevant sounds for letters in words they were learning to read. Because letters are concrete units with distinct identities in contrast to sounds, they may very well dominate once they become established as symbols.

It is possible that the process of forming orthographic images is instructive for beginning readers who speak a nonstandard dialect of English in which phonemes in words are deleted. As letter symbols for sounds are established in lexical memory, these speakers may learn to include the missing sounds in their word pronunciations. Such changes in speech would be expected if learning to read entails a process of amalgamating letters to phonological segments. Some evidence for this possibility is available. Desberg, Elliott, & Marsh (in press) examined the relationship among reading, spelling, and math achievement scores and dialect radicalism in a group of Black elementary school children. Those who had better command of standard English forms were better readers and spellers than children who did not. In contrast, achievement in math was not related to dialect. This suggests that dialect speakers may very well acquire knowledge of standard English word pronunciations primarily by learning to read and to spell words.

Development of Orthographic Images.

Although the evidence is convincing that children acquire orthographic images of words as they learn to read, it is not so clear how this capability develops. According to amalgamation theory, not one but several subskills are involved and need to be acquired. The high correlations observed between various basic reading skills and scores on the spelling-aided sound learning task (Ehri & Wilce, 1979) indicate this. Some of the relevant subskills confirmed by others as being important predictors or correlates of beginning reading are: familiarity with alphabet letters and knowledge of their names (Bond & Dykstra, 1967; Richek, 1977; Speer & Lamb, 1976); knowledge of the system for deriving sounds from letter sequences (Guthrie & Siefert, 1977; Mason, 1976; Speer & Lamb, 1976; Venezky & Johnson, 1973); phonemic segmentation (Fox & Routh, 1975, 1976; Liberman, 1973; Liberman & Shankweiler, 1977; Liberman et al., 1977).

One type of experience which may contribute to the acquisition of orthographic image-forming skill is practice at inventing spellings. Such experience might promote the acquisition of children's knowledge of orthography as a speech-mapping system. This is suggested by Chomsky (1971, 1977) and Read (1971, 1973) who studied the spellings of pre-schoolers lacking much experience with the orthographic conventions of English. These children were observed to adopt a system for generating their spellings. The letters used to represent sounds were quite consistent and predictable though phonetic distinctions governing their choices were not always those used by an adult. In selecting letters, not acoustic segments but rather articulatory features were monitored. That is, the child paid attention to what his mouth was doing during word pronunciations and he abstracted from dimensions of this sort in choosing his letters. The letters chosen were ones whose names shared some feature with the sound detected in the word (e.g., BOT, GRL, YL (while), HRAN (train)). As the inventor became more familiar with standard spellings, his choices of letters to map sounds became more conventional, and morphemic patterns rather than single letter-sound mappings were adopted (i.e., past tense sound /t/ spelled first as WALKT shifted to the letter D and became WALKD, Read, 1971).

Such inventive spelling experiences might very well help beginning readers acquire some of the component capabilities needed to begin storing orthographic images of words, i.e., capabilities such as

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memory for letter shape, knowledge of letters as symbols for sounds, segmentation of words into phonemes. One possible advantage of introducing readers to the regularities of orthographic speech mapping by having them invent spellings is that they may acquire knowledge of a very flexible system which can be used to generate and justify many alternative word spelling patterns (Ehri, 1979). This may prove particularly valuable in learning to read English, a language which requires the beginner to store and remember conventional spellings which are systematic but highly variant in mapping speech (Venezky, 1970).

Spelling experiences may also enable learners to form more accurate or complete orthographic images, over and above that achieved by learning to read words accurately. Blumberg and Block (1975) found that third through sixth graders who were taught to spell words by writing them before viewing them learned the complete forms faster than children who saw and then wrote the words. Blumberg and Block speculate that the former method was more effective because it induced learners to analyze word spellings more thoroughly, particularly the parts which deviated from phonetic expectations. In another study with fifth-sixth graders, Thompson and Block (1975) found that practice in distinguishing the correct spellings of difficult words was less effective than practice in writing the words.

In summary, this chapter has reviewed and discussed several studies yielding evidence for the operation of orthographic images as they underlie printed word learning and create a close relationship between reading and spelling skills. Findings indicate that orthographic images can be scanned like real words seen in print, that they include all of the letters in a word's spelling, not just boundary letters or letters mapping into sounds, that silent letters may have a special status in these images. Findings suggest that the presence of orthographic images in memory increases the likelihood that the spellings produced by readers resemble single conventional forms rather than phonetic variants. In the acquisition of orthographic images, sound may provide an essential base such that learners are led to create phonological segments for unpronounced letters and unstressed vowels in order that the letters symbolizing these sounds may be implanted and retained in the image. Besides their central role in reading and spelling, orthographic images were shown to have important cognitive functions facilitating verbal memory and affecting the pronunciation of words. The ability to form orthographic images as symbols for sounds was found to emerge during the first two years of reading instruction and was among the capabilities distinguishing beginning readers who had acquired large repertoires of printed words from those who had not. Though promising and provocative, the claims and findings arising from word identity amalgamation theory as well as their implications for reading and spelling instruction are preliminary in need of further investigation.

Chapter 4: The Influence of Orthography on Readers' Conceptualization of Sound Segments in Words

One issue receiving attention in a number of reading acquisition studies is the role of phonemic and syllabic awareness in learning to read words printed in alphabetic orthography. Results of several studies have indicated that awareness of sound segments in words is a prerequisite or at least a facilitator of printed word learning (Ehri, 1979; Fox & Routh, 1975, 1976; Golinkoff, 1978; Liberman, 1973; Liberman, Shankweiler, Liberman, Fowler, & Fischer, 1977; Rosner, 1974). The present study was intended to show that enhanced phonemic and syllabic awareness is also a consequence of learning to read words. This study was conceived as a means of gaining additional evidence for a theory of printed word learning, referred to as word identity amalgamation theory, in which sound structure awareness is regarded as central to the process of storing the orthographic representations of words in lexical memory (Ehri, 1978, in press-a, in press-b, Ehri & Wilce, 1979; Ehri and Roberts, 1979). To understand the role of sound awareness and the rationale for this study, a brief summary of the theory is presented.

According to amalgamation theory, the major task facing beginning readers is learning how to incorporate printed language into their existing knowledge of spoken language. In English, the primary unit of printed language is the <u>word</u>, so it is at a lexical level that the most important learning takes place. The lexicon is viewed as consisting of abstract word units having several different identities: <u>phonological</u> identities (how words sound and are articulated); <u>syntactic</u> identities (grammatical roles in sentences); and <u>semantic</u> identities (meanings). In the course of learning to read, another identity is added to the lexicon: an <u>orthographic</u> image of the word. The term amalgamation refers to processes by which the orthographic identity is combined with the other identities to form a single integrated unit in lexical memory. Orthographic forms get amalgamated with phonological identities when letters are processed as symbols for sounds. Orthographic identities become amalgamated with syntactic and semantic identities when printed words are read and given meaningful interpretations in sentence contexts. As a result of these experiences, orthographic images are established in lexical memory as symbols for meanings as well as sounds.

The focus of the present study was upon the print-sound amalgamation process. According to the theory, orthographic images are stored not as rotely memorized visual figures but as sequences of letters bearing systematic relationships to acoustic and/or articulatory segments already stored in lexical memory as the word's phonological identity. The first few times a printed word is seen, its component letters either singly or in combination are recognized and processed as symbols for component sounds within that word, the letters are glued onto the word's sound structure in memory, an orthographic image is formed, and it becomes a visual symbol for the word. To the extent that individual letters within a word are grounded in sound, a clear orthographic representation is formed which can be used for reading printed words accurately and rapidly and also for producing correct spellings.

Our previous studies exploring the adequacy of this theory led us to the present study. In one series of experiments (Ehri & Wilce, 1979), we gave a nonsense-sound learning task to beginning readers and found that memory for the sounds was boosted when relevant letters symbolizing those sounds were provided as mnemonics. We also found that the ability to profit from letters in remembering sounds was highly correlated with the size of beginning readers' repertoire of printed words, suggesting that this letter storage process may underlie memory for the printed forms of words. In studying the characteristics of orthographic images (Ehri, in press-a, in press-b), we found that silent letters as well as pronounced letters were retained and represented in memory.

The present study grew out of an interest in whether memory for some silent or nondistinctively pronounced letters might be accounted for by print-sound amalgamation processes. Based on our theory, we reasoned that when people learn the printed forms of words, this experience may cause them to think differently about these words than people who have not learned the printed forms. Specifically, as people engage in studying letters in a word's spelling, processing the letters as sound symbols, and forming letter-sound amalgams, they may acquire a new conceptualization of the word's sound structure, particularly if the spelling includes letters symbolizing additional or different sounds than are apparent or typically included in pronunciations. For example, learning orthographic forms of the words "match" (pronounced "mach") and "interesting" (pronounced "intresting") may cause readers to re-conceptualize the sound structures of these words to include the extra phoneme "t" and the extra syllable "er," respectively. If amalgamation theory is correct, if letters are retained in memory by being processed as sound symbols, then acquisition of spellings containing such extra letters should alter the reader's view of the word's sound structure.

Two experiments were conducted to gather evidence for this possibility. In the first experiment, fourth graders segmented words which had potential extra sounds into syllables or phonemes. This was in order to assess their conceptualizations of the sound structures of these words. Then they spelled the words. This was to determine whether they were aware of the extra letters in the words' orthographic forms. Target words chosen for their syllabic structure all contained extra syllables in their spellings (i.e., cam<u>e</u>ra, gen<u>e</u>ral). Target words chosen for their phonemic properties had extra letters corresponding to potential articulatory segments (e.g., ca<u>t</u>ch, ba<u>d</u>ge, com<u>b</u>), and these were matched to another set of words having parallel pronunciations but lacking these extra letters (e.g., much, page, home).

Based on amalgamation theory, two predictions were formulated. In the syllable segmentation task, it was expected that whether or not an extra syllable was detected would depend upon whether the child had learned the word's orthographic form. In the phonemic segmentation task, it was expected that, among children who knew the spellings of words, extra segments would be detected in words whose orthographic identities included letters symbolizing those segments but omitted in words lacking these letter symbols.

Experiment 1

Subjects. The subjects were 24 fourth graders, 11 males, 13 females, mean age 9 years 7 months, all enrolled in a middle class elementary school in Northern California.

Materials. Words whose spellings contained one more syllable than their typical pronunciations were selected to study the effect of print on syllabic awareness. The following list of target words was employed: different (pronounced "diffrent"), comfortable ("comfterbul"), decimal ("desmal"), several ("sevral"), interesting ("intresting"), general ("genral"), temperature ("tempature" or "tempertue"), valuable ("valyable"), camera ("camra"), miserable ("misrable" or "miserble"), family ("famly").

Words selected to study the effect of print upon phoneme awareness are listed in Table 4-1 along with a set of control words selected because their pronunciations were parallel to the target words yet their spellings lacked the extra letters suggesting an additional phoneme.

Insert Table 4-1 about here.

Filler words were mixed in with the target words in the segmentation tasks to obscure the presence of any pattern and to prevent the formation of a response set. Fillers in the syllable task were: balloon, alligator, dictionary, chimney, everybody, flowers. Fillers in the phonemic task were: up, soft, all, milk, skunk, glad, on, must.

Procedures. Children were tested individually on two occasions. In the first session, they segmented words syllabically and then spelled these words. In the second session, they segmented words phonemically and then spelled them.

In the syllable segmentation task, children were first taught how to break words apart into syllables with four examples (television, teacher, bicycle, telephone). Segmentation entailed positioning chips in a row, one for each syllable as children pronounced it separately.

Table 4-1

List of Extra-Letter and Control Word Pairs, Frequency that Extra Phonemes Were Detected (Phonemic Segmentation Task) and Frequency of Correct Word Spellings

(Maximum = 24 subjects per word)

Word Pairs		Phoneme Detection		Spellings	
Extra-Letter	Control	Extra-Letter	Control	Extra-Letter	Control
catch	much	15	1	19	24
new	do	18	0	24	24
can you	menu	19	0	24	20
own	old	12	0	19	24
comb	home	6	0	20	24
badge	page	13	0	17	24
pitch	rich	13	3	18	24
empty	--	12	-	13	--
	Means	13.5	0.6	19.3	23.4

Then they segmented 11 target words mixed with with 6 filler words, all containing 2-4 syllables. Before segmenting, children heard the word pronounced by the experimenter, once in isolation, once in a meaningful sentence, and they repeated it. At the end of the task, subjects wrote out the target words. The experimenter avoided pronouncing the words slowly and deliberately so that the extra syllables would not be obvious in her speech.

In the phonemic segmentation task, subjects practiced analyzing the following sounds correctly into phonemic segments: a, as, has; ip, sip, stip, strip; oy, boy, boyk; en, end, rend, frend. After this training exercise, they were given 23 words (2-5 phonemes in length) to segment. Subjects heard each word in a sentence, repeated the word, then positioned chips in a row as they vocalized each segment. The experimenter asked whether they could find any more sounds until the subject said "No." After the segmentation task, subjects wrote out the target words.

Results

To assess whether children's conceptualization of the syllabic structure of words was related to their knowledge of word spellings, response contingencies were counted. Results are reported in Table 4-2. A chi square test of independence was significant, with chi square = 45.27 $p < .01$, indicating

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Insert Table 4-2 about here.

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that segmentation responses were not independent of spelling knowledge. As expected, children were more apt to include extra syllables in their segmentations if they were familiar with the spellings of the words. If they did not know the spellings, then they were not likely to regard the syllables as present in the spoken forms.

To verify the pattern for each of the 11 words, the proportion of extra syllables detected in the segmentation task was calculated separately for correct spellings and for incorrect spellings of the words. These results are presented in Table 4-3. It is apparent that some of the words were spelled correctly by very few subjects, hence differences in percentages for these words should be viewed more cautiously. Even with this limitation in mind, it is still striking that for all words but one ("several"), a greater proportion of syllables was detected for words spelled correctly than incorrectly.

Insert Table 4-3 about here.

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Table 4-2

Number of Responses as a Function of Whether Extra Syllables Were Detected or Omitted in the Segmentation Task and Whether Spellings Were Written Correctly or Incorrectly[a]

		Spelling		
		Known	Unknown	Total
Syllable	Detected	61	39	100
	Omitted	33	131	164
	Total	94	170	264

[a]Responses summed over 24 subjects, each given 11 words to segment

Table 4-3

Proportion of Extra Syllables Detected in the Segmentation Task

When Words Were Spelled Correctly and Incorrectly

Extra-Syllable Words	Proportion of Syllables Detected For: Correct Spellings*	Incorrect Spellings*	Difference
different	57% (14)	20% (10)	37%
comfortable	100% (7)	3[illegible] (17)	65%
decimal	100% (1)	39% (23)	61%
several	38% (8)	44% (16)	-6%
interesting	92% (13)	45% (11)	47%
general	57% (7)	35% (17)	22%
temperature	100% (2)	0% (22)	100%
valuable	50% (4)	0% (20)	50%
camera	50% (12)	25% (12)	25%
miserable	100% (3)	5% (21)	95%
family	56% (23)	0% (1)	56%
Mean	80% (8.5)	25% (15.4)	

*Number of spellings given in parentheses (max = 24)

To assess the influence of orthography in the phonemic segmentation task, the number of times an extra sound was detected in the segmentations of target words was counted and compared across pairs. As evident in Table 4-1, sounds were discovered frequently in words whose spellings included a letter for that sound but were almost never detected in words whose pronunciations were parallel but whose spellings lacked the letter.

Children were able to spell most of the phoneme target words. However, there were some misspellings. To determine whether subjects were less apt to detect an extra segment if they did not know that the extra letter was present in the word's spelling, the number of these cases was counted. There were 31 misspellings in which the extra letter was omitted. In 77% of these, the extra sound was also not detected in the segmentation task. (If "empty" is excluded from this analysis, the percentage jumps to 90%.) This suggests that it is when children acquire orthographic symbols that they become aware of additional phonemes in the pronunciations of words.

From Table 4-1, it is clear that not all letters were equally apt to persuade subjects of the existence of an additional sound in the word. For example, the letter B at the end of "comb" was not often regarded as symbolizing a sound even though it was spelled accurately.

It was evident from subjects' comments in the phoneme task that spellings were influencing their segmentations. Some remarked about their uncertainty whether you could really hear the B in comb or the T in pitch. However, it was not the case that spellings were the sole basis for segmentations. Only a couple subjects allocated chips for silent E and for C and H separately. Most children ignored truly silent letters and they created only one sound in segmenting words spelled with consonant digraphs such as CH.

Discussion

These results supported predictions that subjects' conceptualizations of the syllabic and phonemic segments in words would be influenced by their knowledge of the orthographic forms of the words. However, some limitations of the data need to be mentioned. The index used in the case of syllables (Tables 4-2 & 4-3) was the total number of responses summed over subjects. Since this violates one assumption of the Chi-square test (i.e., independence among observations), its results are merely suggestive. Also, target words used in the syllable task were more difficult to spell and there were many more incorrect spellings than in the phoneme task. Thus, subjects who knew how to spell few words contributed little to differential performance patterns. It may be that the relationship between orthographic knowledge and syllable conceptualizations holds mainly for better spellers. This possibility is suggested by other findings (Frith, 1978; 1979) and needs further study.

Although a causal inference was desired, findings of Experiment 1 demonstrated only that a correlation exists between orthographic knowledge of words and conceptualization of their sound structure. The phoneme words explored in Experiment 1 were learned outside the laboratory, and so it is not clear that subjects' sound structure conceptualizations were acquired from reading the words rather than from some other experience. Also, the experimental and control phoneme words were similar but not identical in pronunciation. A second experiment was conducted to show that phoneme conceptualizations arise specifically out of reading experiences with words and that, for identically pronounced words, the way readers conceptualize their sound structure depends upon which sounds they see symbolized in the words' spellings.

Experiment 2

Subjects. Middle class, Northern California fourth graders were selected, 10 males, 14 females, mean age 116 months.

Materials. Five nonsense words, each with two spellings were created as names for pictures of animals (i.e., elephant, duck, cow, snake, pig). One spelling included an extra letter which corresponded to a potential sound in the word. The other spelling lacked this extra letter. Pronunciations were identical for pair members. The pairs (extra letters underlined) were: banyu - banu; drowl - drol; simpty - simty; tadge - taj; zitch - zich.

Procedures. Subjects were matched on the basis of similar printed word reading scores on a list of 84 words taken from Calfee & Calfee's (1977) Interactive Reading Assessment System. One member of each pair learned the set of names spelled with the extra letter, the other member learned the control set. Children were tested individually. On one day, they were given the word recognition test. On a subsequent day, they completed three tasks ordered as follows: word learning, phonemic segmentation, spelling.

In the word learning task, children practiced reading the five names printed alongside pictures of animals for a minimum of three trials or till they performed perfectly. Then they were shown the names alone and asked to recall the associated animals to a criterion of one perfect trial. Then they were shown the animal pictures and tried to recall the names for a minimum of three trials or one perfect trial.

In the phonemic segmentation task, first the experimenter demonstrated phonemic segmentation with an example and had children practice on the following sounds to a criterion of one perfect segmentation: a, as, has, ti, tin, stin, stindy. Children repeated each sound, then divided it into segments by lining up counters to identify each phoneme as they pronounced it. Then they were reminded of the animals, shown each picture but not the print, and asked to segment its name which was pronounced by the experimenter.

After this, their memory for the orthographic forms of the names was checked by having them write out the spellings.

Results

Before results of the phonemic segmentation task are presented, it is necessary to consider the adequacy of subjects' preparation for this task. To verify that pairs of experimental and control subjects were equivalent in their word reading ability, a matched-pair t-test was conducted on their printed word recognition scores on the Calfee test. The mean number of correctly read words was 64.2 for the extra-letter group, 64.4 for the control group, $t(11) = 0.22$, $p > .05$.

Nevertheless, the extra-letter subjects took significantly fewer trials than the control subjects in learning to read the animal names to a criterion of one perfect trial: $\bar{X} = 2.3$ trials vs. 3.5 trials, $t(11) = 2.88$, $p < .05$. In order to account for this difference, the types of errors made by the two groups in pronouncing the words during the learning trials were compared. For three words, the presence of extra letters appeared to reduce the frequency of mispronunciations. Children who learned to read "banu" omitted the /y/ sound 14 times in their pronunciations, whereas this omission occurred only four times with "banyu." The CH sound in "zich" was erroneously pronounced /k/ or /θ/ four times while this error never occurred with "zitch." With "taj," mispronunciations of the vowel occurred seven times and /j/ two times, whereas only three vowel errors occurred with "tadge," a form in which DG functions as a marker to shorten the preceding vowel, according to Venezky (1970). These results suggest that extra letters in word spellings may reduce the time needed to learn printed words, either because they help learners decode the words more accurately and/or because they improve learners' memories for correct pronunciations. One exception to this generalization did occur, indicating that extra letters may not always serve this function. The presence of an extra W in "drowl" (a rhyme of "bowl") prompted more vowel mispronunciations (i.e., rhymes of "towel" and "fool") than "drol" (i.e., 7 vs. 2 errors).

Despite some initial decoding inaccuracies, all subjects in both groups were able to reach criterion in learning the nonsense names. That they had stored the words in memory was apparent from performances on the spelling task where the mean numbers spelled correctly (maximum = 5) were high and equivalent, $\bar{X} = 4.2$ for the extra-letter group, 4.5 for the control group, $t(11) = 1.75$, $p > .05$. Among the spellings produced, the extra letter was included in 89% of the extra-letter subjects' productions and was omitted in 93% of the control subjects' spellings. These data confirm that most of the orthographic forms were successfully stored in memory and available for use in the segmentation task.

Of primary interest were the phonemic segmentations of extra-letter and control subjects. Results offered unanimous support for the hypothesis. Extra letters were distinguished as separate phonemic segments almost exclusively by subjects who learned these spellings. Whereas all of the extraletter subjects included between 2 and 5 extra-letter sounds in their segmentations, only two out of 12 control subjects found any extra sounds, and only one apiece. A matched-pair t-test was highly significant, $t(11) = 7.83$, $p < .01$. The mean numbers of segments detected by the two groups were 2.9 for extra letter subjects, 0.2 for control subjects (maximum = 5 segments). These findings indicate that the visual forms of words acquired from reading experienced serve to shape learners' conceptualizations of the phoneme segments in those words.

Inspection of segmentations revealed that some words were more apt to provoke extra-letter segments than others. The proportion of subjects out of 12 who detected an extra segment in each of the following words was: tadge (83%), zitch (83%), simpty (58%), banyu (33%), drowl (33%). These proportions differ somewhat from those observed in Experiment 1 with parallel word forms (i.e., badge 54%, pitch 54%, empty 50%, can you 79%, own 50%). Two differences between the experiments might account for some of the variation. Subjects in Experiment 1 were less accurate in their spellings than subjects in Experiment 2. Also, they had not been exposed to the spellings just prior to the segmentation task. Although individual spellings and individual subjects may introduce variability into the process, nevertheless present data make it clear that the process does operate.

Discussion

Hypotheses received clearcut support in the two experiments. Readers' conceptualizations of the sound structure of words did appear to be influenced by their knowledge of word spellings. When given the task of segmenting words into syllables, children were more apt to detect extra syllables if they knew that the words' spellings included letters symbolizing these extra sounds. In segmenting by phonemes, whether children detected an extra segment depended upon whether spellings of the words contained extra letters symbolizing these phonemes. The influence of spellings on phonemic segmentation was evident with both real words learned outside the laboratory and nonsense words taught to subjects in Experiment 2.

The importance of syllabic and phonological awareness as a prerequisite in learning to read words has been recognized by several researchers (Ehri, 1979; Fox & Routh, 1975, 1976; Gleitman & Rozin, 1973, 1977; Goldstein, 1976; Golinkoff, 1978; Liberman, 1973; Liberman, Shankweiler, Liberman, Fowler, & Fischer, 1977; Rosner, 1974; Rozin & Gleitman, 1977). The present study extends these findings by showing that syllabic and phonemic awareness is also a consequence of printed word learning. According to amalgamation theory, the relationship is best characterized as a two-way interactive process. Readers need to be able to analyze words into sounds so as to recognize what segments there are to be symbolized in print. Correspondingly, when they look at the printed forms of words, they need to be able to justify the presence of letters by finding sounds in the word for them to symbolize. Their skill in doing this depends upon the extent of their general knowledge of orthographic speech-mapping patterns (i.e., knowing which letters can be silent, which combine with others to symbolize sound, etc.). It also depends upon their ability to analyze and possibly modify the word's sound structure to take account of unexpected letters. This reciprocal processing of letter-sound relationships is thought to be necessary in order for letters to enter memory and form orthographic images which are grounded in sound. Present findings contribute support to this picture of printed word learning by indicating that orthography does leave its mark on the reader's conceptualization of the sound structure of words, very possibly in the way portrayed by the theory.

Of course, word learning processes explored in the present study do not explain how all letters get stored in lexical memory. Clearly there are limitations on the extent that pronunciations of words can be conceptualized to include a sound for every letter. In the present study, letters having potential correlates in sound were examined. Truly silent letters represent another class of letters which are very likely remembered in other ways, possibly by recognizing their functional role as markers affecting the sounds of other letters (i.e., silent E's, double consonants) (Venezky, 1970), or as part of a letter cluster which as a whole symbolizes a typical sound or blend of sounds (i.e., ghost, talk, light, cough, ache, debt, amateur, autumn, guess, honest, know, sign), or as a purely visual figure occupying space in the orthographic image but lacking any root in sound (i.e., business, island, castle, dahlia, hemmorhage, Wednesday, awkward, answer, Lincoln). Factors influencing memory for letters which are not grounded in a single sound might be how frequently the words have been seen, and whether the reader has seen enough different lexical instances to induce the spelling pattern as a general visual form or as a letter cluster mapping speech. These processes await study.

Other researchers have identified changes effected by orthography on readers' awareness of sounds in words. Studies of preschoolers' invented spellings (Read, 1971, 1973) reveal that children may classify sounds in unconventional ways until they learn more about standard letter-sound relationships and word spellings. For example, prereaders may treat the affrication at the beginnings of words such as "train" and "chair" as the same single sound (spelled with an H), whereas first graders who have learned about conventional print regard the initial sound in "train" as more like "teddy" than like "chair," and they analyze "tr" as two rather than one sound. Other shifts occurring in the conceptualization of sounds which may be provoked by experience with print are: aveolar flaps perceived by the prereader as D ("dirty" spelled DERDY) shifting to T; preconsonantal nasals which may not be distinguished as separate sound segments ("sink" spelled SIC) prior to contact with conventional spellings; verb inflections perceived phonetically at the outset (WALKT) but shifting to a morphophonemic basis (WALKD) with print experience. Liberman, Liberman, Mattingly, and Shankweiler (1980) describe data of a different sort indicating that learning to read stimulates phonological development. They cite an unpublished study by Morais, Cary, Alegria, and Bertelson in which the phonological segmentation capabilities of matched groups of literate and illiterate adults in Portugal were compared. Whereas the literates passed the test, the illiterates did not. It may be that conceptualization of words as comprised of phoneme segments requires knowing about letters as sound symbols and having such visual models available in memory.

Results of the present study suggest that acquisition of spellings may alter the way readers perceive those words as being pronounced, particularly if there is a discrepancy between the spellings and their typical pronunciations. This possibility carries some interesting implications regarding the impact of reading acquisition on language learning. It is commonly believed that Black English (BE) speaking children learn Standard English (SE) word pronunciations by listening to SE speakers. However, an equally important experience may be learning to read and spell words. This may be one of the primary ways that BE speaking children learn which consonants are missing from the endings of words in their speech (i.e., morphological endings such as past tense, plurals, final /l/, /t/, /d/, /r/) (Labov, 1967). When they learn to process letters as sound symbols and to store printed words in memory, the need to justify extra letters may cause them to reconceptualize the sound structure to include these letters. This process may be facilitated by the presence of SE models to reinforce these print-based pronunciations.

Some correlational evidence in support of this possibility is offered by Desberg, Elliott, and Marsh (1980) who examined the relationship among reading, spelling, and math achievement scores and dialect radicalism in a group of Black elementary school children. Those who had better command of SE forms were better readers and spellers than those who did not. In contrast, achievement in math was not related to dialect. Though this evidence falls short of indicating a causal relationship, it does suggest that dialect speakers may acquire knowledge of SE word pronunciations by learning to read and spell words. More evidence is needed on this possibility.

The impact of print upon pronunciations may not be limited to nonstandard dialect speakers. It may be that the process of learning to read and spell words teaches all readers a new literary English dialect reflecting the visible phonology and syntax characterizing printed forms. Word pronunciations such as those entailing extra syllables in the present study may be examples of forms unique to this dialect. The possibility that learning to read equips the speaker with such a dialect explains a curious phenomenon, described by Goodman and Buck (1973) who listened to several proficient BE speaking children read a text aloud and then retell the story from memory. Whereas the readers showed no dialect miscues in the reading task, they displayed much dialect involvement during their retelling immediately afterwards. The reason why speakers may be able to read text without their spoken dialects is that print activates its own set of pronunciations, those which were created when the words' spellings were formed in memory and amalgamated to sounds. Though intriguing, this extension of present findings, is speculative and in need of further study.

The idea that word spellings provide an alternative, psychologically compelling model for sound and that they compete with pronunciations in speech when the two differ has been proposed by Kerek (1976). However the consequence he suggests is not that the two co-exist but rather that pronunciations mapped in print may drive out and replace spoken forms. He proposes the iconic principle of "one graphic form - one phonetic form" (p. 326). According to this principle, when orthography is discrepant with speech, there is pressure to change pronunciations so as to maximize the iconic relationship. Kerek cites several examples of historical shifts in pronunciation which conform to orthographic patterns, for example "victuals" which used to be pronounced "vittels." Although Kerek may be right about orthography creating pressure, whether or not spellings take over in speech will very likely depend upon whether competing spoken forms have a strong oral tradition and also whether the community of speakers tends to be literate or illiterate.

In sum, this discussion makes it apparent that study of the impact of orthography and learning to read upon speech production as well as linguistic and metalinguistic development offers many interesting possibilities for future research.

Chapter 5: Effects of Image Training on Printed Word Learning in Children

The purpose of this study was to compare the benefits of two types of practice on what children learn about printed words. The practice procedures were designed to test whether the kinds of learning experiences regarded as central by word identity amalgamation theory might indeed prove more beneficial in learning to pronounce and to spell words. According to Ehri's theory, the process of learning to read and to spell words entails storing the printed forms as visual letter-analyzed images in lexical memory. Letters are thought to enter memory not in a rote fashion but rather by being recognized as symbols for sound segments detected in the word's pronunciation. The study reported here was intended to determine whether explicit instruction and practice in the formation and storage of orthographic images might enhance children's ability to read and spell those words.

Recent studies (Paivio, 1969, 1971; Shepard, 1978; Kosslyn & Pomerantz, 1977) have provided clear evidence that most people have the capability of forming mental images which they claim to "see" inside their heads. Although using pictures or objects rather than printed words as stimuli, this research has indicated that images may be effectively utilized as mnemonic devices for retrieving items from memory. Such findings seem to hold particularly firm for items which are predominantly visual in their original form.

While supporting evidence for orthographic images is relatively recent, the general concept has been a part of reading theory for some time. In an early study on the relationship between reading and spelling, Kottmeyer (1952) noted that children taught to read by the "look-say" method of instruction were able to accurately write out words which they had learned to read but had not practiced spelling. He reasoned that the children had somehow formed mental images of the words while they were reading and that this visualization was later called upon for reference when it became necessary to produce spellings for the words. Mackworth and Mackworth (1974) have postulated that differences in scores between good and poor readers on a task of spelling judgment are due to better readers' skill in using a clear internal image of the word as a "match" for the test words. More recently, Simon and Simon (1973) and Simon (1976) have attempted to explain the spelling production activities of children in terms of specific visual images which are said to provide varying degrees of information needed to write words. According to Simon (1976), these images may be complete or incomplete depending upon previous experience in reading and writing the words. In addition, complete motor representations may also be present in memory for words which have been written many times.

The above conjectures concerning visual word images have arisen primarily in the context of studies on spelling and have not been assigned a role in any theory of reading. No attempt has been made to

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determine the stage at which visual images emerge as useful tools for young readers. Nor have efforts been directed toward noting the relationship, if any, between visual images and overall reading ability. These questions have been considered by Ehri who has postulated that orthographic images are the major source of information for rapid word recognition as well as correct spelling production. Her first attempts to provide evidence for this theory sought to verify that beginning readers possessed the ability to form orthographic images functioning as mnemonic devices for word storage. These studies also sought to determine the point at which imaging ability became operant. Findings (Ehri & Wilce, 1979) indicated that childrens' memory for CVC nonsense sounds was improved when they were shown letters symbolizing those sounds during study trials. Ehri interprets results as indicating that orthographic images play a central role. She argues that spellings were used by children to form orthographic images which were then stored in memory and recalled during the test phase. Whereas only some first graders were able to benefit from letters in learning sounds, most second graders found the spellings useful. This suggest that the ability to utilize orthography as a mnemonic device emerges somewhere between the first and second year of reading instruction.

In order to confirm the hypothesis that the children were actually forming orthographic images and subsequently retrieving them from memory, an additional experiment was undertaken in which specific instructions to imagine spellings was given to one experimental group. The children in this condition listened to a CVC pseudoword spelled orally and were instructed to make an image of it in their heads. Control subjects merely pronounced the words twice. It was reasoned that if spellings facilitate recall because they provide orthographic images to be stored in memory, then performance should be better when the children are told to imagine the spellings. This prediction was confirmed.

Further studies in image recall and spelling production have provided additional evidence that children acquire images of the orthographic properties of familiar words, images which include silent letters and irregularities in spelling (Ehri & Wilce, 1979; Ehri & Roberts, 1979).

The present study was designed to investigate the role which specific instruction might play in fostering the formation of orthographic images in beginning (second grade) readers, particularly readers of average and low ability, and to examine which aspects of word knowledge might benefit from this instruction.

Second graders (spring semester) were selected as subjects. Results of several pretests were used to form matched pairs and to distinguish three reader ability levels (i.e., high, average, low). Two types of training procedures were devised, one in which subjects practiced imagining the spellings of printed words, another in which subjects merely looked at spellings but never consulted their memories for information about the words. Pair members were assigned randomly, one to the experimental (image training) group, one to the control group. Prior to the word training sessions, all subjects were taught to pronounce and identify the meanings of ten printed nonsense words. Nonsense words were chosen because it was impossible to locate appropriate real words unknown to all subjects. In teaching the children to recognize the words, an attempt was made to approximate the lexical condition which a child might normally encounter in adding a novel word to his vocabulary. All of the words were taught as nouns labeling unusual pictured objects or creatures (i.e., a scarthop was a plant which grew tools instead of flowers.)

During the training sessions, experimental children practiced forming and consulting orthographic images of the words. Control subjects performed similar operations but always with the printed forms in full view. Three word learning tasks each requiring a different type of letter analysis were designed to direct subjects' attention to orthographic details of the target words. For experimental subjects, the first analysis task entailed locating the positions of letters on a tagboard strip according to the position of the sounds they symbolized in the words. This procedure was intended to help subjects amalgamate letters and letter patterns to sounds. In the second task, experimental subjects were required to consult an image of the word in order to answer questions about the presence or absence of specific letters. This procedure was intended to help them detect and correct unclear visual components of the image. The third analysis task required experimental subjects to unscramble the letters of each word to produce its correct spelling. This focused attention upon the sequencing of component letters. Control subjects performed the same tasks but were required to look at the word on a card rather than consult their memories in order to position letters or answer questions correctly.

At one and five day intervals following the training sessions, various posttests were administerd to measure subjects' knowledge of the various identities of target words: accuracy and speed of pronunciations; spellings; meanings. It was expected that children given image training would acquire more complete knowledge of the orthographic details of words than control subjects since they practiced committing letters to memory. In addition, because their orthographic knowledge would be more complete, experimental subjects were expected to decode words more accurately and rapidly than control subjects, particularly on a delayed recall task. According to amalgamation theory, words whose spellings are more completely amalgamated to their sounds should be faster to pronounce. Evidence for this is suggested by Frith (1978) who found that , in a sample of good sixth grade readers, those who were also good spellers were faster at decoding familiar words than those who were poor spellers.

Since the word training procedures were not designed to influence semantic acquisition processes, experimental and control subjects were not expected to differ in their knowledge of word meanings.

Finally, it was expected that instruction would exert a bigger impact upon the word knowledge of poorer readers. Since good readers are more likely to engage in effective learning activities (i.e., image storing processes) spontaneously than poor readers, the benefits of image training were expected to be more substantial among the poorer readers.

Some questions of lesser importance were also addressed in the present study. Performances of the three reader ability groups were compared in the various tasks to determine which word learning skills might best differentiate the groups. The order in which two posttests were administered was counterbalanced across subjects to determine whether prior completion of one might contaminate perform- ance in the other. This information was considered useful in the design of future studies. Since children's knowledge and skill in learning several different aspects of printed words were measured in the present study (i.e., decoding accuracy and speed, trials to learn pronunciations and meanings, spelling production and recognition, memory for word meanings), correlations among the various measures were examined to determine which skills might be more closely related and interdependent.

METHOD

Subjects

Fifty-four second graders, 27 males and 27 females, mean age 7 years, 9 months, were utilized as subjects. The children were taken from four classrooms in an upper middle class school. The study was conducted in the Spring.

Matched pairs of subjects were formed using three pre-test measures: a general word recognition task, a portion of the Wide Range Achievement Test, and the Reading and Language sub-tests of the CTBS which had been administered by school personnel the previous May. Members of each pair were randomly assigned to the experimental and control groups.

Materials and Procedures

The experimenter worked with each child individually on five occasions. During the first session, five pretests were given to measure various aspects of the child's knowledge of printed language. During three word training sessions, each child was taught to decode and understand the meanings of ten nonsense words: owumbly, moaple, croolark, bischa, ploinder, scarthop, teagic, ghirb, druffant, rostinvam. Experimental subjects were then given additional training in letter sounds and letter locations using techniques designed to accentuate and improve visual images of the words. Control subjects were taken through tasks which were comparable except in image formation procedures. In the final session several post-tests were administered to measure the effects of training.

Pre-Tests

California Test of Basic Skills (CTBS). The most recent Reading and Language sub-test scores available were those given to subjects by teachers at the completion of their first grade year. Scores were not available for 12 new students. The experimenter noted grade equivalents for each child's Reading and Language sub-tests and averaged them to provide a single Reading/Language equivalent (i.e., Reading 2.2, Language 1.8, Average = 2.0).

Word Identification and WRAT. Each child was asked to read aloud 130 words varying in difficulty. Forty-three of these words were randomly selected from the Dolch Basic Sight Word Test and 42 words were taken from the Johnson List of Second-Grade and Residual Words. The remaining 45 words were drawn from the Wide Range Achievement Test (WRAT), Level 1 Word Recognition sub-test, grade equivalents 1.0 - 6.1 inclusive. The words were typed on white 3 x 5 inch cards and placed in a small ring binder. The child was allowed to turn the cards and to proceed at his own rate. Instruction was given to skip words not immediately recognized and to avoid lengthy "sounding out" of any word.

Decoding Nonsense Target Words. Subjects were shown the 10 nonsense words which would later be used in training and they attempted to create pronunciations for each. The words were typed individually on 3 x 5 inch cards and presented in a small ring binder. Students were allowed to proceed at their own pace, told not to skip any words and encouraged to "sound out" if necessary.

Oral Spelling. Children were asked to listen to a tape recording in which the experimenter spelled but did not pronounce 12 real words varying in length from 3-6 letters. The words were taken from the Word Recognition pre-test previously described. Pilot testing in a comparable population indicated that these words should have been easily recognized in print by most of the subjects. To check on this, performances in the word identification task were inspected. Results revealed that only 3% of the word readings were incorrect, all errors coming from the low ability readers.

The words were: green, little, them, saw, black, show, who, close, best, please, eat, better. Children were instructed to listen to each oral spelling and to try and write it in their heads as they listened. As soon as the word was recognized, subjects said it aloud. Ten seconds were allowed to identify each spelling.

Spelling. The same 12 words used in the Oral Spelling pre-test were pronounced and the child was asked to write each one. Spellings were scored on two levels, the overall correctness of the word and its correct length (i.e., who spelled woh would be incorrect in overall spelling but correct in that it contained three letters, better spelled beter would be incorrect in both instances.)

Training

All training sessions were made up of two distinct phases, a preliminary word learning phase which was conducted identically for both experimental and control subjects, followed by an experimentally manipulated word analysis phase. In the latter phase, experimental subjects were given instruction in how to form visual images and were asked to perform three analysis tasks requiring the use of those images. Control subjects performed the same analysis tasks but were given no instruction in forming visual images. They performed the three tasks while looking at a card displaying the printed word. Training sessions were spread over 3 days with four words being taught on the first day, three words on the second day and three words on the third day, for a total of ten words. For each word set taught on each day, preliminary word identification preceded the three analysis tasks. At the end of the second and the third training sessions, the previously learned words were reviewed.

Preliminary Word Identification Learning. Nonsense words were chosen as targets for training. However, it was desirable that the children treat these words as if they were real thus allowing the analysis tasks to more closely approximate conditions which might be found in actual word learning. To do this, the children were taught to read each nonsense word and to provide a meaning for it prior to the analytic phase of training.

At the beginning of each session the experimenter presented the children with the three or four words to be learned that day. The words were shown individually, printed in the lower portion of a 5 x 7 inch card. A distinctive and unusual object or animal was chosen as the meaning for each word, and a picture of this figure was drawn in the upper portion of the card. These pictures are illustrated in Figure 5-1. Names for the pictures and definitions were as follows: druffant - a cat with five tails; ploinder - a book that talks; ghirb - a two-headed pig with clothes; teagic - a creature from outer space with a horn nose; croolark - a hat for rabbits; owumbly - a flying hippopotamus; rostinvam - a ladder with hands and feet; moaple - a car with an umbrella; bischa - a cow with three eyes; scarthop - a plant that grows tools.

Insert Figure 5-1 about here.

On the first trial, the children were told how to pronounce the word and were given an oral description of the picture. To verify pronunciation and understanding, the experimenter had the subjects repeat both the word and its meaning. On subsequent trials, subjects were shown the printed words alone and asked to recall their pronunciations and meanings. The experimenter corrected any errors or omissions but not until after the child had attempted to recall both responses. The picture cards were shown following each response on the first recall trial. On subsequent trials, corrections were made orally. Four different word orders were employed across trials. Each child was taken to a criterion of one perfect trial or a minimum of four trials.

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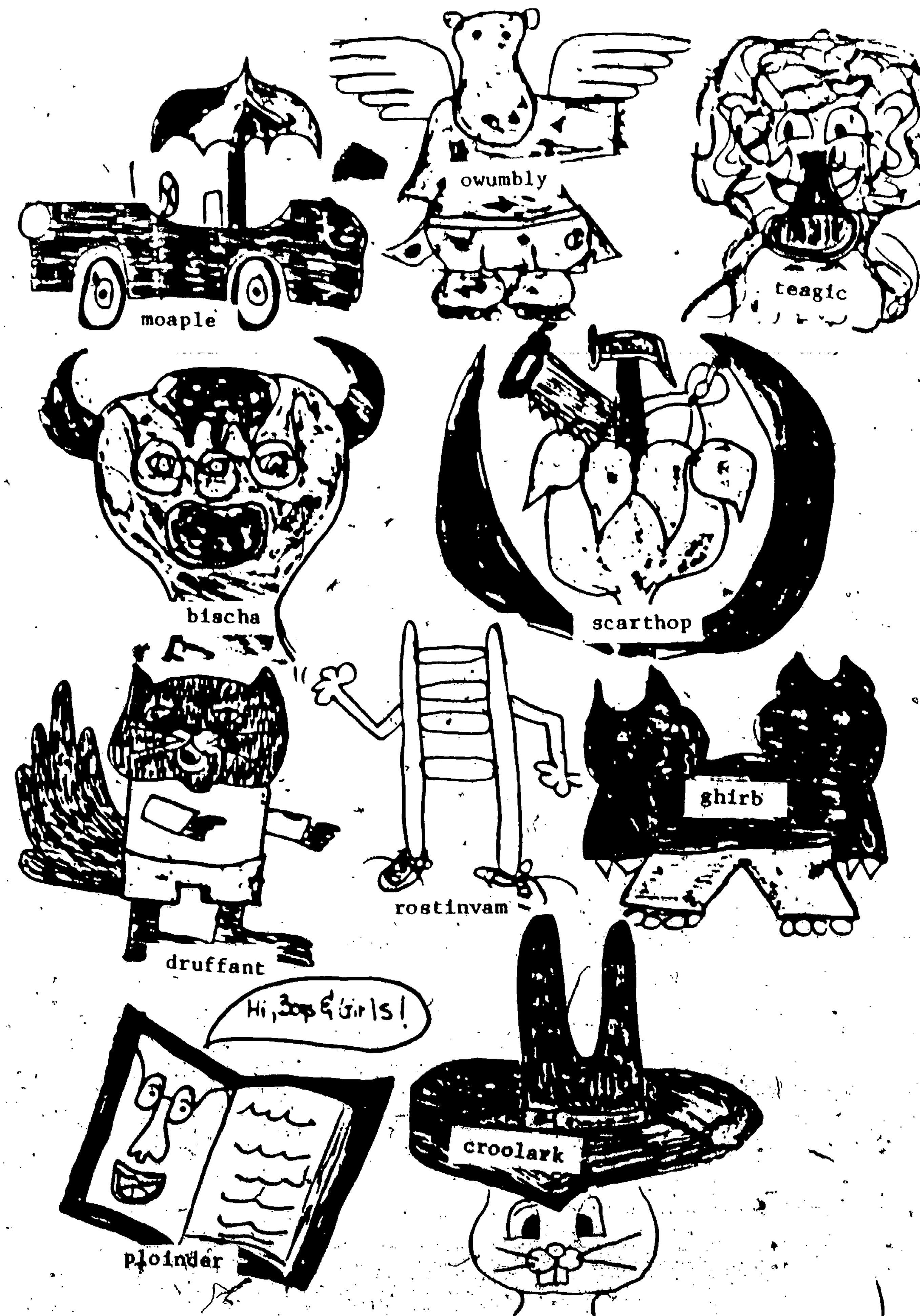

Figure 5-1. Pictures and their names.

On Day 2 and Day 3, review trials were given immediately following the word analysis tasks. The Day 2 review included the four words learned on Day 1 plus the three words learned on Day 2. The Day 3 review included all ten words. On review trials, children were shown each word and asked to pronounce it and to give its meaning. They were taken to a criterion of one perfect trial. All children received a minimum of three trials.

Word Analysis Training. Following word identification learning on each day, subjects were told that they would next perform several tasks which would help them learn more about the words. The three word analysis tasks were presented successively and always in the same order: letter placement, letter verificaton, and letter unscrambling.

The three analysis tasks were designed to encourage experimental subjects to coordinate the sounds with the positions of the letters in the target words and to store these amalgams in memory. This was brought about by requiring the children to form images of the words and to relate letters to sounds. Throughout the tasks the experimental children were called upon to use their stored images to recall both orthographic and phonetic details of each word. By means of specific error correction procedures, experimental subjects were able to amend and improve their images thus allowing more complete storage of the words.

Whereas experimental subjects utilized their memories of word forms, control subjects performed the analysis tasks always with the printed words in full view on 3 x 5 inch cards. Such a procedure made it possible for control subjects to practice discriminating specific phonological and orthographic details of the words without engaging or testing the adequacy of their memories for the word forms.

Prior to beginning the tasks in the experimental condition, subjects were given instructions designed to help them understand the nature of visual images. The children were asked if they knew the meaning of the word "imagination". If any child did not appear to understand, the experimenter described imagination as the following: the making of pictures in one's head, remembering events or people, and "seeing" them in the mind as if they were real. Subjects were told that they would need to use their imaginations in learning more about the words which had just been presented. Subjects were asked to close their eyes and to try to imagine their own classroom teacher walking to the blackboard, picking up a piece of chalk, and turning to write a word on the board. The children were told to watch the teacher print the word "tree" on the board, then put the chalk down and stand aside thus leaving the printed word alone on the board. At each step in this process the children were asked if they could "see" what had been described. In all cases affirmation was elicited before proceeding.

At the point where the child imagined the word alone on the blackboard, he was asked how many letters he saw in the word.

Following his response, the materials to be used in the first word analysis task were introduced. Experimental subjects performed this practice exercise using the word "tree" as an example before proceeding to the nonsense words. Control subjects also practiced with the word "tree." However, they had none of the preliminary visual image instructions. Then the three analytic tasks commenced.

Letter Placement. For each word, experimental subjects were shown a strip of tagboard which displayed the appropriate number of blank squares corresponding to each letter in the word. Children were asked to imagine the word with a letter in each box. After several seconds, the experimenter began handing the child, one at a time, the letters in the word. The child positioned each on the strip and then handed it back to the experimenter. The letters were presented systematically: first the beginning and ending letters, then consonants which were distinctly sounded, then easily recognized vowels, and lastly silent letters and more difficult vowel patterns. In this way images were systematically constructed, with the more familiar letter-sound patterns placed first thus constraining the placement of letters thought to be more difficult.

Additional questions were employed for 29 letters or pairs prior to their placement on the strip. To insure that all vowels and some of the less obvious consonants became attached to sounds, the child was first asked to begin pronouncing the word until he reached a sound designated by the experimenter and then to identify the name(s) of the letter(s) that made the sound. (For example, E: "Say the word teagic until you come to the sound /i/." S: "teagi-" E: "What letter makes that sound?" S: "I.") Such questions were employed for all vowels and consonants which did not clearly map one sound. Silent letters were also queried although the child was asked a slightly different question. (For example, E: "In the word ghirb there is a letter which does not make any sound at all. Do you know what it is?")

Errors were corrected by showing the printed word and asking subjects to locate the right letter for the sound or the correct position for a mislaid letter. Corrections took place immediately following each error. All errors were noted by E and the children were asked at the end of each word to repeat portions where mistakes had been made.

Control subjects were shown the same strip of tagboard but accompanied by the printed word displayed above the paper strip. For each word, the experimenter handed the subjects its letters, one at a time. Subjects pronounced the name of that letter, then located its position in the displayed word by counting the number of letters between the initial letter and it. Then they counted the same number of spaces on the paper strip, placed the letter in its space, pronounced the number of that space, and handed the letter back to the experimenter.

The letter placement procedure was performed once for each nonsense word. Letters were presented in the same order for all subjects. Portions of the task resulting in errors were repeated only for experimental subjects since the control subjects made no errors. Only the experimental subjects answered additional questions requiring the location of more difficult letters for sounds in words.

Letter Verification. In this task both experimental and control subjects were asked a series of questions concerning the presence or absence of specific letters in the target words. All questions were answered "yes" or "no". After experimental subjects were reminded about how to form images of printed words in their minds, they were asked to imagine each of the 3 or 4 target words. When they acknowledged they could "see" them, the experimenter inquired whether each of several single letters was present in the word (i.e., "Does it have a K?"). Half of the letters were present in the word, half absent. Distractor letters (i.e., those absent) were selected to be confusing in that they corresponded to sound segments in the words (i.e., U for bischa, D for rostinvam). The order of letter presentation was random. If experimental subjects answered incorrectly, they were shown the word printed on a card and asked whether the letter was there, and if so where. Such errors were noted and children were asked about that letter again after the other letters had been queried for that word.

Control subjects were asked the same questions in the same order but were shown each word printed on a card and were instructed to consult it to answer the question.

Letter Unscrambling. For each word, experimental subjects were given a paper strip (identical to that used in the Letter Placement task) accompanied by small letter cards scrambled on a tray. The tray contained only the letters of the word to be spelled. The experimenter instructed the children to recall what the word looked like and then to unscramble the letters, placing them in their correct positions on the paper strip. Upon completion, children were given an opportunity to change the spelling if it did not look right to them. If their spelling was incorrect, the experimenter showed the printed card and had children rearrange the letters to correct it.

Control subjects were also given the paper strip and scrambled letter tray but had the printed word card placed above the paper strip. In placing the letters, children were instructed to start with the first letter of the word and to match, in order, the remaining letters to those on the printed card.

Post-Tests

Several post-tests were administered, one on the day following the last training session, the rest five days later. For four pairs of subjects, the latter delay was slightly longer. Eleven pairs of subjects received only the 5-day delay post-tests. The experimenter met individually with the children and all tests were completed in one or two sessions.

Spelling: One Day Delay. In order to assess short term retention of spellings for the training words, 16 of the 27 subject pairs were seen on the day following the final training session. The experimenter pronounced each word and the child wrote it. After all ten words had been written, the children were instructed to look carefully at each of their spellings as the experimenter pronounced the words a second time. If a child indicated that a spelling "looked right", the experimenter proceeded to the next word. If the spelling did not look right, the child was instructed to write it again on another line. The most accurate spelling was the one scored.

Spellings were scored according to three criteria: number of words spelled perfectly (maximum = 10); number of spellings which contained the corrrect number of letters (i.e., memory for word length) (maximum = 10); number of letters remembered correctly (maximum = 71). In addition, a subset of letters thought to be especially difficult to remember was identified. These letters were considered difficult because they did not correspond to sounds heard in the word, they could be confused with other letters making similar sounds, or they were completely silent. Scored was the number of these letters or letter pairs recalled correctly (maximum = 14). The letters were: oa and e in moaple, u in owumbly, c in bischa, oi in ploinder, c and o in scarthop, ea, g and c in teagic, h in ghirb, ff and a in druffant, and i in rostinvam.

Spelling: Five Day Delay. This post-test served as an indicator of spelling retention following a delay of five days. The procedures were identical to those described for the One-Day Delay Spelling post-test. All subjects were given this task.

Word Pronunciation. Two types of word reading tasks were given. Ten pairs of subjects read the ten target words listed in a column; 17 pairs of subjects read the words flashed individually on a screen. The second task replaced the first when the requisite audio-visual equipment became available.

Children reading the list of words were presented with a folder containing the training words typed in a single column. Children read the words aloud and were recorded on tape. Accuracy and latency in reading the list were recorded, the latter with a stopwatch.

Latencies to individual words were collected with the audio-visual equipment. Children were seated 3 feet from a screen and viewed slides of each printed word (visual angle of 2.5°). A microphone was placed a few inches to the left of the child's face. E sat in front of a voice-activated timing device and recorded the number of seconds (to the nearest 1/1000 of a second) which elapsed between the presentation of the word and the onset of the child's pronunciation. Each word was displayed twice in random order.

Oral Spelling. The procedures used in this task were identical to those described for the Oral Spelling Pre-test. The children listened to recorded spellings of each of the training words. They were scored on the number correctly identified.

Spelling Recognition. The children were shown ten cards each displaying a row of four possible spellings for each of the ten words (i.e., (1) tejiç (2) tegik (3) teagic (4) tiejic). To make the distractors attractive, they were selected from misspellings produced in pilot testing. The correct alternative varied among the second, third and fourth positions on the cards. After E pronounced each word, the child either pointed to or gave the number of the word he deter- mined to be the correctly spelled form.

Picture-Word Matching. The child was presented with two 8 1/2 x 11 inch cards. Each displayed the ten pictures with a target word printed beneath each picture. In half of the cases, the word correctly identified the animal or object. The other half were incorrect. The child was instructed to proceed as quickly as possible, to place a finger beneath each picture and to say "yes" if the picture represented the meaning of the words, "no" if it did not. The child did not pronounce the words or identify the pictures orally. Accuracy was noted and the task was tape-recorded and later timed with a stopwatch.

Word Definitions. Subjects were given a small ring binder containing 3 x 5 inch cards with each of the ten words printed on them. The children were asked to read each word aloud and to provide its meaning by oral description (i.e., "druffant - a cat with five tails"). No corrections were offered for inaccurate pronunciations or incorrect meanings, and unknown words were passed over.

Pre-tests and post-tests were administered to subjects in the order given above. The order of presentation of the Word Pronunciation and Five-Day Delay Spelling Production post-tests were counterbalanced across subjects pairs to assess any learning or practice effects.

RESULTS

Subject pairs were divided into three reader ability levels based on their pretest scores on the word identification task comprised of 130 printed words. There were 9 pairs of subjects at each level. High ability readers recognized between 120 and 128 words, medium ability readers between 106 and 118 words, and low ability readers between 45 and 106 words.

Performances during pretest, training, and posttest phases of the experiment were analyzed for several purposes: to establish that experimental and control groups were equally matched in basic reading ability; to determine whether image-trained subjects acquired more extensive orthographic knowledge of words than control subjects; to determine whether effects of training were more substantial among lower ability readers; to determine whether the ordering of the word pronunciation and spelling tasks made a difference in performances; to analyze the course of preliminary word training and image training among the three reader ability groups to clarify the importance of individual differences; to examine the correlations among selected training and posttest measures to determine the strength of inter-relationships among various aspects of printed word knowledge.

Equivalence of Groups

To verify that image and control groups did not differ in any important way, matched pair t-tests were performed on seven pre-test scores. Mean values are reported in Table 5-1. Differences were insignificant on all tests.

Insert Table 5-1 about here

Further verification that the groups were equal was sought from performances in the preliminary phase of word training. Matched pair t-tests were performed on two measures of progress: the number of initial trials needed by subjects to learn the three sets of words to criterion (Day 1 + Day 2 + Day 3 scores), and the number of review trials which subjects needed to reach the criterion of 1 perfect trial (Day 2 review trials + Day 3 review trials). The difference between experimental and control groups on the number of review trials to criterion was insignificant, but the difference between groups on the number of initial exposures was significant favoring the control condition. Mean values are given in Table 5-1. This difference eludes explanation since the two groups had not as yet experienced any difference in treatment and they were found to be well matched on pre-test measures.

To determine whether this difference in number of initial trials to criterion resulted because experimental subjects took longer in learning to decode words or in learning word meanings, the number of trials to a criterion of one perfect performance was counted separately for pronunciation accuracy and for meaning accuracy. Mean values are reported in Table 5-1. According to matched-pair t-tests, neither difference between groups was significant ($p > .05$).

To determine whether the difference in number of trials to criterion for the experimental and control groups was localized in any one of the three reading levels, scores were analyzed separately for the three levels. Mean values are displayed in Table 5-2. An analysis of variance was performed with reader ability level, training group, and decoding vs. meaning as the three independent variables.

Insert Table 5-2 about here

Results revealed significant effects of ability, $F(2,24) = 13.34$ $p < .01$, and an interaction between ability and group, $F(2,24) = 4.16$, $p < .05$. There was no main effect of group, $F(1,24) = 2.63$, $p > .05$, or interaction between group and decoding vs. meaning, $F < 1$. From the mean values in Table 5-2 it is apparent that differences favoring the

TABLE 5-1

Mean Scores on Pre-Tests, Preliminary Word Training and Post-Tests for Image & Control Groups

	Image	Control	Maximum Score	Matched-pair t - value	S.D.	# of Pairs
Pre-Tests						
Word Identification	106.67	107.00	(130)	-.32 n.s.	20.65	27
WRAT	32.26	32.26	(45)	0.00 n.s.	7.52	27
CTBS (Grade equivalent)	2.27	2.28		0.00 n.s.	.36	16
Nonsense Decoding	3.37	2.88	(10)	1.25 n.s.	2.31	27
Oral Spelling	7.52	6.81	(12)	1.42 n.s.	2.82	27
Spelling						
Words: Perfect	9.52	9.19	(12)	1.32 n.s.	2.38	27
Words: Correct Length	10.67	10.04	(12)	-.25 n.s.	1.68	27
Preliminary Word Training						
Initial Exposures - Total trials	10.81	9.19		-2.04 *	4.24	27
Decoding - trials to criterion	8.41	7.81		-.04 n.s.		27
Meaning - trials to criterion	8.19	6.96		-1.56 n.s.		27
Review - trials to criterion	6.37	6.41		.03 n.s.	2.52	27
Post-Tests						
Spelling - One Day Delay						
Words: Perfect	4.75	2.69	(10)	2.75 **	3.01	16
Words: Correct Length	7.19	5.00	(10)	4.10 **	2.46	16
Inclusion of Correct Letters	61.31	58.50	(71)	1[illegible] n.s.	10.28	16
Inclusion of Difficult Letters	8.75	6.94	(14)	1.96 *	3.97	16

TABLE 5-1 con't.

Post-Tests con't	Image	Control	Maximum Score	Matched-pair t - value	S.D.	# of Pairs
Spelling - Five Day Delay						
Words: Perfect	4.67	3.41	(10)	2.69 **	3.08	27
Words: Correct Length	6.85	5.15	(10)	3.32 **	2.69	27
Inclusion of Correct Letters	62.89	59.00	(71)	2.58 **	8.48	27
Inclusion of Difficult Letters	9.33	7.33	(14)	2.09 *	3.63	27
Word Pronunciations						
Accuracy - List	9.50	9.70	(10)	-.56 n.s.	.68	10
Accuracy - Screen	18.94	18.65	(20)	.67 n.s.	1.94	17
Latency - List	11.41	10.94	(sec.)	-.59 n.s.	4.59	10
Latency - Screen						
1st Exposure	2.12	2.02	(sec.)	-1.37 n.s.	.35	17
2nd Exposure	1.97	1.99	(sec.)	.11 n.s.	.37	17
Fastest time	1.79	1.69	(sec.)	1.51 n.s.	.22	17
2nd fastest time	1.89	1.81	(sec.)	-1.17 n.s.	.27	17
Oral Spelling	8.52	8.63	(10)	-.29 n.s.	1.52	27
Spelling Recognition	8.37	7.67	(10)	1.56 n.s.	1.90	27
Picture-Word Matching						
Accuracy	18.47	19.04	(20)	-1.23 n.s.	1.32	27
Latency	52.41	53.68	(sec.)	.26 n.s.	18.05	24
Word Definitions						
Pronunciation Accuracy	9.96	9.78	(10)	2.47 **	.33	27
Correct Meanings	8.59	9.15	(10)	-2.17 *	1.36	27

* $p < .05$
** $p < .01$

TABLE 5-2

Mean Scores as a Function of

Training Condition and Reader

Ability Level

Task Measure	Reader Ability High	Medium	Low
Initial Trials to criterion[a]			
Image Group	5.39	7.06	12.44
Control Group	6.22	6.56	9.39
Difference	-.83	+ .50	+3.05
Word Read. Accuracy (untimed)			
Image Group	10.00	10.00	9.89
Control Group	10.00	9.89	9.44
Difference	0.00	+.11	+.45
Perfect Word Spellings (5 day delay)			
Image Group	7.00	5.44	1.56
Control Group	5.00	3.33	1.00
Difference	+2.00	+2.11	+.56
Recall of Correct Letters (5 day delay)			
Image Group	68.1	65.4	55.1
Control Group	63.8	61.2	52.0
Difference	+4.3	+4.2	+3.1
Recall of Difficult Letters (5 day delay)			
Image Group	11.4	10.7	5.9
Control Group	9.6	7.9	4.6
Difference	+1.8	+2.8	+1.3

[a]Means are not total trials to criterion (ttc.) but ttc. averaged for decoding ttc. and meaning ttc.

control group in number of trials to criterion were localized mainly in the low ability group. These findings indicate that low ability readers in the control group were slightly more advanced in both pronunciation and semantic word learning skills than low ability readers in the experimental group. However, although their skills may have differed, knowledge of the target words at the end of this preliminary phase of training should not have distinguished the groups since subjects were all taken to criterion.

Training Effects

Effects of the training conditions were assessed with several posttests designed to measure different aspects of printed word learning. Knowledge of the orthographic identity of the words was measured in two spelling production tasks, one given the day after the final training session and one given after a five day delay. Orthographic knowledge was also measured in tests of spelling recognition and oral spelling identification. Knowledge of the semantic identity of the words was measured in two tasks; one where subjects were required to indicate a match or mismatch between pictures and target words printed beneath them; and one where subjects read each word on a card and supplied its meaning orally. The extent to which spellings were amalgamated to pronunciations was assessed by measuring subjects' accuracy and latency in reading the target words either on a list or presented individually on a screen. An additional measure of word reading accuracy was taken in the Word Definition posttest where subjects were required to read each of the words aloud before giving its meaning. As there were no instructions to complete the task rapidly, this score may be considered an index of subjects' ability to read the target words without any time pressure.

Results supported the expectation that image-trained subjects would acquire superior knowledge of the orthographic details of words. As evident in Table 5-1, experimental subjects outperformed control subjects on 7 of the 10 spelling measures. Several aspects of orthographic knowledge clearly distinguished the groups: memory for correct word spellings; memory for word length, memory for difficult letters.

One of the orthographic tasks yielding no treatment difference was the oral spelling task. This required the child to identify the correct target word after hearing it spelled aloud on a tape recorder. From observation of subjects' performances, it was apparent that this task was inadequately designed. Although subjects were not told ahead of time that the words they would hear were the target words, they quickly developed this expectation. In many instances, the words were guessed following the experimenter's pronunciation of the first or second letters only. It was apparent that subjects were choosing from a predetermined set of words rather than constructing mental images of the words in order to recognize them. For this task to have been effective, target words should have been mixed in with several distractors composed of familiar words as well as unfamiliar pseudowords. This would have forced subjects to process more of the letters in identifying target words.

A second orthographic task failing to produce significant results required subjects to choose the correct spelling of each target word from among four alternative spellings. The difference between groups was not significant (i.e., $\bar{X}$ (image) = 8.4 vs. $\bar{X}$ (control) = 7.7 correct). In light of the pronounced spelling production differences between the two groups, this absence of a difference is interesting. It reveals that the visual exposure training experienced by control subjects was as effective as the letter memory training in enabling subjects to discriminate correct from incorrect spellings. These results combine with those above to show that the benefits of orthographic image training were primarily on the production side of the spelling process.

Despite their superior knowledge of orthographic details, experimental subjects were not, in general, able to pronounce aloud the target words more rapidly or accurately than control subjects. Both groups, regardless of list or screen presentation, performed near ceiling in pronouncing the words, and their latencies were equivalent. A significant difference favoring experimental subjects was detected on the untimed accuracy measure in the Word Definition posttest ($\underline{t}(26) = 2.47$, $\underline{p} < .05$). However, this difference was accounted for by only 5 pairs, all lower ability readers whose control member read 9 of the 10 words correctly while the experimental member read all 10. From these findings, it is concluded that the two groups did not differ in their decoding ability with the target words, despite differences in training experiences and acquired knowledge of letter details. These findings indicate that more complete knowledge of word spellings does not necessarily improve one's ability to read the words accurately or rapidly. Apparently partial knowledge is sufficient to support maximum performance.

Knowledge of the meanings of words was not expected to distinguish the two groups of subjects since both learned the meanings to criterion during the preliminary training phase and since training experiences were not designed to influence this aspect of word knowledge. As displayed in Table 5-1, neither response accuracy nor latency scores in the picture-word matching task distinguished the groups. However, a difference in performance was detected in the word definition task. Although performances were close to ceiling in both groups, control subjects were able to define significantly more words correctly than experimental subjects. Thus, a difference between experimental and control groups which was apparent during the preliminary phase of word training surfaced in the posttests despite the use of a trials-to-criterion procedure. Apparently, this procedure did not compensate completely for initial differences in semantic word knowledge. Inspection of errors in this task indicated that there were twice as many omissions as mistaken identifications (i.e., 44 vs. 21 errors, respectively), suggesting the greater importance of memory failure than incorrect word-meaning associations in this task.

Interactions Between Training Effects and Reader Ability Levels

In order to determine whether the effects of training were more substantial among the poorer beginning readers, several analyses of variance were conducted on various posttest measures of word knowledge. In each case, the independent variables were reader ability (high, middle, low) and treatment (experimental, control). For tasks administered to only a subset of the sample, two levels of reader ability were distinguished, high and low.

Not surprisingly, there were significant main effects of reader ability detected in most of the analyses. Mean values for the three groups are reported in Table 5-3. Tukey post hoc pairwise comparison procedures were used to locate the source of the differences. In most cases, scores of the low ability readers were significantly lower than scores of the middle and high ability groups which did not differ.

Insert Table 5-3 about here

Contrary to expectations, few if any significant interactions emerged. The only interaction which reached significance occurred with the untimed word pronunciation accuracy measure taken in the Word Definition task, $F(2,24) = 3.71$, $p < .05$. Mean values are given in Table 5-2. Inspection of scores revealed that whereas high ability readers in both groups performed perfectly, among middle and lower ability readers, control subjects were slightly less accurate than experimental subjects. Since ceiling effects precluded the possibility of observing differences among better readers, results cannot be interpreted as supporting the hypothesis. From these findings, it is concluded that training effects were not more substantial among lower than higher ability readers.

Effects of Task Order

Because of the possibility that order of completion of the word pronunciation and spelling posttests might make a difference in performance, the tasks were given in counterbalanced order across subject pairs. Statistical assessment of order effects by ability group was precluded since the number of subjects in each cell was small and variable. This occurred because an unequal number of pairs received each order across ability groups (i.e., spelling before vs. after word pronunciation = 5 vs. 4 good reader pairs, 4 vs. 5 middle reader pairs, 3 vs. 6 low ability reader pairs, respectively), and because subjects were not all given the same type of word pronunciation test (i.e., some read word lists, others read words on a screen).

To determine whether task order affected performance, selected mean scores on subsets of the total sample balanced for ability were analyzed statistically. Regarding spelling performance, it did not appear that scores were significantly higher among subjects who saw the words before they spelled them. Whereas a mean of 61.2 letters

TABLE 5-3

Mean Performance as a Function of Reader Ability Level

Task Measure	Reader Ability High	Mid.	Low	Maximum Score	Min. Signif. Diff.[a]	ANOVA[c] F-value	S.D.	# of pairs
PRETESTS								
Word Identification	123.6	114.1	82.8 [b]	(130)	13.01	33.47**	15.64	27
POSTTESTS								
Spelling Productions (5 day delay)								
Words: Perfect	6.0	4.4	1.3 [b]	(10)	2.05	16.95**	2.47	27
Words: Correct Length	7.7	6.2	4.1 [b]	(10)	2.00	9.87**	2.41	27
Correct Letters	65.9	63.3	53.6 [b]	(71)	6.07	14.40**	7.30	27
Difficult Letters	10.5	9.3	5.2 [b]	(14)	2.41	16.30**	2.90	27
Oral Spellings	9.0	9.3	7.4 [b]	(10)	1.53	10.94**	1.27	27
Spelling Recognition	8.9	8.5	6.6 [b]	(10)	1.31	11.01**	1.58	27
Word Pronunciations								
Accuracy - List	9.8	---	9.4	(10)	---	3.20n.s.	.50	10
Accuracy - Screen	19.9	---	17.4 [b]	(20)	---	8.98 *	2.14	14
Mean Latency - List	8.9	---	13.5	(sec)	---	3.97n.s.	5.13	10
Mean Latency - Screen	1.8	---	2.3 [b]	(sec)	---	14.00**	.49	14
Untimed accuracy	10.0	9.9	9.7	(10)	.27	5.64**	.32	27
Meanings								
Picture-Word Matching	19.2	19.0	18.4	(20)	---	1.06n.s.	1.65	27
Definitions	9.1	9.6	8.0	(10)	1.[illegible]	5.69**	1.41	27
PRELIMINARY TRAINING								
Initial trials to criterion	5.8	6.8	10.9 [b]	(open)	2.63	13.34**	4.45	27
Review trials to criterion	4.6	3.9	6.4	(open)	3.65	9.75**	6.19	27

[a] Tukey Post Hoc Pairwise Comparison tests: T(S.D.), $p < .05$

[b] Mean of Low Ability Group is significantly different from each of the other two means, according to Tukey test. For two-mean comparisons, differences are significant according to F-value.

[c] *$p < .05$; **$p < .01$; n.s. not significant

was recalled when spellings were solicited first; 63.3 letters were recalled when spellings were produced after words were read, $F(1,22) < 1$. In contrast, word pronunciation measures did appear to be affected by whether subjects had previously spelled the words. In the ANOVA of mean word reading latencies (screen presentation only), the factors were task order, and first vs. second presentation of the words. The main effect of order was not significant, $F(1,12) = 2.87$, $p > .05$. However, the main effect of presentation was significant $F(1,12) = 7.02$, $p < .05$, as well as the interaction between presentation and order, $F(1,12) = 9.83$, $p < .01$. Mean values are given in Table 5-4. It is apparent that the spelling task served as a word priming

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Insert Table 5-4 about here.

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experience. The reaction times of subjects who had just spelled the words were substantially lower than the subjects who had not. Furthermore, reaction times in reading the words a second time dropped among non-pre-spellers but remained about the same level among pre-spellers. Accuracy scores as well as latencies appeared to be affected by task order. Among middle ability readers, every subject who had already spelled the words read them perfectly ($N=8$). In contrast, only 4 out of 10 middle ability unprimed subjects read all the words perfectly, the remainder misreading 1-2 words. These findings indicate that the experience of spelling the words served to make them more available as responses and to enhance performance on a word pronunciation task given subsequently.

This provides one explanation why training effects may not have been apparent in word pronunciation performances. Priming might have washed out differences. To check on this possibility, the word pronunciation scores of only those subjects who were not primed with the spelling task were compared. However, no pattern favoring either the image-trained group or the control group was apparent. Thus, it was not the case that priming diluted training effects. The conclusion reached above that image training did not enhance subjects' word decoding skill remains unchanged.

Since more of the high than the low ability readers were primed prior to the word pronunciation task, this may explain why the word pronunciation scores of high ability readers were superior. (See Table 5-3.) To determine whether the difference in mean scores between high and low ability readers was attenuated among unprimed subjects, their mean scores were compared. Results showed that the difference was still just as clearcut: mean pronunciation latencies (screen) = 2.0 seconds for 6 unprimed high readers vs. 2.5 seconds for 10 unprimed low readers; mean pronunciation accuracies = 19.7 correct (high) vs. 16.9 correct (low).

Only some of the subjects were given two spelling tests, the first test one day after training and the second test five days after training. The remainder received only the five-day test. To deter-

TABLE 5-4

Mean Word Reading Latencies in Seconds (Screen Presentation) as a Function of Task Order and Word Exposure (N = 28 subjects)[a]

Exposure	Spelling Before	No Spell, Before	Mean
First Reading	1.83	2.11	1.97
Second Reading	1.85	1.91	1.88
Mean	1.84	2.01	1.92

[a]MSE (12) = .0168

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mine whether subjects benefited from having the first test, scores of a subset of the sample were subjected to an analysis of variance. The dependent measure was the number of letters recalled on the five-day test. Results fell short of significance though the difference was sizeable and in the expected direction. Whereas subjects given the earlier test recalled a mean of 62.9 letters, subjects not having the earlier test recalled 57.8 letters correctly, $F(1,14) = 2.57$, $p > .05$. With more subjects, the effect probably would have reached significance.

Analysis of Performance During Image Training

Since the printed words were always visible, responses of control subjects were close to perfect in all of the word analysis training tasks and hence were uninteresting. In contrast, image-trained subjects were required to use their memories to perform the tasks and success among individuals varied greatly. These responses were subjected to analyses of variance in order to compare the course of image learning for the three reader ability groups. Mean values are reported in Table 5-5.

Insert Table 5-5 about here.

Before describing the results, the dependent measures should be explained. In the Letter Placement task, we counted the number of times subjects placed a letter in the wrong position on the tagboard strip, and the number of times subjects were unable to identify the correct letter corresponding to a designated sound or to identify a silent letter. In the Letter Verification task, we counted the number of times subjects misjudged the presence and absence of designated letters. Errors to present and absent letters were entered as a repeated measure in the ANOVA. Also, errors in this task were analyzed for two types of letters, those which clearly corresponded to sounds in the words, and those which lacked a single unambiguous correlate in sound. This variable was entered as a repeated measure in the ANOVA. In the Letter Unscrambling task, we counted the number of words subjects spelled correctly during their first attempt and also following an attempt to correct those they judged not to look right.

Main effects of reader ability level were significant in all five analyses ($p < .05$). Post hoc pair-wise comparisons using Tukey's procedure showed that significantly lower correct scores, or higher error scores were achieved by low ability readers than each of the other two groups whose means were not significantly different.

In the analysis of letter verification errors, a significant interaction emerged. As apparent in Table 5-5, high and middle ability readers made more errors in misjudging present than absent letters whereas low ability readers displayed the reverse difficulty. In other words, poorer readers had more trouble rejecting phonetically

TABLE 5-5
Mean Performance During Training as a Function
of Reader Ability Level

	Reader Ability High	Reader Ability Mid.	Reader Ability Low	Maximum Score	Min. Signif. Diff.[a]	ANOVA F-values	Standard Deviation
IMAGE TRAINED SUBJECTS (N = 27)							
Letter Placement Task							
Errors in Letter Position	3.9	5.4	10.4[b]	(59)	2.25	14.45**	2.70
Errors in Sound-Letter Identification	8.3	6.6	12.2[b]	(29)	2.81	6.63**	3.38
Letter Verification Task							
Mean Errors	5.2	5.5	11.8[b]		3.71	12.53** (main effect)	4.46
Errors on Letters Absent	4.0	3.8	13.2	(71)			
Errors on Letters Present	6.3	7.2	10.3	(71)		6.48** (interaction)	2.82
Difference	-2.3	-3.4	+2.9				
Errors on Present & Absent Letters							
Clearly Related to Sound	3.6	3.2	8.1	(36)			
Less Clearly Related	6.8	7.7	15.4	(35)		12.81** (main effect)	4.43
Mean	5.2	5.4	11.8[b]		3.69		
Letter Unscrambling Task							
Mean Correct	9.7	9.3	5.9	(10)	1.55	22.01** (main effect)	1.86
First Attempt	9.6	8.9	4.9				
Second Attempt	9.9	9.7	7.0			6.99** (interaction)	.74
Gain	+.3	+.8	+2.1				
PRELIMINARY TRAINING (N = 54)							
Initial Trials to Criterion							
Pronouncing Words	5.0	7.4	11.9	(open)			
Defining Words	6.6	6.2	9.9	(open)		10.32** (interaction)	1.79
Difference	-1.6	+1.2	+ 2.0				

[a] Tukey Post Hoc Pairwise Comparison test: T(S.D.) $p < .05$.
[b] Mean of Low Ability Group is significantly different from each of the other means (Tukey test).

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plausible distractor letters than accepting letters truly in the word, whereas good readers were able to reject incorrect letters more easily than to determine which letters were correct. This finding suggests that poorer readers may have been performing differently from good readers in consulting images and making judgments. Perhaps the poorer readers were depending more upon sound and less upon a visual representation of the word. As a result, they were more susceptible to phonetically plausible distractors. The fact that poorer readers were making phonetic errors means that they were aware of the letter-sound relations. This contrasts with the claims of some (Liberman and Shankweiler, 1977) that poorer readers are unskilled in phonetic analysis.

Responses in the letter verification task were compared for letters clearly related to sound to those not clearly related. Not surprisingly, the former were much easier to judge accurately. (See Table 5-5.)

In the Letter Unscrambling task, subjects' attempts to correct their own perceived misspellings boosted their scores significantly, $F(1,24) = 28.27$, $p < .01$, particularly in the poor reader group. (See Table 5-5.) Since high and middle ability readers were performing almost at ceiling, there was little room for them to improve. This finding points to the role of orthographic images in producing correct spellings, especially among poorer readers. Being able to see inaccurate spellings provides information useful for correcting errors, very possibly because it enables subjects to evaluate the form against their internal stored image. Subjects with less effective phonological coding skills needed to generate initial spellings (i.e., poorer readers) may benefit the most from this experience.

Analysis of Performance During Preliminary Word Training

To further explore differences in word learning as a function of reader ability level, performances during the preliminary phase of word training were examined. The dependent measure was the number of trials to a criterion of one perfect performance. Trials were summed for the three word sets across the three days of initial training and across the two days of review. The independent variables in the two analyses of variance were reader ability (3 levels), training group assignment (image vs. control), and response type (pronouncing vs. defining words). In the analysis of initial trials to criterion, the main effect of ability was significant (see Table 5-3). Also, ability interacted with treatment. The inexplicable fact that low ability control subjects tended to learn the words in fewer trials than low ability experimentals has already been discussed above. Most interesting in this analysis was the significant interaction which emerged between ability and response type. Mean scores are presented at the bottom of Table 5-5. It is apparent that whereas high ability readers learned word pronunciations faster than word meanings, the opposite pattern was exhibited by the other two groups, with the difference favoring meaning over pronunciation being largest among low ability readers. Viewed another way, reader groups differed more widely in

ERIC

their ability to learn word pronunciations (i.e., range in mean trials = 7) than in their ability to learn word meanings (i.e., range = 3). In other words, letter-sound decoding was a more important capability distinguishing good from poor readers than semantic word learning ability. Learning pronunciations was especially easy for good readers and especially hard for poor readers.

In the analysis of review trials to criterion, the main effect of reader ability was significant (see Table 5-3). Interestingly a main effect of response type also emerged, $F(1,24) = 43.41$, $p < .01$. Subjects required fewer review trials to reach criterion in pronouncing words than in defining them (i.e., means = 3.9 vs. 6.1 trials). The interaction with reading ability was not significant ($p > .05$). Combined with the above results, this suggests that although it may take longer for some children, primarily poorer readers, to learn pronunciations than meanings for unfamiliar printed words, once they are learned, pronunciations are less easily forgotten than meanings. The reason is that whereas meanings are arbitrarily related to printed forms, pronunciations are symbolized by letters in the word and these are the cues which govern their storage and secure their retrieval.

Correlational Analysis

Correlations among selected measures from the preliminary word training tasks, the image training tasks, and pre- and posttests were examined in order to identify which aspects of word training were most predictive of performance as well as to determine which tasks were most closely related. Results are given in Table 5-6.

Insert Table 5-6 about here.

The measure of time to learn word pronunciations during the preliminary phase of word training (i.e., trials to criterion) was significantly correlated with all but the word definition posttest. The significant correlations were all substantial, ranging from .54 to .74, $p < .01$. The measure of time to learn word meanings was significantly correlated with the same measures but to a lesser extent, ranging from .27 ($p < .05$) to .52 ($p < .01$). This suggests not surprisingly, that word pronunciation learning skill was a greater contributor to word pronunciation and spelling posttest performance than semantic learning processes. Semantic learning scores were significantly correlated with word definition posttest scores in contrast to word pronunciation learning. This is as expected since the former both reflect knowledge of word meanings. However, the correlation was quite low, $r = .27$, possibly because posttest definition performances were close to ceiling.

The two trials-to-criterion measures of word learning were highly correlated with each other, $r = .66$, $p < .01$, indicating that learning to decode novel printed words and learning their meanings do not develop independently contrary to theories which suggest that separate

ERIC

5-27

TABLE 5-6
Intercorrelations Among Selected Measures

	1	2	3	4	5	6	7
PRETEST							
1. Word Ident.	---						
PRELIM. TRAINING							
2. Decode - TTC[a]	-.74**	---					
3. Meaning - TTC[a]	-.52**	.66**	---				
IMAGE TRAINING							
4. Letter Placement Errors	-.60**	.49*	.39*	---			
5. Letter Verif. Errors - Absent	-.74**	.76**	.75**	.64**	---		
6. Letter Verif. Errors - Present	-.43*	.53**	.54**	.56**	.64**	---	
7. Letter Unscrambl.[b]	.77**	-.71**	-.71**	-.71**	.82**	-.53**	---
POSTTESTS							
8. Spell - Words[c]	.60**	-.58**	-.38**	-.63**	-.70**	-.69**	.69**
9. Spell - Letters[c]	.69**	-.64**	-.45**	-.55**	-.75**	-.54**	.81**
10. Spell - Difficult Let[c]	.61**	-.54**	-.38**	-.58**	-.72**	-.58**	.83**
11. Pron. - Accuracy[d]	.65**	-.60**	-.50**	-.25 n.s.	-.49*	-.55*	.63**
12. Pron. Latency[d]	-.75**	.55**	.35*	.30 n.s.	.34 n.s.	.48 n.s.	-.29 n.s.
13. Definitions	.29*	-.18 n.s.	-.27*	-.40*	-.30 n.s.	-.37 n.s.	.18 n.s.

[a]TTC = trials to criterion
[b]Letter unscrambling measure was the number correct after children were allowed to modify unscramblings which did not look right to them.
[c]Five-day delay spelling test.
[d]Word pronunciations measured on screen
* $p < .05$
** $p \leq .01$

ERIC

TABLE 5-6 (cont.)

Intercorrelations Among Selected Measures

	8	9	10	11	12	No. of Subjects
PRETEST						
1. Word Ident.						54
PRELIM TRAINING						
2. Decode - TTC						54
3. Meaning - TTC						54
IMAGE TRAINING						
4. Letter Placement Errors						27
5. Letter Verif. Errors - Absent						27
6. Letter Verif. Errors - Present						27
7. Letter Unscrambl.[b]						27
POSTTESTS						
8. Spell - Words[c]	---					54
9. Spell - Letters[c]	.88**	---				54
10. Spell - Difficult Let[c]	.93**	.90**	---			54
11. Pron. - Accuracy[d]	.48**	.64**	.41*	---		34
12. Pron. Latency[d]	-.46**	-.46**	-.48**	-.42*	---	34
13. Definitions	.11 n.s.	.02 n.s.	.08 n.s.	.25 n.s.	-.29 n.s.	54

[a]TTC = trials to criterion

[b]Letter unscrambling measure was the number correct after children were allowed to modify unscramblings which did not look right to them.

[c]Five-day delay spelling test.

[d]Word pronunciations measured on screen

* $p < .05$

** $p < .01$

paths, one from print to sound, another from print to meaning, may be established when subjects learn to read words (Baron, 1977). Their interdependence is very likely attributable to the need for a pronunciation to aid learners in discriminating among the orthographic stimuli sufficiently so that the appropriate meaning can be attached to each (Samuels, 1976). Because these were pseudowords, however, processes reflected here may differ from those involved in learning real words whose pronunciations are already familiar.

Correlations among performances on the four image training tasks were quite high, ranging from .53 to .82, $p < .01$. This indicates a common underlying base, presumably the presence of spellings in memory. Performances on these training indicators were most highly correlated with spelling posttest performances, the values ranging from .54 to .83 $p < .01$. Correlations were somewhat lower between image training measures and posttest word pronunciation accuracy scores, the values ranging from .25 (not significant) to .63, $p < .01$. However, image training correlations were lowest and in most cases not significantly different from zero for posttest word pronunciation latencies (i.e., r ranging from .29 to .48, $p > .05$) and word definitions (i.e., r ranging from .18, n.s., to .40, $p < .05$). Consistent with training effects described above, these results indicate that factors important for image training performances were those important for spelling and for pronouncing the words accurately. However, they bore little relationship to subjects' speed in pronouncing words and likewise to subjects' acquisition of word meanings.

Some other interesting relationships were apparent among the correlations. In the image training task involving letter verification, subjects had to reject letters plausibly pronounced but not present in spellings, and they had to accept letters present in spellings. Performance on the former task was very highly correlated with an important indicator of reading ability, printed word knowledge, more so than the other measure. Whereas the absent letter measure was correlated .74 with word identification pretest scores, ($p < .01$), the present letter measure was correlated only .43, $p < .05$. This difference was statistically significant, $t(24) = 2.49$, $p < .01$, according to Hotelling's test (Walker and Lev, 1953). The plausible letter rejection measure was also highly correlated with both of the trials to criterion measures (decoding and meaning) obtained during preliminary word learning, significantly more so than the letter present measure, $t(24) = 2.05$ and 1.85, $p < .05$. These findings suggest that the ability to reject phonetically plausible but incorrect letters may be a particulary important indicator of the ability to learn and retain printed words in memory. If indeed orthographic images of words are stored and are clearer among better readers, and if in a letter verification task when visual information about letters is missing, readers judge on the basis of sound, then phonetically plausible letters would be expected to deceive these readers. In contrast, since many present letters do have correlates in sound, this measure should be less sensitive since readers lacking orthographic images could still succeed on the sounded letters.

There was one other image training task which also yielded particularly high correlations with pre- and posttest measures, ability to unscramble the letters to produce correct spellings of the words. This too may be a particularly sensitive index of orthographic word memory.

The fact that correlations between preliminary training, image training, and posttest measures were strong despite the use of error correction, feedback, rehearsal of incorrect responses, and mastery learning suggests that individual differences among subjects in their word learning skills are very powerful and that instructional procedures, at least of the sort used here, are not influential enought to overcome these differences.

Analysis of correlations among the posttest measures revealed a pattern consistent with expectations. Spelling and word pronunciation measures were significantly correlated with each other but not with the semantic word definition measure. Noteworthy is the pattern of correlations between word pronunciation accuracy and spelling scores. The correlation between pronunciation accuracy and total letters recalled is significantly higher, $r = .64$, than the correlations between pronunciation accuracy and correct word spellings, $r = .48$, $p < .025$, or difficult letters recalled, $r = .41$, $p < .01$. This is consistent with the hypothesis that only partial letter information is central in decoding words accurately. Most important are those letters which clearly map the sounds in the words.

DISCUSSION

Findings offered support for some but not all hypotheses derived from word identity amalgamation theory. As expected, subjects receiving image training were better at producing correct spellings than control subjects. Differences were apparent regardless of the measure of spelling production used. Effects of training were particularly striking on subjects' memory for word length, with t-values exceeding $p < .0005$ on the one-day posttest and $p < .005$ on the five-day test. This suggests that letter memory (image) training made subjects keenly aware of how many letters had to be included in the words. This is perhaps surprising given the fact that part of the training given to control subjects in the letter placement task required them to count letters in order to locate their positions in words. This would lead one to expect diminished rather than exaggerated differences on memory for length.

In contrast to marked differences in spelling production ability, the groups did not differ significantly in being able to distinguish correct from incorrect spellings although the difference was in the expected direction. The failure to detect a difference on the recognition test may have occurred because the distractor spellings were not sufficiently attractive. However, if this were a poorly designed test, one would not expect scores to correlate as highly as they did with spelling production scores ($r = .66$, $p < .01$). This suggests that the absence of a difference in word recognition between

ERIC

groups may be real. Assuming that a spelling recognition test reflects subjects' "passive" knowledge of how words should look whereas a spelling production task requires active reconstruction of letters, it may be that the two groups were quite similar in the former respect. Certainly the control group spent plenty of time looking at the words and locating letters. This experience may have been sufficient to establish fairly accurate passive knowledge of word forms in memory.

Based on amalgamation theory, it was expected that image and control groups might differ in their accuracy and speed at pronouncing the pseudowords as a consequence of the fact that letter memory subjects had acquired more complete knowledge of the orthographic forms of the words. In a previous study, Frith (1978) found that good spellers were somewhat faster at pronouncing familiar words than unexpectedly poor spellers. Also, Rayner and Posnansky (1978) found that pictures were named faster with completely accurate spellings printed on the pictures than with graphically similar misspellings. One reason for the advantage in processing might be that the presence of more of the letters either in memory or in print facilitates retrieval of the word and its pronunciation. However, present findings did not support the hypothesis. Both groups performed similarly. One reason might be that word decoding performances were close to maximum, precluding the detection of differences. This appeared to be the case with the accuracy measures where scores were close to perfect. However, examination of latencies, which might be expected to leave more room for variation, failed to reflect expected differences. In fact, the opposite pattern between means was apparent although the difference favoring the control group was not significant. Thus, it is not true that words whose orthographic forms are stored more completely in lexical memory are thereby pronounced more accurately and rapidly. Apparently partial knowledge of letters is sufficient to support maximum performance. This should come as no surprise given several facts about printed words, namely, that letter sequences are highly constrained by orthographic conventions creating much redundancy among the letters, only a portion of the permissible letter sequences symbolize words familiar in speech, and only a portion of these have been seen and learned by children. Since the set of possible word responses for familiar letter sequences is so constrained, it becomes clear how word recognition can be completely successful when only some of the letter details are store in memory.

As evident above, present findings failed to yield a uniform picture of printed word learning. Although the image training procedure sharpened subjects' knowledge of orthograpic details more than the letter identification procedure, the benefits of training were not apparent in any word processing task except spelling production. This raises uncertainty about what the effects of image training really were and whether this procedure actually contributed to the development of orthographic images. Experimental subjects were required to imagine and consult images of printed words. No child complained about not being able to do this, and they all appeared to be working with images in their heads (i.e., rolling their eyes upward

ERIC

or closing their eyes). But were orthographic image actually being altered and improved by their activities? And were posttest performances actually mediated by images presumably constructed during training? Since only spelling production was boosted by image training, it may be that letter memorization rather than image construction was the critical activity responsible for success. Perhaps orthographic images are formed and improved not by actively imagining letters but rather by looking at words and recognizing how at least some of the letters symbolize sounds in the pronunciations. Perhaps readers acquired orthographic images as well as they could by learning to pronounce the words during preliminary training and so there was little room left to be improved by image training.

One aim of amalgamation theory is to specify the nature of the information about printed words retained in memory. Comparison of the recall accuracies of subjects on the various measures of printed word knowledge revealed some interesting differences suggesting characteristics of this stored information. Subjects were much more accurate in recalling letters in words (i.e., means of 89% correct for image subjects, 83% for controls) than they were at producing entirely accurate spellings (i.e., 47% for imagers, 31% for controls). Spelling recognition success was also much higher (i.e., 84%; 77%). Difficult letters were not as well remembered (i.e., 62%; 49%). These results show that subjects have substantial knowledge about orthographic details, particularly letters with clear correlates in sound, even though they may not be able to produce perfect spellings very well. Assuming that the information used in these tasks comes primarily from orthographic images, these data suggest that images have substantial letter detail but may still lack the precision, clarity or whatever to support perfect production of word spellings, particularly when the spellings are not straightforward mappings of sound. Additional orthographic information, perhaps stored in a different form (i.e., footnotes about correct letters or motor writing programs) may be needed to insure complete accuracy in spelling words. The fact that despite extensive practice on spellings, subjects in the present study did not learn very many completely suggests that it may be quite difficult for learners to engage in effective memory tactics to preserve all the details in memory.

It is interesting to note that letter knowledge was found to be more important for reading words than perfect spelling knowledge in the present study. This was suggested by the significantly higher correlation between letter recall and pronunciation accuracy ($r = .64$) than between word spelling and pronunciation accuracy ($r = .48$). This is consistent with the conclusion reached above that partial knowledge of spellings is more critical than complete knowledge for reading words successfully.

The critical difference in training procedures thought to account for the superior performance of image-trained subjects on the spelling production posttests was the activation of memory processes. Whereas experimental subjects were required to consult orthographic images of words stored in their heads to perform in the training tasks, control subjects always had the printed forms of the words in full view to consult in answering questions. However, there was one other procedural difference besides dependence upon memory which distinguished the groups. Experimental subjects received additional questions about letter-sound relations of 29 more-difficult-to-remember letters in the letter placement training task. The purpose was to facilitate the amalgamation process by helping them recognize how these letters fit into the sound structure of the words. Since control subjects did not receive any parallel training, it remains unclear whether the letter memory component or this component or both were responsible for image-trained subjects' superior knowledge of spellings. Since both components are considered important in storing orthographic information in memory, the extent to which each contributes should be assessed.

The value of letter memory practice for learning spellings appeared to be recognized by some of the better readers in the control group. These subjects tried to get the experimenter to take away the printed words and allow them to answer without looking at the cards. Trying to remember, they asserted, would be "more fun." Given these comments, one might worry that the absence of training differences on some measures resulted because control subjects used their memories to rehearse letters despite instructions. However, if this were true, interactions between reader ability and training effects would have been evident, and this did not happen.

Present findings carry implications regarding the question of how instruction in spelling should be structured to be most effective. Two components are suggested as important by present findings: letter memory rehearsal and feedback, plus learning how letters fit into the sound structure of words. It is interesting to note that these procedures are not prominent in spelling texts. According to an analysis of the performances required in 7 commonly used commercial elementary spelling programs (Cronnell and Humes, 1979),

> "The practice provided by spelling books most commonly involves writing the words that are printed on the page. Sometimes the spelling task explicitly directs students to copy words. More often, the task entails choosing a listed word and writing it--another kind of copying task. Although some tasks could be completed without looking at the words printed on the page, students may not do this. Instead, some students probably complete all of their spelling practice by merely copying words."

Assuming that copy practice is equivalent to what control subjects did in the present study, findings show that this is less effective than alternative procedures for remembering spellings.

In addition to examining image training effects on printed word learning, another purpose of the present study was to assess the importance of individual differences. It is interesting to note that whereas training condition did not produce the expected relationship between spelling and reading words, this relationship was clearly apparent in the correlations between spelling performances (words and letters correct) and word decoding accuracy and speed measures (r between .46 and .64, $p < .01$; see Table 5-6). In other words, subjects who differed in orthographic knowledge of words because of differences in their learning experiences with the words did not as consequence differ in their accuracy or speed in reading the words. In contrast, subjects who differed in orthographic knowledge of the words because of individual differences brought to the task did differ in their ability to read the words. This suggests that positive correlations observed between spelling and reading words are not caused so much by differences in how the words are learned but is rather accounted for by individual differences in underlying factors such as knowledge or skill development or learning strategies. It may be that subjects who have better knowlege of orthography as a system mapping speech will learn spellings better and will be faster and more accurate at pronouncing words than subjects with poorer skills, and this advantage may exist almost regardless of what method is used to learn the words or how extensively the words are practiced. This phenomenon was apparent in a study by Hogaboam and Perfetti (1978) who taught pseudowords to good and poor readers and found that even with extensive practice, the difference in word decoding speed favoring the better readers still remained. In this case, practice pronouncing the words did not compensate for underlying decoding skills differentiating the groups. In the present study, differences between good and poor readers were evident on almost every measure. (See Tables 5-2, 5-3, and 5-5.) This was despite the fact that subjects had been taken to criterion in pronouncing and defining words and had received extensive practice with word spellings. These results all point to the conclusion that individual differences in reading/spelling skills are more powerful than the specific nature of the learning experiences in accounting for differences in reading and spelling performances.

What strategy, skill, or processing difference might be the critical ones distinguishing good and poor readers? Results of the present study in agreement with Hogaboam and Perfetti (1978) point to decoding skills as more central than semantic skills. As evident at the bottom of Table 5-5, the gap in performance between high and low ability readers was greater in the number of trials needed to learn the pronunciations of printed words than in the number needed to learn word meanings during the preliminary training phase. On the posttests, high and low ability readers differed substantially in their memory for letters in words but only minimally in memory for meanings. This suggests that capabilities involving letter-sound relations and letter memory separate the two groups.

One capability regarded as an important part of decoding skills involves the ability to analyze words into phonemic segments so that letters can be processed as symbols for these sounds (Liberman and Shakweiler, 1977; Gleitman and Rozin, 1973). Although this may be

ERIC

important among children just learning to read, one finding in the present study raised the possibility that more experienced poorer readers (i.e., second graders, with two years of reading experience) may not be all that insensitive to sound segments in words. This was suggested by their performance patterns in the letter verification training task. In judging whether letters were present or absent in words, poorer readers were particularly susceptible to phonetically plausible but incorrect letters. (See Table 5-5.) In order to fall for these letters, subjects had to be aware that there was a sound segment in the word corresponding to these letters. It may be that poorer readers are not insensitive to sounds in words but rather they are less able to incorporate this information into the processing required to store and retain printed words in memory. Additional research is needed to clarify more precisely how this processing words and which aspects of poor readers' decoding-memory skills are deficient.

Present findings are consonant with our other studies pointing to the importance of a multi-faceted view of printed word learning and indicating that some identities of words are more interdependent in their development than others. Results exposed one difference in the course of learning the semantic and phonological identities of the unfamiliar printed pseudowords. Performance on the review trials following criterion learning of meanings and pronunciations revealed that pronunciations were better remembered than meanings. This was true even among poorer readers who required more trials to reach criterion with pronunciations than meanings and who as a result completed trials beyond criterion with meanings. Despite this overlearning, the meanings were not remembered as well. Very likely, this is because the attachment of pronunciations to spellings entails amalgamating acoustic or articulatory elements of the motor program to letters symbolizing these elements whereas the attachment of meanings to print is arbitrary.

Analysis of the intercorrelations among measures revealed that spelling and word pronunciation accuracy measures were strongly related, suggesting interdependence in their development and execution. These measures were moderately correlated with the measure of word meaning acquisition but only weakly correlated with posttest measures of word meaning. One interpretation for this finding is that learning the meanings and pronunciations of printed words is an interdependent process during the acquisition phase but dependence declines once these identities have beeen established in memory. In other words, in order to establish meanings for printed words in memory, it is necessary that pronunciations and spellings also be learned. However, once learning is complete, semantic recognition operates independently of the others. This suggest that although mature readers may be able to bypass sound and go directly from print to meaning in recognizing familiar words, they were quite dependent upon sound in acquiring this skill when the words were unfamiliar. The possibility of a shift in this respect constitutes a case where mature word processing abilities do not reflect their acquisition histories accurately.

Present findings disclosed some important methodological considerations in the assessment of reaction times to printed words. It was apparent that subjects who performed the spelling production posttest before the word identification test were able to read the words faster and more accurately then subjects who completed the word reading task before any other posttests. This reveals that having another task served to prime subjects for the words and hence to reduce their dependence upon printed forms in order to pronounce words. This priming phenomenon accompanied by a lack of attention to letters was obvious in the oral spelling task which came third in the sequence of posttests. Many subjects were able to identify words successfully after hearing only one or two letters. Previous studies have indicated that priming effects for printed words may last up to 48 hours (Scarborough, Cortese, and Scarborough, 1977). In the design of studies such as the present one, this priming phenomenon is a problem since it serves to reduce the sensitivity of word decoding measures to training effects. For sensitivity to be maximal, the word reading task should be given before the subjects are reminded of the words by any other task. Also, posttesting should probably be delayed for several days following word training. Furthermore, it may be important to teach a sufficient number of words in order to make printed word processing approximate responses to an open rather than a closed set of stimuli.

One other procedural variation was found to make a difference in the assessment of word reading latencies. Two types of reaction time measures were employed: the times to read a list of the words measured with a stopwatch; and times to read individual words measured with a voice-activated relay attached to a timer. Differences as a function of reader ability proved significant on the latter but not the former measure where the variance among subjects was sizeable. (See Table 5-3). This shows that the difference in sensitivity between these two measures can mean the difference between success and failure in experiments like the present one.

Chapter 6: Effects of Image Training on Printed Word Learning in Beginning Readers

A second study was conducted to determine whether explicit training in the formation of complete orthograpic images would enable beginning readers to identify the words more accurately and rapidly as well as to produce more complete spellings. This study differed from the one reported in Chapter 5 in that first rather than second graders were tested, the words were real rather than made up, and each subject served as his own control in the comparison of word learning methods. Also, procedures used to facilitate image formation as well as to posttest subjects differed in several respects.

In previous studies, it has been found that good readers have better word recognition skills than poor readers (Perfetti and Hogaboam, 1975). Also, good spellers appear to be faster at recognizing words in isolation than unexpectedly poor spellers (i.e., subjects who can read adequately but are poor spellers) (Frith, 1978). One reason why these differences might exist is that good readers/spellers have more complete knowledge of letter details for words than poor readers/spellers. According to Ehri (in press-a), possession of more complete orthographic images in memory should facilitate the process of matching external print to internal images, and this should enhance the process of recognizing and pronouncing words. Evidence from the above studies, however, falls short of confirming this hypothesis. Differences in word processing were observed between high and low ability subjects, and it is not clear whether these differences arose from specific word knowledge or from other characteristics distinguishing the two groups. Results of the study reported in Chapter 5 provide evidence that superior knowledge of word spellings does not result in more skilled word reading. The purpose of the present study was to test this hypothesis in a slightly different way.

The experimental design entailed teaching two sets of unfamiliar real words to the same beginning readers in two contrasting ways. The set of words in the experimental condition was practiced according to procedures thought likely to enhance the establishment of orthographic images in memory. Children learned to pronounce the printed words, then they learned how the letters symbolized separate sound segments in the pronunciations, then they practiced imagining the words and identifying component letters in their images. The set of words in the control condition was simply read several times. Posttests were given 5 to 7 days later to measure effects of word training on subjects' speed and accuracy at decoding the words and their knowledge of word spellings. This delay was thought adequate to tap subjects' long-term storage of the words in lexical memory.

Methods

Subjects

Two samples of children were selected for training, one from first grade classes tested in the spring (N = 15), one from a parochial school and a day-care center tested in the summer (N = 11). The latter group included three post-kindergarten subjects who had begun learning to read. There were 17 females and 9 males, mean age 84.3 months.

Materials and Procedures

The experimenter worked individually with children on from 5 to 13 occasions (median = 7). During the first session, several pretests were administered. Word training required from 3 to 11 sessions. The time was allocated as follows: one or a portion of one session for preliminary word reading, 2 to 10 sessions for image training, only 5-10 minutes for control training, and one or a portion of one session for reviewing the words at the end of training. Posttests were administered during the final one or two sessions which were conducted 5-7 days after the final training session (except in 3 cases where posttests were given 3, 13, or 14 days after training due to sickness or vacations).

Pretests

Several pretests were given to assess subjects' ability to read target words and various aspects of their reading skills. The tests were given in the following order.

Printed Word Identification. Children were shown and asked to read 114 words which included 71 taken from their classroom texts, 16 target words serving as candidates for training, and 27 words commonly learned during beginning reading. Each word was printed on a small card. Children were told to guess or skip any unknown words.

Writing Letters. The experimenter named 14 letters (5 vowels, 9 consonants) and had children write each in lower case form.

Decoding CVCs. Ten consonant-vowel-consonant (CVC) units were printed beneath animal pictures on cards (i.e., baf, jik, fop, dev, lum). There were two CVCs testing each short vowel sound. Children attempted to read each made-up animal name. If unsuccessful, they identified the sound symbolized by each letter and then attempted to blend the sounds to pronounce the name. No corrective feedback was provided.

Naming Letters. Children saw and named 25 lower-case letters (all but L) printed in five rows of 5 letters each. They were told to go as rapidly as possible without making errors and to skip any unknown letters. Latencies were timed with a stopwatch.

Spelling-Aided Sound Learning. This task developed by Ehri and Wilce (1979) was included in order to assess children's ability to use letters to store sounds in memory. Subjects were given a maximum of 7 trials to learn four CVC nonsense sounds in a paired associate task. The sounds were: hes, fug, kiv, pab. The stimulus prompts were the initial letters of each unit. The anticipation method was used. On the first trial and after each recall attempt, children were shown a spelling of the unit. Of interest was whether the spellings would serve as a mnemonic and enable children to learn the sounds. Children were told to pay attention to the letters because they would help them remember the sounds.

Word Training

A within-subjects design was used to compare the effects of two kinds of learning experiences on children's knowledge of printed words. In one condition, subjects practiced forming and consulting orthographic images of the words in memory. In the other condition, they simply practiced reading the words.

Words thought to be unfamiliar to first graders were paired according to letter length and comparable letter-sound complexity. The 8 pairs were: cube - gold; obey - easy; silly - angry; dream - noise; spider - window; punish - filthy; trouble - thirsty; garbage - whisper. Members of 6-letter pairs considered interchangeable as were members of 7-letter pairs. The words were printed on cards alone and with pictures which illustrated the meaning of each target word.

For each child, 6 pairs of words were selected for training. Word members were assigned randomly to the image and control conditions. The words selected were ones the child could not read readily on the word identificatin pretest. (There were 3 subjects each of whom could read one of the six training words on the pretest. In two cases, the word was included in the control set, in one case in the image set.)

Training was divided into four sessions. First, subjects learned to read all the words. Then they completed image training with half of the words, and they practiced reading the other half. The order of completion of the two latter sessions was counterbalanced among subjects. A review was conducted at the end of training.

Preliminary Word Reading. Children saw and read all 12 words printed beneath pictures. The experimenter corrected any errors or omissions. On the first trial, she explained how the picture illustrated the word's meaning. The set of words was shuffled after each trial and re-presented until the child could read each word quickly on two consecutive trials. As soon as individual words reached this criterion, they were dropped from the deck. Next, printed words without pictures were practiced with the dropout procedure to the same criterion. This exercise was repeated once.

ERIC

At the end, words were divided into the two sets to be taught separately, and subjects' accuracy and latency in reading each set was measured.

Control Word Training. Children saw and read each of the 6 words on cards 6 times.

Image Training. There were four phases. First, children were taught to segment the words phonemically. This was in order to create sounds for the letters to symbolize. Then, they were shown how letters in the spelling corresponded to these sounds. Next, they practiced imagining the words' spellings and recognizing whether particular letters named by the experimenter were present or not. Finally, they practiced imagining spellings and naming the letters themselves. Details of these phases are described below.

1. Phonemic Segmentation

The child was shown how to break up words into their component sounds by watching and then imitating the experimenter segment "bat." She said the word, then put down a colored square as she pronounced a sound for each phoneme. Work commenced with the target words. During trial 1, the experimenter pronounced each word, had children repeat it, then divide it into segments. If unsuccessful, the experimenter demonstrated the correct response, and children imitated it. Practice continued to a criterion of two perfect segmentations or a 3-trial maximum per word. Words upon reaching criterion were dropped from subsequent trials.

2. Letter-Sound Analysis

Children were told that in this task they would see how to make sense of the spellings. The experimenter displayed each spelling comprised of moveable letter squares propped up on a tray. On the first trials, subjects read each word. Then the experimenter moved one or two letters to the left on the tray as she pronounced phonemic segments symbolized by the letters, one segment at a time. Then she repeated the word pronouncing it slowly and running her finger beneath the letters as she passed over each sound. On the first trial, children imitated this routine for each word. On Trials 2 and 3, children performed these rountines from memory. Errors were corrected by reviewing phonemic segmentation with colored squares or by demonstrating and explaining the correct response

Silent letters were clustered with an appropriate adjacent letter as in "dream" and "trouble" segmented as d/r/ea/m and t/r/ou/b/le.

3. Letter Recognition

Children were told that in this task they would see whether the words had moved into their heads. They were told to pretend that

ERIC

they were looking at the cards with the printed words and to try to get a clear picture of all the letters in their heads. Each word was pronounced, children repeated it and named the first letter. Then the experimenter identified in random order all the other letters plus two non-occurring letters. For each, children indicted whether they could see the letter in their image. After completing each word, they looked at its printed form and identified any errors they had made. For letters missed, the experimenter asked them to find each in the word and to locate the sound it symbolized in the pronunciation (i.e., if the child missed D in "spider," he would say /d/ and "spid-" stopping when he came to the sound). Children then closed their eyes and practiced imagining the word with all the letters again.

Performance continued to a criterion of two perfect consecutive trials or a maximum of four trials per word. Words reaching criterion were dropped.

4. Letter Production

Children were told to imagine each word and to name its letters. If unsuccessful, they looked at the word, located their errors, and searched for relevant sounds symbolizing any letters omitted. Silent letters were taught as having no separate sound but rather joining with other letters to make particular sounds.

For 10 of the subjects, this task was performed from 1 to 3 times. For 16 of the subjects, training was extended to a criterion of 2 perfect consecutive trials for all 6 words. Words reaching criterion were dropped.

Review. A review of all 12 target words was given at the end of training. Children read each word and recalled its picture. Errors were corrected by the experimenter and these words were reviewed until correct.

Posttests

Several posttests were given to assess the effects of word training experiences. Not all proved to be well designed or appropriate for first graders. Because two of the tasks were time-consuming to administer, because responses of interest appeared to be obscured by irrelevant factors, and because no differences between treatment conditions were evident in performance, they were dropped after the first round of subjects was tested: a cloze sentence reading task, and a word search task.

The following tasks were given to all subjects in the order listed below.

Memory Drum Word Reading. Following practice with 6 familiar words, children saw and pronounced 32 words presented on a memory drum. Words were exposed for 1 second with 3 seconds intervening before the next word appeared. The list included the 16 target words plus 16 graphically similar words. The latter words all shared at least a first letter with one of the target words and some shared more, up to four letters.

List Word Reading. Each set of 6 target words was listed twice, once in each of two columns in a folder. Subjects read the two columns on each list as rapidly as possible without making mistakes. A different random order of words was presented in each column. The order of presentation of the image and control word sets was counterbalanced across subjects. Latencies were measured with a stopwatch for the first column and for both columns combined.

Word Spelling. Children were told to imagine each word and to record its letters on paper. If they thought the word did not look right, they were asked to write it again. Words from both training conditions were presented in mixed up order.

Results and Discussion

In order to compare effects of the two types of word learning experiences, matched-pair t-tests were conducted on posttest scores. Results are presented in Table 6-1. Image training had the

Insert Table 6-1 about here.

effect of boosting subjects' knowledge of orthographic details over that acquired by simply pronouncing the words repeatedly. However, superior knowledge of spellings did not enhance subjects' accuracy or speed in pronouncing the words. These results reveal that explicit training in the formation and use of orthographic images in memory can improve beginning readers' ability to spell words but not their ability to decode words. Apparently partial knowledge of orthographic forms is sufficient to support maximum performance in the latter case. These conclusions are identical to those reached in the study reported in Chapter 5.

Because 16 of the 26 subjects were taken to criterion in the Letter Production training task while the others were given only 1 to 3 trials, it was expected that the posttest performances of the former subjects might be superior. One difficulty arose making statistical comparisons more difficult. Inspection of pretest means and standard deviations of the two groups on the word identification measure revealed that the criterion-trained subjects included some of the less advanced readers and their scores were much more variable than scores of the non-criterion subjects. Nevertheless, posttest means revealed the expected pattern. The relevant values are displayed in Table 6-2. Inspection of scores disclosed

Insert Table 6-2 about here.

Table 6-1

Mean Performance on the Posttests as a Function of

Word Training Experiences (N = 26)

Posttest	Training Image	Training Control	t-stat.		Max. Score	S.D.
Word Read. Accuracy						
Memory Drum	3.58	3.58	0	n.s.	(6)	1.50
List	10.88	11.27	1.39	n.s.	(12)	1.37
Word Read. Latency						
List (6 words)	9.22	8.51	.79	n.s.	(sec)	3.38
List (12 words)	20.22	17.13	1.36	n.s.	(sec)	7.20
Spelling						
Words perfect	2.61	0.85	6.22	**	(6)	1.31
Letters recalled	30.00	24.88	5.84	**	(33.8)	3.98

Table 6-2

Comparison of Posttest Performances of Subjects

Taken vs. Not Taken to Criterion in Letter

Production Training

	Max. Score	Means Criterion (N=16)	Means Not (N=10)	Stand. Dev. Crit.	Stand. Dev. Not
PRETEST					
Word Identif.	(114)	58.81	63.40	20.16	10.94
POSTTEST					
Read "Image" Words					
Accuracy (M.D.)	(6)	3.69	3.40	1.66	1.43
Accuracy (List)	(6)	4.31	5.80	1.74	0.42
Latency (List)	(sec.)	9.95	8.06	4.81	3.57
Spelling "Image" Words					
Words Correct	(6)	3.13	1.80	1.36	1.32
Letters Correct	(33-36)	31.13	28.20	2.49	2.94
Spelling Control Words					
Words Correct	(6)	0.94	0.70	1.24	1.06
Letters Correct	(33-36)	24.50	25.50	6.16	2.32

differences favoring the criterion subjects only in spelling the image words, not in spelling control words or in reading the word sets. T-tests confirmed that criterion subjects produced more accurate spellings of image-trained words than non-criterion subjects: for words correct, $t(24) = 2.45$, $p < .025$; for letters correct, $t(24) = 2.91$, $p < .01$. These findings fit with those above in suggesting that image training contributes primarily by boosting memory for word spellings. Furthermore, they indicate that much of the gain in spelling knowledge resulted from the training task in which practice to criterion was given in imagining words and identifying the letters in their spellings.

Pearson product-moment correlation coefficients were calculated to examine the strength of relationships among the various pretests, training tasks, and posttests. Measures displaying variability and typifying performance in each task were selected: (1) CVCs decoded correctly; (2) speed in naming alphabet letters; (3) CVC sounds recalled correctly on Trial 4 of the sound learning task; (4) printed words read correctly; (5) target words read accurately following preliminary word training; (6) speed in reading target words following preliminary training; (7) image words segmented into phonemes once correctly during image training; (8) image words in which letter-sound relations were identified correctly on Trial 3; (9) image words in which letters were recognized correctly twice; (10) image words in which letters were produced correctly on Trial 1; (11) target words read correctly on memory drum; (12) target words read accurately on list; (13) speed in reading target words on list; (14) target words correctly spelled; (15) number of letters correctly recalled in target word spellings. Correlations are reported in Table 6-3. Since subjects differed in the amount of

Insert Table 6-3 about here.

image word training received, scores of only those given criterion training were used to calculate correlations involving posttest scores (Variables 11-15). Correlations between the image training measures (Variables 7-10) and posttest measures (Variables 11-15) were calculated only on performances involving image-trained words.

Of particular interest were the correlations involving the sound learning pretest measure which Ehri and Wilce (1979) interpret as an indicator of subjects' ability to store letters in memory as symbols for sounds and which they propose as a central factor underlying printed word learning skill. The word training provided in this study involved teaching children to form and store images of printed words in memory and so it was expected that sound learning scores would reflect subjects' success in engaging in these image-acquiring activities. As evident in Table 6-3, sound learning scores were significantly correlated with 3 of the 4 image-training activities. These results suggest that phonemic segmentation, letter-sound analysis and recognition of letters in imagined spellings are

Table 6-3

Correlations Between Pretest, Training, and Posttest Measures

	CVC 1	LET 2	S.L. 3	W.I. 4	WRA 5	WRL 6	P.S. 7	LSA 8	LR 9
<u>PRETESTS</u>									
1. CVC Decoding	--								
2. Letter Name Cat.	-.26	--							
3. Sound Learning	.38*	-.34*	--						
4. Word Identif.	.46**	-.50**	.41**	--					
<u>PRELIMINARY TRAINING</u>									
5. Word Accuracy	.43*	-.45**	.21	.55**	--				
6. Word Latencies	-.10	.69**	-.27	-.39*	-.45*	--			
<u>IMAGE TRAINING[a]</u>									
7. Phon. Seg.	.68**	-.52**	.42*	.56**	.62**	-.25	--		
8. Let-Sound Amalgam.	.53**	-.50**	.38*	.43*	.50**	-.26	.68**	--	
9. Let. Recog. Judg.	.32	-.45*	.40*	.70**	.42*	-.32	.43*	.26	--
10. Letter Prod.	.22	-.30	.06	.49**	.48**	-.49**	.28	.21	.71**
<u>POSTTESTS[a]</u>									
11. Read Words - Mem. Drum.	-.03	-.39	.09	.39	.17	.08	.01	.10	.14
12. Read Words - List Acc.	.50*	-.38	.34	.60**	.39	-.29	.41	.33	.38
13. Read Words - Latency	-.13	.08	-.04	-.23	.05	-.00	.15	.13	-.21
14. Spelling - Words Cor.	.21	-.38	.33	.73**	.52*	-.39	.46*	.42	.76**
15. Spelling - Let. Cor.	.60**	-.71**	.32	.60**	.58**	-.31	.47*	.30	.63**

*$p < .05$ **$p < .01$

[a]Correlations of Var. 7-10 with Var. 11-15 were calculated on scores for image-word set only. Relevant statistics for the 6 words in the set are given in the final columns in parentheses. Other statistics were calculated on all 12 words.

Table 6-3 (cont.)
Correlations Between Pretest, Training, and Posttest Measures

	LP 10	RWM 11	RWA 12	RWL 13	S-W 14	Mean	Max. Score	S.D.	No. Ss
PRETESTS									
1. CVC Decoding						4.92	10	2.96	26
2. Let. Name Lat,						22.92	sec.	7.68	26
3. Sound Learning						1.88	4	1.21	26
4. Word Identif.						60.58	114	17.09	26
PRELIMINARY TRAINING									
5. Word Accuracy						10.27	12	1 71	
6. Word Latencies						24.31	sec.	9.91	26
IMAGE TRAINING[a]									
7. Phon. Seg.						4.23	6	1.77	26
8. Let-Sound Amalgam.						4.81	6		26
9. Let. Recog. Judg.						2.77	6	1.61	26
10. Letter Prod.						2.27	6	1.56	26
POSTTESTS[a]									
11. Read Words - Mem. Drum.	.21	—				7.50	12	2.45	16
						(3.69)	(6)	(1.66)	(16)
12. Read Words - List Acc.	.51*	-.45*	—			9.25	12	2.46	16
						(4.31)	(6)	(1.74)	(16)
13. Read Words - Latency	-.24	-.30	-.14	—		18.81	sec.	5.39	16
						(9.95)	(sec.)	(4.81)	(16)
14. Spelling - Words Cor.	.77**	.47*	.82**	-.19**	—	4.06	12	2.29	16
						(3.13)	(6)	(1.36)	(16)
15. Spelling - Let. Cor.	.47**	.46*	.69**	-.10	.64**	55.63	66-72	8.29	16
						(31.13)	(33-36)	(2.45)	(16)

*$p < .05$ **$p < .01$

[a]Correlations of Var. 7-10 with Var. 11-15 were calculated on scores for image-word set only. Relevant statistics for the 6 words in the set are given in the final columns in parentheses. Other statistics were calculated on all 12 words.

ERIC

closely related to and may be part of the ability to store letters in memory as symbols for sounds. In contrast, the ability to identify the letters in word images was not correlated significantly with sound learning. This suggests that letter production may not be as central as letter recognition in storing alphabetic images of words in memory.

Although most of the training tasks as well as the pretests measuring letter-sound analytic skills were correlated with sound learning scores, the measures of word reading skill (preliminary training and posttest scores) were not. These results conflict with the expectation that this skill is centrally involved in printed word learning. One reason for the absence of a relationship and also the failure to detect stronger correlations involving sound learning may be that the skill was not really operational among most of these beginners. Inspection of performances in this task revealed that most had difficulty learning the sounds. Only 7, or 27% of the sample were able to reach a criterion of two perfect recollections in 8 attempted trials. Another reason why correlations were not very impressive may be that since subjects were given training on this aspect of word knowledge, the variability in posttest performance as a funcion of this factor was reduced to a minimum. If true, one would expect low correlations for performance on image-trained words but higher correlations on control words. Inspection of the correlations between sound learning and posttest performances for image-trained and control words separately disclosed only one correlation which was higher and significant in the case of control words: sound learning was significantly correlated with posttest list word reading accuracy scores for control words, $\underline{r} = .53$, $\underline{p} < .05$, but not for image words, $\underline{r} = .05$, $\underline{p} > .05$. Thus, only weak support for this explanation was found. A third possibility is that there were too few subjects and too few words to yield very powerful tests of the hypothesis.

One procedural difference between the sound learning task used in the present and the previous studies should be mentioned. Subjects here were told to make use of the letters in remembering sounds whereas in the previous study they were shown the letters but not told how to use them. This difference may have had something to do with the lower correlations observed. Further research is needed to clarify whether the sound learning task does reflect an important component of printed word learning, and if so what it is.

As we have observed in other studies (Chapters 5 and 7), children's ability to read a list of printed words constitutes a powerful predictor of their performances in many types of alphabetic tasks. As evident in Table 6-3, the pretest word identification measure was significantly correlated with almost all of the other measures (86% of them), more so than any of the other pretests (43-57%). This shows that the more printed words beginners have stored in lexical memory, the more effectively they will learn new printed words.

The other pretests appeared related to more specific aspects of printed word learning. CVC decoding and letter naming speed were highly correlated with letter-sound analysis measures (Variables 7 and 8) and with memory for correct letters in the posttest (Variable 15). However, they were in general less strongly related to whole word measures. This points to the importance of letter-sound analytic skills for learning letter components of words but not necessarily whole word spellings.

It is interesting to note that success on the image training tasks (Var. 7-10) contributed primarily to posttest performance on the spelling tasks rather than the word reading tasks. These results further contribute to the conclusion that image training benefits spelling rather than word reading ability.

There are some problems limiting inferences based on correlations. It may be that word training washed out otherwise significant effects, precluding conclusions about the involvement of some variables. Also, because so many variables were interrelated, it is not clear which might be responsible for what. Furthermore, tasks were given in a fixed order, so it is not clear how performance on one affected performance on another and thereby altered correlations involving the latter variable. Also, it was the case that better readers were taught longer words than poorer readers since they could read the shorter easier words comprising the potential target set. The effect of this would be to reduce correlations between measures. These limitations must be kept in mind as interpretations are formed.

One goal of the present study was not met. We had hoped to determine whether superior knowledge of printed words would benefit the reading of sentences containing those words. However, difficulties in the design of an adequate sentence reading task prevented achievement of this objective.

In conclusion, results of the present study confirmed findings reported in Chapter 5 that training in the formation of orthographic images given to beginning readers is beneficial in improving their ability to spell the words but not to read the words.

Chapter 7: Do Beginners Learn Printed Words Better in Contexts or in Isolation?[a]

One of the most important capabilities in learning to read is learning to recognize printed words. Research on beginning readers performed by Shankweiler and Liberman (1972) and Firth (1972) reveals high correlations between the ability to identify printed words and skill in reading text. The purpose of this study was to explore skills and experiences which facilitate the written word acquisition process among beginning readers. There is substantial disagreement about which skills and experiences are most important. Some authorities stress letter-sound mapping skills (Rozin & Gleitman, 1977; Liberman & Shankweiler, 1977). Others emphasize the importance of learning to recognize printed words rapidly and automatically (LaBerge & Samuels, 1974; Perfetti & Hogaboam, 1975; Perfetti & Lesgold, 1977). Still others proclaim the centrality of learning to recognize the meanings of printed words as they participate in larger sentence and story contexts (Goodman, 1972; Smith, 1973). Disagreement arises also about the best way to develop word recognition skill. One recommendation is that beginners practice reading single words on flash cards to improve decoding accuracy and speed. People offering this approach assume that once a pronunciation is derived, word meanings are accessed automatically. However, others object, arguing that pronunciation does not guarantee that words will be interpreted quickly and correctly. An alternative recommendation is that beginners practice reading words in story contexts so that meanings can be aroused and attached directly to printed forms.

In order to contend with these multiple issues and uncertainties surrounding the word learning process, Ehri has proposed a theory of printed word learning which integrates some of these seemingly disparate views (Ehri, 1978, in press-a, in press-b; Ehri & Wilce, 1979). According to the theory, reading capabilities get underway when the reader becomes able to store printed words in lexical memory. The lexicon is conceptualized as a repository for words a child has acquired by learning to speak. Each word has several identities: a pronunciation or phonological identity, a characteristic form class or syntactic identity, and a meaning or semantic identity. When the child learns to read, another identity is added to the lexicon. As he/she practices reading a word, its orthographic form is retained in memory and amalgamated with the word's other identities so that one unit is formed. Once orthographic identities of words are established, the reader no longer needs to use general decoding skills to identify these words. Visual images have replaced sound as the address in memory, so the reader can recognize the word by simply matching the print to his stored visual representation.

[a]Referred to in other chapters as Ehri and Roberts (1979). Published in Child Development, 50, 675-685.

Since words have several identities which undergo amalgamation during reading acquisition, the process of learning printed words is viewed as having not one but several dimensions to be investigated. One can examine not only whether readers can recognize a word's phonological identity from its graphic form, but also whether they can recognize how the word functions grammatically and what it might mean in sentence contexts. In addition, one can examine how completely the orthographic form has been stored in memory by having readers write out the word or distinguish correct from incorrect spellings.

In considering how word identity amalgamation develops, one can expect various types of skills and experiences to prove central to one or another aspect. In order to store the orthographic identities of words, very likely the reader must possess systematic knowledge of letters as they map into sounds, he must be able to use this knowledge to store word spellings in memory, and he must spend some time attending to and analyzing the written forms of single words. A different type of experience is probably important for attaching syntactic and semantic identities to printed word forms. The reader must practice recognizing and interpreting printed words accurately as he reads text for meaning. In this way, the meanings become active at the time the reader looks at and decodes the printed form.

The purpose of the present study was to compare the effects of two types of word learning experiences. Beginning readers were taught to read words which were printed either in meaningful sentence contexts or singly on flash cards. Based on the above view, it was expected that context trained subjects would learn more about the semantic identities of printed words, whereas flash card trained subjects would remember more about orthographic identities.

The possibility that semantic identities are not learned well when words are seen in isolation receives support from a number of sources. Goodman (1973) is highly critical of the flash card method of teaching words. He has asserted that if readers are taught to pronounce isolated words, they will learn merely to "bark at print." One reason is that the meanings of many words are not salient in isolation. This is particularly true of context-dependent words (i.e., is, was, of, from) which must be embedded in sentences to have meaning and also true of ambiguous words with multiple meanings. Another reason is that children have little practice recognizing single words as units of spoken language. In speech, attention is directed at meanings of phrases and sentences rather than words. Evidence presented by Ehri (1975, 1976, 1979) indicates that pre-readers do not recognize context-dependent words pronounced in isolation as real words. However, even with interpretable words, children tend to think only minimally about their meanings unless told to do so. Several studies by Rohwer (1971) reveal that young children, unlike adults, do not spontaneously imagine semantic relations to connect noun pairs when the words are presented alone. The levels of processing model (Craik & Lockhart, 1972) describing how information is stored and remembered suggests that people process information to the depth activated by the demands of the task. If nothing more than pronunciation is required, then printed words will be encoded phonemically but not semantically.

The possibility that semantic identities of printed words are learned better if the words are seen in meaningful contexts has some merit. Available evidence on oral reading miscues indicates that syntactic and semantic constraints are very active and exert a strong influence over the word choices a beginner makes as he reads a line of text. When words are misread, substitutes which are syntactically and semantically consistent with the preceding text are produced in their place (Biemiller, 1970; Goodman, 1969; Weber, 1970). This suggests that relevant syntactic and semantic identities are active when beginners encounter new words as they are reading for meaning. If readers identify the words correctly, then this should be a good way to attach appropriate grammatical functions and meanings to printed words, particularly context-dependent words.

Although the context method might be good for learning word meanings, it may not be so good for storing orthographic details. The reader who runs into new words in a text is thinking about meaning. His attention is not directed at component letters, and he spends little time inspecting each word as a separate unit. Furthermore, it is often the case that he can use contextual cues to guess at less familiar printed words and so he has little reason to pay much attention to all the graphic cues. In contrast, the child who studies words printed on flash cards may note and remember much more about word spellings.

In the present study, context and isolation methods of word learning were employed with end-of-the-year first graders who were trained to read 16 words in one of the two ways. Half of the children read the words printed in meaningful sentence contexts. The other half read the words printed singly on flash cards and then listened to meaningful sentences containing the words. Several pre- and posttests were given to assess whether children who always encountered the words in sentences would learn as much about the meanings and spellings of words as children studying the words in isolation. Although isolation subjects were provided with sentence contexts identifying word meanings, this information was presented only after they had pronounced the words. Since meanings were not active at the time isolation learners looked at and decoded words, it was expected that orthographic-semantic amalgamation would be less effective.

In the present study, word learning was assessed in various ways. Orthographic knowledge was measuped by examing subjects' accuracy and speed in reading the words, their ability to spell the words, and their ability to discriminate correct spellings from a set of plausible misspellings. Syntactic/semantic knowledge of word identities was assessed by having subjects produce meaningful sentences containing the words, either sentences like the ones they were given during training or other sentences.

The words selected for training were homonym pairs, that is, words which are identical in sound yet have two different spellings, each associated with a different and distinctive meaning. Homonyms were chosen because we wanted to study the process of attaching meanings to spellings without sound being an important mediating variable. By using homonyms, we insured that being able to pronounce a printed word would not guarantee correct retrieval of its meaning. By making semantic retrieval a variable process, we could assess whether word training exerted a differential effect.

One additional purpose of the present study was to examine the relationship between various beginning reading capabilities and word learning skill. Two types of capabilities were measured, those tapping knowledge of subcomponents of words (i.e., accuracy and speed at naming alphabet letters, ability to sound out and to spell consonant-vowel-consonant (CVC) nonsense syllables), and those tapping knowledge at a lexical level (i.e., number of printed words known, detection of misspellings of words, knowledge of spellings of past-tense verb inflections). Of interest was whether lexical knowledge might prove more central to the acquisition of word identity information than sublexical or letter-sound knowledge. If words are the most important units of printed language and the key to reading acquisition as Ehri's theory suggests, then one might expect children's knowledge of lexical orthographic patterns to contribute more to the word learning process than their sublexical knowledge.

Method

Subjects

The children, 22 females and 15 males, mean age 7.1 years, were taken from the first grade of a middle class elementary school. Children were tested in the Spring. They had undergone 7 to 8 months of beginning reading instruction. Children who had progressed too far or not far enough in the Houghton and Mifflin series were excluded. Subjects retained were those reading in either the second or the final books at the first grade level. Teachers were asked to form matched pairs of subjects based on reading ability. Members of each pair were assigned randomly, one to the isolation condition, one to the printed context condition.

Materials and Procedures

The experimenter worked with each child individually on five occasions. Several pretests were given to measure various aspects of the readers knowledge of printed language. Then word recognition training, either with isolated printed words or with words embedded in written contexts, was provided. Finally, various posttests were administered to measure the effects of word training.

Pretests

Letter Naming. The child was asked to name 25 lower-case letters (all but "x") as fast as possible, to avoid errors, and to skip any he did not know. His performance was timed with a stopwatch.

Homonym and Context-Word Identification. The child was asked to read aloud 167 words presented individually, 16 homonyms plus 151 words to be used in sentence contexts during word training. The latter words were taken from the children's readers.

Recognition of Nonsense Syllable Misspellings. The child was shown spellings or misspellings for 12 CVC sounds pronounced by the experimenter. In three cases, the letters correctly represented the phonemes, and in 9 cases, there were single errors. The child had to detect and correct any misspellings.

Recognition of Word Misspellings. Misspellings of 18 real words were presented. For each word, the experimenter first read a meaningful sentence containing the word (i.e., The boys walk to school.), she repeated the word and then showed the misspelling. In all cases, one letter was missing. For half of the words, the missing letter mapped a phoneme: find, smile, help, away, work, after, there, fish, house. For half, the letter was silent: real, school, like, tree, your, wait, tell, play, walk. The words were presented in random order. The child was asked whether the word was spelled correctly and if not how to correct it.

Four-Choice Discrimination of Target Homonyms. The child was shown 16 cards each displaying a row of four possible spellings for each of the 16 homonyms (i.e., (1) waks (2) whacks (3) wax (4) wex). To make the distractors attractive, they were selected from misspellings produced by subjects in a pilot task. The correct alternative varied between the second, third, and fourth positions on the cards. The experimenter first read a meaningful sentence containing the homonym (i.e., The wax from the candle dripped onto the table.). Then she presented the printed words and had the subject point to the correctly spelled form.

Decoding Nonsense Syllable. Children were told to read aloud eight CVC nonsense stimuli printed on cards: Baf, Har, Nep, Reb, Jin, Fip, Tuk, Vug.

Spelling Nonsense Syllables. Eight CVC nonsense syllables were pronounced by the experimenter, the child repeated the name, and then wrote it out. The CVC forms contained short vowels but were otherwise different from those used above.

Spelling Inflected Verbs. Six past tense verbs were pronounced and the child was asked to write out each. The verbs were chosen so that the inflectional -ED endings did not always map into the two separate phonemes predicted by the letters. In two cases, the letters mapped into a separate syllable (i.e., started, nodded). In two cases, only the final letter -D mapped correctly into sound as a voiced /d/ (i.e., cleaned, turned). In two cases, the letter -D mapped a final voiceless /t/ (i.e., watched, soaped). For each word, the child listened to a defining sentence context (i.e., The boy watched his mother do the dishes.) and then tried to write out the target verb. Scored was the number of times he/she wrote out the inflection correctly.

Detection of Verb Misspellings. The child was shown a misspelled version of the above six verbs. In each of these, the inflection was spelled phonetically: WATCHT, CLEAND, SOAPT, TURND, STARTID, NODDID. The child judged whether each was correct and if not how to make it right.

Word Learning

The following homonym pairs were selected for training: which-witch, wring-ring, rows-rose, choose-chews, bald-bawled, wax-whacks, buries-berries, haul-hall. The homonyms were divided into two sets, A and B, with a member of each pair assigned randomly to one of the sets. During word training, these sets were always taught separately, never mixed. Subjects saw either Set A or B on Day 1, the other set on Day 2, and both sets presented separately on Day 3. The sets were kept separate in order to minimize chances that the child would mix up the homonyms or recognize that he was learning two different words with the same sound. Apparently, this effort was successful. It was not until the posttest when the forms were shown together that any child commented about the fact that the words sounded the same.

For each homonym, four sentence contexts were written to highlight the distinctive meanings of the homonyms. For example, the word "witch" was presented in sentences such as, "Here comes the bad witch." "The witch is hiding in the tree." The other words in the sentences were drawn from the children's classroom texts to insure that context words would be familiar and would thus aid context-reading subjects in learning the syntactic and semantic identities of unfamiliar target words. In addition, supplementary material in the form of questions, instructions or pictures was created for each sentence. These were designed to insure that subjects thought about meanings of the words after they read them. For example, the child might be told to pretend to perform the action he had just read about or heard. Sentences were organized into four blocks so that each homonym occurred once in each of the blocks.

The stimuli were printed on cards. For the printed context condition, each sentence was typed on one line in lower case letters (except for an initial capital) on a 5x8 card. Only the homonym was underlined. For the isolated word condition, each homonym was typed alone on a card.

Subjects were matched according to teacher ratings of their reading ability. Pair members were assigned randomly to learn the homonyms either as isolated words or as part of printed contexts. Each child completed three days of word training during which he read each of the 16 homonyms a total of 16 times. On Day 1, he was exposed twice to four sentences for each member of one homonym set (A or B). On Day 2, he was given four sentences twice for each member of the other set. On Day 3, he read the sentences twice for both sets of homonyms. The sentences were presented in blocks, with each of the eight homonyms included once in each block. The order of the sentences in each block was determined randomly. The order of presentation of homonym sets was counterbalanced among subject pairs.

Children were instructed to read each card, to think about meanings, and also to pay attention to the letters in the words so that they could learn to say the words themselves. (Since most other words were familiar and could be read by subjects viewing sentence contexts, this instruction was presumably interpreted as pertaining mainly to letters in homonyms.) Children were told that after they read each card, the experimenter and the subject would talk about what it meant. Subjects assigned to the printed context condition were shown the cards with sentences and were told to read each aloud. Reading errors were corrected by the experimenter. Subjects assigned to the isolated word condition were shown each homonym printed alone, were told to pronounce it, were corrected if wrong, and then heard a sentence context read by the experimenter. Prior to the learning trials, isolation as well as context subjects were informed that the oral sentence contexts conveyed the words' meanings. During the first presentation of each blocked list, the experimenter presented supplementary material in the form of comments or questions to evoke further semantic processing of the homonyms. During the second presentation of the blocked list, children read the cards with the same sentences but without the supplementary material.

Posttests

Homonym Identification and Sentence Production. Subjects were shown each of the homonyms they had been taught, were asked to read it aloud, and then to recall either exactly or approximately one of the sentences which had accompanied the word. If they could not remember a sentence, they were told to identify the meaning in their own words. In fact, children had no trouble producing sentence contexts. The list of 16 homonyms was presented twice, each in a different order. Pair members were separated by at least two other words on the lists. If a word was misread, the experimenter corrected it before the context was requested.

Two-choice Homonym Discrimination. The subject was shown 32 cards displaying sentences he had heard or read during training. The homonym was replaced by a blank space. Homonym pairs were printed beneath the sentences as Choices (1) and (2). The experimenter read each sentence and then had subject point to the correctly spelled word. Each homonym was tested twice.

Homonym Reading Accuracy and Latency. The subject was shown each set of eight homonyms printed in a column and was told to read them as fast as possible without errors and to skip any he did not recognize. His latencies on Set A and Set B were measured with a stopwatch.

Context Word Identification. This task was identical to the second pretest above except that the target homonyms were not included.

Homonym Spelling. The experimenter read each of 16 sentences taken from the word training task, repeated the homonym from that sentence, and had subject spell the form. Pair members were separated by at least four other words. The subject's previous spellings were covered up as he proceeded through the task.

Four-choice Discrimination of Homonyms. This task was identical to the fifth pretest described above.

Both pretests and posttests were administered to subjects in the order given above.

Results

There were 18 pairs of first graders trained and tested. Complete data were obtained from all but two pairs who missed out on the four-choice homonym discrimination task. One extra subject was trained and tested in the printed context condition, and her responses were included in the correlational analysis reported below.

In order to verify that subjects assigned to the isolation and context training groups were comparable in basic reading skills and familiarity with the target homonyms, their performances on the pretests were subjected to matched-pair *t*-tests (two-tailed). None of these differences was statistically significant ($p > .05$). Mean values are given in Table 7-1.

Insert Table 7-1 about here.

Training methods were successful in teaching subjects in both conditions to pronounce almost all of the target homonyms. Two of the posttests required subjects to read isolated printed homonyms. All but one subject read every homonym perfectly at least once in these tests. (The one exceptional subject always misread one homonym.) Mean values for the two groups are given in Table 7-1. Matched-pair *t*-tests indicated that the groups did not differ in this capability ($p > .05$).

Although all subjects learned to pronounce the homonyms accurately, the two groups did not acquire equivalent information about other aspects of the words' identities. The purpose of the sentence production posttest was to see whether subjects recognized correct meanings for homonyms. In this task, children were shown the printed words and asked to recall one of the training sentences they had been given or to create their own sentence. Mean values are reported in Table 7-1 where it is apparent that the context reading group produced significantly more correct sentences for the homonyms than the isolation group, $t(17) = 3.21$, $p < .01$. This was despite the fact

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Table 7-1

Mean Scores on the Pretests and Posttests

for the Isolation and Printed Context Groups

	Isolation	Context	(Maximum Score)	Standard Deviation
Lexical Pretests				
Read Context Words	134	128 n.s.	(151)	18.9
Word Misspellings	12.7	12.0 n.s.	(18)	3.7
-ED Misspellings	2.0	2.1 n.s.	(6)	2.3
Spell -ED	3.3	3.5 n.s.	(6)	2.4
Sublexical Pretests				
Letter Name Latency (Sec.)	19.1	21.0 n.s.		5.4
CVC Misspellings	10.1	9.3 n.s.	(12)	1.8
Decode CVC	5.8	5.0 n.s.	(8)	2.4
Spell CVC	4.7	4.2 n.s.	(8)	1.9
Homonym Tests**				
Word Reading Accuracy				
Pretest	7.4	5.9 n.s.	(16)	4.2
Posttest (No. 3)	15.9	15.7 n.s.	(16)	0.9
Posttest (No. 1)	31.9	31.6 n.s.	(32)	1.3
Word Read Latency (Sec.)	10.9	15.7 *		5.7
Sentence Production	18.9	22.7 *	(32)	4.7
Discrimination (Two)	23.4	24.4 n.s.	(32)	4.9
Discrimination (Four)				
Pretest	6.6	7.7 n.s.	(16)	2.6
Posttest	11.1	10.5 n.s.	(16)	2.6
Pre-Posttest Gain	+4.4	+2.7 *		+2.4
Discrimination (Four)				
Other Homonym Chosen	3.6	3.5		2.3
Misspelling Chosen	1.4	2.0		1.4
Spelling				
Words Correct	5.1	4.9 n.s.	(16)	3.0
Letters Correct	67.7	63.9 *(sign test)		

*$p < .05$
**Each was a posttest unless otherwise designated

that both groups were exposed to all sentences the same number of times during training. A check of the errors committed by subjects revealed that it was not the case that the isolation group had more trouble remembering the sentences. There were very few instances where subjects failed to recall one of the training sentences. Practically all errors, ~~97%~~, were cases where the sentences were appropriate but for the other homonym. This indicates that the groups differed primarily in their ability to retrieve correct semantic identities corresponding to particular spellings. These findings support the hypothesis that reading words in printed contexts is a better way to help subjects amalgamate semantic identities to orthographic forms than reading words in isolation and hearing contexts.

Whereas context subjects were superior in recognizing the semantic identities of words, the isolation subjects were somewhat more familiar and facile with word forms. The purposes of the homonym discrimination, reading speed, and spelling posttests were to measure children's memory for orthographic details and their facility with the words as units. Results of some of these tests yielded significant differences. Isolation subjects were able to read the list of homonyms about 5 seconds faster than context subjects, $\underline{t}(17) = 3.94$, $\underline{p} < .01$. On the four-choice discrimination task, although posttest scores did not differ, $\underline{t}(15) = 0.83$, $\underline{p} > .05$, the gain in number of words correctly identified from preto posttest was greater among isolation than among context subjects, $\underline{t}(15) = 2.56$, $\underline{p} < .05$. Analysis of the errors committed by subjects in this task revealed that both groups chose the incorrect member of the homonym pair about the same number of times. The major difference distinguishing the two groups was that context subjects tended to select a misspelling more often than isolation subjects. However, the means were small (see Table 7-1) and this difference fell short of significance, $\underline{t}(15) = 1.62$, $.05 < \underline{p} < .10$.

If it is true that isolation subjects were more attentive to orthographic details than context subjects, one would expect spellings to reflect this. However, as evident in Table 7-1, mean values on the spelling test did not differ, $\underline{t}(17) = 0.25$, $\underline{p} > .05$. Furthermore, the means were quite low. In this task, the experimenter read a sentence containing each homonym and had subjects write the word. To receive credit, subjects had to record the correct member of the pair and spell it perfectly. We reasoned that such a strict scoring method might be insensitive, particularly since isolation subjects did not learn semantic identities so well. Perhaps if we accepted either homonym and also gave credit for partially correct spellings, we might detect differences. We adopted a different scoring criterion and counted simply the number of letters recorded which were correct for either of the two homonyms. To illustrate, if a child wrote WHITCH for either "which" or "witch" he was given a score of six for that spelling. (Such blended spellings were observed occasionally.) If he wrote BARRES for "berries" or "buries," his score was five. Because the distribution of scores was skewed, a matched-pair sign test was used. Comparison of the pairs of scores revealed that disproportionately more of the isolation subjects (i.e., 14 out of 18) had higher letter scores than their context mates, $z = 2.12$, $p < .05$. Mean scores are given in Table 7-1. These findings combined with those above offer support for the hypothesis that studying words in isolation is a better way for readers to learn about orthographic identities than reading words in contexts where attention is directed at meanings rather than form.

Subjects in the context group received practice reading printed sentence contexts as well as homonyms. Though these background words were taken from the children's classroom texts, most subjects were not able to read all 151 words on the pretest. Comparison of pre-and posttest performances revealed that all but two context children showed gains in the word identification task (mean gain = 10.3 words). (The two exceptions recognized almost all the words at the outset.) Isolation subjects, who did not practice reading these words but simply heard them, displayed a mean gain of only 2.0 words, with 8 of these subjects showing no gains. Thus, context reading yielded one additional benefit not available to isolation subjects. These children learned to recognize several additional printed words.

A secondary purpose of the present study was to compare the importance of lexical and sub-lexical knowledge for word learning processes. Lexical knowledge refers to the reader's knowledge of printed word forms, structural as well as word-specific. Measures of lexical knowledge included the number of printed words children could read, the number of word misspellings (i.e., omitted letters) they could detect and correct when the letters were pronounced and when they were silent, the number of verb inflec- tions spelled correctly, and the number of verb inflection misspell- ings noted and corrected. Measures of sub-lexical knowledge consisted of letter naming speed, decoding and spelling CVC nonsense syllables, and recognition-correction of CVC misspellings.

Correlation coefficients were examined to determine whether lexical or sub-lexical capabilities contributed more to processes involved in learning semantic and orthographic identities of homonyms. Results are reported in Table 7-2. Inspection of the significant correlations involving sentence production scores, the measure of semantic identity learning (Variable 10), revealed that only the lexical measures (Variables 1-5), not the sub-lexical measures (Variables 6-9), correlated with performance. Inspection of

Insert Table 7-2 about here.

the significant lexical and sublexical correlations involving the orthographic measures -- homonym spelling (Variable 12) and fourchoice discrimination (Variable 13) -- indicated that lexical correlations (Variables 1-5) were generally higher than sub-lexical correlations (Variables 6-9).

The four-choice homonym discrimination task (Variable 13) had been given as a pretest. In order to examine correlations between this

Table 2

Statistically Significant Correlation Coefficients Between Measures (N = 37 Subjects)

	Lexical 1	2	3	4	5	Sublexical 6	7	8	9
Pretest-Lexical									
1. Read Context Words	--								
2. Silent Misspellings	.59**	--							
3. Pronounced Misspellings	.64**	.72**	--						
4. -ED Misspellings	.50**	.61**	.45**	--					
5. Spell -ED	.59**	.59**	.50**	.70**	--				
Pretest - Sub-lexical									
6. Letter Name Latency	-.63**	-.18	-.32	-.12	-.17	--			
7. CVC Misspellings	.42**	.20	.48**	.17	.24	-.05	--		
8. Decode CVC	.54**	.50**	.70**	.45**	.39*	-.15	.44**	--	
9. Spell CVC	.58**	.38*	.66**	.38*	.36*	-.28	.60**	.82**	--
Posttest - Homonyms									
10. Sentence Production	.45**	.52**	.39*	.61**	.58**	-.06	.13	.28	.31
11. Word Read Latency	-.78**	-.34*	-.46**	-.24	-.31	.74**	-.25	-.35*	-.43**
12. Spell	.63**	.70**	.69**	.67**	.69**	-.30	.17	.53**	.47**
13. Discriminate (Four)	.73**	.70**	.57**	.64**	.66**	-.28	.36*	.49**	.47**

*$r \geq .33$, $p < .05$

**$r \geq .42$, $p < .01$

Table 2 (Cont'd.)

Statistically Significant Correlation Coefficients Between Measures (N = 37 Subjects)

Posttests

	10	11	12	13
	Partial Correlations			
Pretest-Lexical				
1. Read Context Words	.37*		.48**	.63**
2. Silent Misspellings	.46**		.59**	.60**
3. Pronounced Misspellings	.28		.53**	.36*
4. -ED Misspellings	.56**		.57**	.54**
5. Spell -ED	.53**		.58**	.58**
Pretest - Sub-lexical				
6. Letter Name Latency				
7. CVC Misspellings				
8. Decode CVC				
9. Spell CVC				
Posttest - Homonyms				
10. Sentence Production	--			
11. Word Read Latency	-.07	--		
12. Spell	.68**	-.40*	--	
13. Discriminate (Four)	.59**	-.51**	.68**	--

*$r \geq .33$, $p < .05$

**$r \geq .42$, $p < .01$

measure and lexical and sub-lexical measures with the effects of pretest knowledge removed, partial correlation coefficients were calculated. Out of eight correlations, three, all lexical, were significantly greater than zero: reading context words (Variable 1), $r = .68$, $p < .01$; silent letter misspelling (Variable 2), $r = .62$, $p < .01$; pronounced letter misspelling (Variable 3), $r = .55$, $p < .01$. Decoding CVC's (Variable 8) just missed significance, $r = .37$, $.05 < p < .10$.

To further confirm the greater importance of knowledge at the lexical than the sublexical level for learning the orthographic and semantic identities of words, partial correlations were calculated. This was necessary because lexical and sublexical tasks were significantly correlated with each other. It was expected that even when sublexical knowledge was partialed out, the correlations between lexical knowledge and homonym scores would remain significant. The sublexical measure chosen to be partialed out was the CVC decoding measure (Variable 8). Results are reported on the second page of Table 7-2. They were for the most part consistent with expectations. Correlations remained significant except in the case of Variable 3 (recognizing pronounced letter misspellings) which bore the highest correlation with the sublexical CVC variable ($r = .70$). Very likely, this task reflects lexical knowledge less adequately than the other tasks since, unlike the others, success is possible using sublexical letter-sound knowledge. In sum, these results offer evidence for the greater contribution of lexical than sublexical knowledge in learning word identities.

Performances in the two verb inflection pretests were examined in order to determine whether children who produced the ED inflection correctly in their spellings also recognized when this form was misspelled. The misspellings were thought to be attractive because they mapped the final sounds in the verbs phonetically (i.e., WATCHT, STARTID). Scores of the children were classified as high or low in each task. Results are given in Table 7-3. There were 19 children who produced ED correctly in most of their spellings. However, nine of these subjects subsequently accepted most of the phonetic

Insert Table 7-3 about here.

misspellings as correct also. Some of these children recognized the discrepancy but decided that the phonetic forms were preferable: "It sounds better so it must be right." In contrast, other children also recognized the discrepancy but proclaimed their awareness of the lexical regularity and stuck with their earlier answers, stating that they were sure ED was right "even though you don't hear it." These responses disclose an instance where knowledge of lexical patterns is in competition with the principle that letters map their sounds. It is interesting that there were a number of children who "knew better" yet were persuaded by the letter-sound rule. Others recognized the lexical pattern as a different type of regularity from the letter-sound

Table 3

Number of Children Receiving High and Low Scores (Maximum = 6) in the Verb Inflection Spelling Tasks

Recognition of -ED Misspelling	Production of -ED Low (0-3)	High (4-6)	Total
Low (0-3)	17	9	26
High (4-6)	1	10	11
Total	18	19	37

consistency principle. Achievement of this awareness may represent important progress in the acquisition of reading competence.

Discussion

Findings of the present study indicate that there is merit in distinguishing and studying several aspects of printed words as they are learned by beginning readers. Results are interpreted as offering support for the word identity amalgamation view. Results showed that the particular aspects of words which get noticed and stored in the lexicon are influenced by readers' experiences. Reading words in printed contexts appears to be a better way to amalgamate meanings to print than reading words on flash cards and listening to meanings. The explanation for the advantage of contexts is that when words are read, appropriate syntactic and semantic cues are activated at the time the reader looks at the graphic form. Information such as the word's grammatical role, its position relative to other words, and its semantic features thus become attached to graphic cues. In contrast, when words are viewed and pronounced in isolation, the reader thinks only minimally about syntax and meaning.

Although context readers learn more about word meanings, they appear to learn less about the orthographic identities of words than subjects studying the words on flash cards. The advantage thought to be provided by isolated word training is that readers have more time to study words as separate units, to analyze letter details, to note how letters map sounds, and to store more complete images in their lexicons.

Although a particular type of word was selected in the present study, the intent was to obtain results which could be generalized to the learning of all types of words. It is important to review the rationale for this choice. Homonyms were selected because it was thought that they would better expose the process of amalgamating meaning to print. If words with unique pronunciations and single meanings had been taught, this would have provided subjects with two routes into the lexicon. If recognition based on orthographic cues had failed, they could have used sound to access meaning. This would have boosted performance close to ceiling on the sentence production task measuring meaning recognition, and differences as a function of word training methods would not have been exposed. By teaching homonyms, we were able to reduce the importance of sound and to place the burden of semantic retrieval on orthography. Note that we are not interpreting present findings as evidence that readers depend less upon sound than upon print, or that they go directly from print to meaning and bypass sound. Such inferences would be inappropriate since the study was set up to limit the role of sound. Rather this experiment was intended simply to explore the process of accessing meaning from print and to determine whether one method of word learning might contribute more than another.

The question of how readers learn to attach meanings to print is important to address. Recent evidence has indicated that beginning

ERIC

readers do not depend upon phonemic recoding in their recognition of printed words which are familiar. Rather they appear to extract meanings directly from print (Barron, 1977; Barron & Baron, 1977; Rader, 1975). What mechanism underlies this is not known. It may be that a direct path is established from the start as words are learned (Baron and Treiman, 1980) or it may be that the phonemic recoding step drops out once orthographic forms become amalgamated to the word's other identities and established as a visual image in memory (Ehri, 1980-a). Present results contribute by suggesting that if children are able to recognize meanings directly from print, they are more apt to acquire this capability by reading printed words in meaningful contexts than in isolation.

A secondary purpose of the present study was to distinguish two types of word learning skills: knowledge of sublexical units (i.e., letter names, single letter-sound correspondences) and knowledge of lexical orthographic patterns which do not map letter-by-letter into sounds. Results indicate that this distinction does appear to characterize two aspects of the reader's knowledge of printed language. The conflict between lexical and sublexical types of orthographic regularity was apparent in the reactions of children to the variable mappings of -ED in the verb inflection spelling tasks. Also, in the misspelling recognition task, children were successful in detecting the absence of silent as well as pronounced letters in familiar words ($\bar{X}$ = 6.0 silent vs. 6.1 pronounced letters correct), indicating that they had acquired orthographic information extending beyond single letter-sound relationships to include the whole word. Baron (1979) reports evidence for a similar distinction, between the use of letter-sound rules and the use of word-specific paths in learning to read words.

The main reason for distinguishing lexical and sublexical skills in the present study was to compare their contributions to the process of learning orthographic and semantic identities of words. As expected, results favored the importance of lexical skills. These results are consistent with Venezky's (1970) analysis which reveals that the heart of the system of orthography as a map for speech is not at the single letter-sound level but at a lexical level entailing patterns of letters co-occurring within words. To progress very far in learning to read English, findings suggest that it may be more important for readers to acquire knowledge of lexical patterns than single letter-sound relationships. Of course, these results are correlational and any causal inferences await verification. Regardless, present findings underscore the importance of distinguishing and studying both types of knowledge as they emerge, interact, and contribute to the process of learning printed words.

Chapter 8: Do Beginners Learn to Read Function Words Better in Sentences or in Lists?

A major hurdle in learning to read is learning to pronounce and to recognize the meanings of printed words accurately and rapidly both in and out of meaningful contexts (Baron, 1977; Barron, 1978; Clay, 1969; LaBerge & Samuels, 1974; Perfetti & Lesgold, 1977; Shankweiler & Liberman, 1972). The present study was intended to explore experiences which influence the printed word learning process among beginning readers. This study follows on the heels of previous studies and was conceptualized according to a theory of printed word learning (Ehri, 1978; in press-a; in press-b; Ehri and Wilce, 1979). Central to this theory is the concept of a lexicon comprised of words having several different identities: a pronunciation or phonological identity; a typical role in sentences or syntactic identity; a meaning or semantic identity. These identities are acquired when children learn to speak. Another identity is added when children learn to read: a visual letter-analyzed image or orthographic identity. In order for orthographic images to become established in memory, readers must possess enough knowledge of orthographic-speech mapping patterns so that spellings are processed as symbols for component sounds detected in word pronunciations. In this way, orthographic identities are amalgamated with phonological identities. Also, orthographic images must come to symbolize syntactic functions and meanings. This develops as readers see and interpret printed words in the context of meaningful sentences. When the various identities of specific words are amalgamated in memory, readers become able to glance at their printed forms and recognize them at once. They can pronounce them accurately and quickly. They can identify at least some of the letters in their spellings. And they can illustrate how the words function in sentences.

From this description, it is apparent that there are a number of aspects of printed words for readers to learn. Ehri and Roberts (1979) examined to what extent acquisition of these aspects might be influenced differentially by two types of word learning experiences, one where readers learned the words in printed sentences, another where readers studied the words on flash cards. The words taught were homonyms, that is, words with different spellings but identical pronunciations (i.e., buries - berries, which - witch, bald - bawled, wax - whacks). These words were chosen because they present special semantic amalgamation problems. Readers must learn which spellings go with which meanings without the aid of pronunciations. First graders who could not read many of the words were selected. Half of them practiced reading the words in sentence contexts. Half read the words in isolation on flash cards and then listened to the same sentences. As expected, the two experiences were found to influence word learning differently. Context reading boosted acquisition of the syntactic-semantic identities of words (i.e., context readers were better able to embed printed homonyms in sentences depicting their correct meanings). However, flash card reading enhanced knowledge of orthographic identities and their amalgamation to pronunciations (i.e., isolation readers read the words faster and knew more of their

ERIC

letters). The explanation for the advantage of sentence reading is that appropriate syntactic and semantic identities were activated for words at the time readers looked at their graphic forms, and so this information became amalgamated to the orthographic images stored in memory. The explanation for the advantage of flash cards is that readers spent more time looking at the words and were forced to rely on letter-sound processing to pronounce the words. This resulted in the storage of more complete information about orthographic identities and how they symbolized phonological identities.

The purpose of the present study was to determine whether these findings would generalize to another class of words also thought to create identity amalgamation problems for beginning readers. Function words, that is, words dependent upon contexts for their meaning (i.e., prepositions, conjunctions, auxiliary and past-tense verbs, relative pronouns) are not familiar to young children. In studies comparing readers' and prereaders' ability to perform various operations with context-dependent words (Ehri, 1975, 1976, 1979), we found that prereaders often did not recognize these as real words when the words were pronounced in isolation. They had difficulty distinguishing them from nonsense words, embedding them in meaningful sentences, detecting their presence in spoken sentences, pulling them out of sentences, and remembering them as responses in a paired associate learning task. Children had much less trouble when the words were meaningful nouns and adjectives. Also, children who had learned to read function words performed these tasks easily.

The present study was intended to see whether the process of learning printed function words would be influenced by the way beginning readers studied these words. First graders were selected. Half practiced reading the words in meaningful sentences. The other half practiced the words in unstructured lists and then listened to the words rearranged into meaningful sentences. Various pre- and posttests were given to assess the effects of training on subjects' knowledge of word identities. It was expected that context readers would learn more about syntactic/semantic identities of printed function words whereas list readers might learn more about their orthographic identities as they had in the previous study. This hypothesis seemed especially important to test since function words are among the first taught to beginners as part of sight vocabulary lists and there is controversy about how instruction should be handled (Goodman, 1965; Hood, 1974; Smith, 1973).

There have been other investigations of printed word learning in beginning readers. Samuels (1967) showed that if pictures accompany printed words, learning is slower than if the words are studied in isolation. Singer, Samuels and Spiroff (1974) compared the effects of sentence contexts as well as pictures and found that learning was less efficient in both cases. These studies differ from the present in that only one aspect of printed word learning was assessed, the ability to pronounce words. As Ehri and Roberts (1979) showed, contexts may retard the process of amalgamating orthographic to phonological identities, but it may aid in amalgamating orthographic to semantic identities. Before concluding that one method is best, it is essential to examine all aspects of the process.

Method

Subjects

Pretesting was used in two middle class elementary schools to select 40 first graders, 18 males and 22 females, mean age 80.8 months. Subjects selected were those who could decode no more than six of the target words and who could be paired with another child scoring similarly on the target word identification test and other pretests. Pair members were assigned randomly to the context and isolation groups. The experiment was conducted in the fall and winter.

Materials and Procedures

The experimenter worked with each child individually on 7-9 occasions to complete the pretest, word training and posttest phases of the experiment. Although there was some variation in scheduling between pairs, members of the same pair received identical treatment. Except where noted, the tasks were presented in the order listed below. Posttests were begun on the day following the final day of word training. All sessions were tape recorded.

Pretests

Word identification. Children read aloud 85 common high frequency words, each printed on a card. These included the 10 target words to be taught plus 47 supplementary words to be used during training and 28 words providing the sentence contexts for the cloze posttest. Mixed in with the words were 19 pictures to be used as symbols for 16 nouns and 3 colors during training. Children named these and were assisted by the experimenter. The pictures were included to maintain the motivation of children unable to read many of the printed words and also to introduce the symbols.

Letter naming. The child was asked to name 25 lowercase letters (all but L) as fast as possible, to avoid errors, and to skip any he did not know. His performance was timed with a stopwatch.

Familiar word spelling. From the nontarget words each child successfully recognized on the word identification task, 6-10 were selected to be written out. Although the particular words varied somewhat between subject pairs, members of the same pair spelled the same words. The dependent measures were the proportions of words and letters written correctly.

Letter-sound knowledge. Children were shown 9 single consonants, 6 consonant pairs (ch, st, sh, th, wh, fr) and 4 vowels (a, e, i, u), and they were asked to produce the typical sound each symbolized. If unsuccessful with the vowels, they were shown a CVC nonsense word and asked to give the vowel sound. They were also given six nonsense words to blend: bif, nep, tuk, zine, rame, rity. The dependent measure summarizing this skill was the total number of correct responses.

Sound learning aided by letter mnemonics. This task developed by Ehri and Wilce (1979) was included in order to assess children's ability to use letters to store sounds in memory. Subjects were given several trials (maximum of 7) to learn four CVC nonsense sounds in a paired associate task. The sounds were: wek, lut, fip, mav. The stimulus prompts were the initial letters of each unit. The anticipation method was used. On the first trial and after each recall attempt, children were shown a spelling of the unit. They were told to pay attention to the letters because they would help them remember the sounds. Used as the dependent measure to compare subjects was the number of sounds correctly recalled on Trial 3.

Printed Word Learning

Ten context-dependent words were selected for training: gave, might, very, while, which, must, both, from, should, enough. For each, three meaningful sentences (4-9 words long) were written. The supplementary words in the sentences were drawn from a set of 47 words. Pictographs symbolizing meanings (or sounds in the case of a few words like "for" - 4, "be" - B, "are" - R) were created for all but 7 function words. Each sentence or list was printed on a separate card. Sentences were printed in rows. Lists displaying the same words but in scrambled order were printed in columns. The supplementary words were printed with pictographs appearing above each word. The reason for including pictographs was to make it easier for children to identify non-target words and for those in the context treatment group to combine the words into meaningful sentences. Some of the sentences are illustrated in Figure 8-1.

Insert Figure 8-1 about here

The first step was to teach subjects to identify all 47 supplementary words. Each was printed on a card. The words were grouped for presentation into sets: function words; people names; animal and object names; actions; feelings and object characteristics. For each word, the experimenter explained how the pictograph represented the concept. To teach function words, attention was drawn to letter-sound corre- spondences, and short sentences were given to illustrate the function words. Each set was practiced to a criterion of two perfect trials. Then the sets were reviewed together once in order and twice mixed up. All children were successful in learning to identify all of the supplementary words.

Training on the target words came next. It was structured so that the two treatment groups read the target and supplementary words the same number of times and responded to the meanings of the sentences in the same way. The critical difference between the groups was that the context group read the target words in sentences while

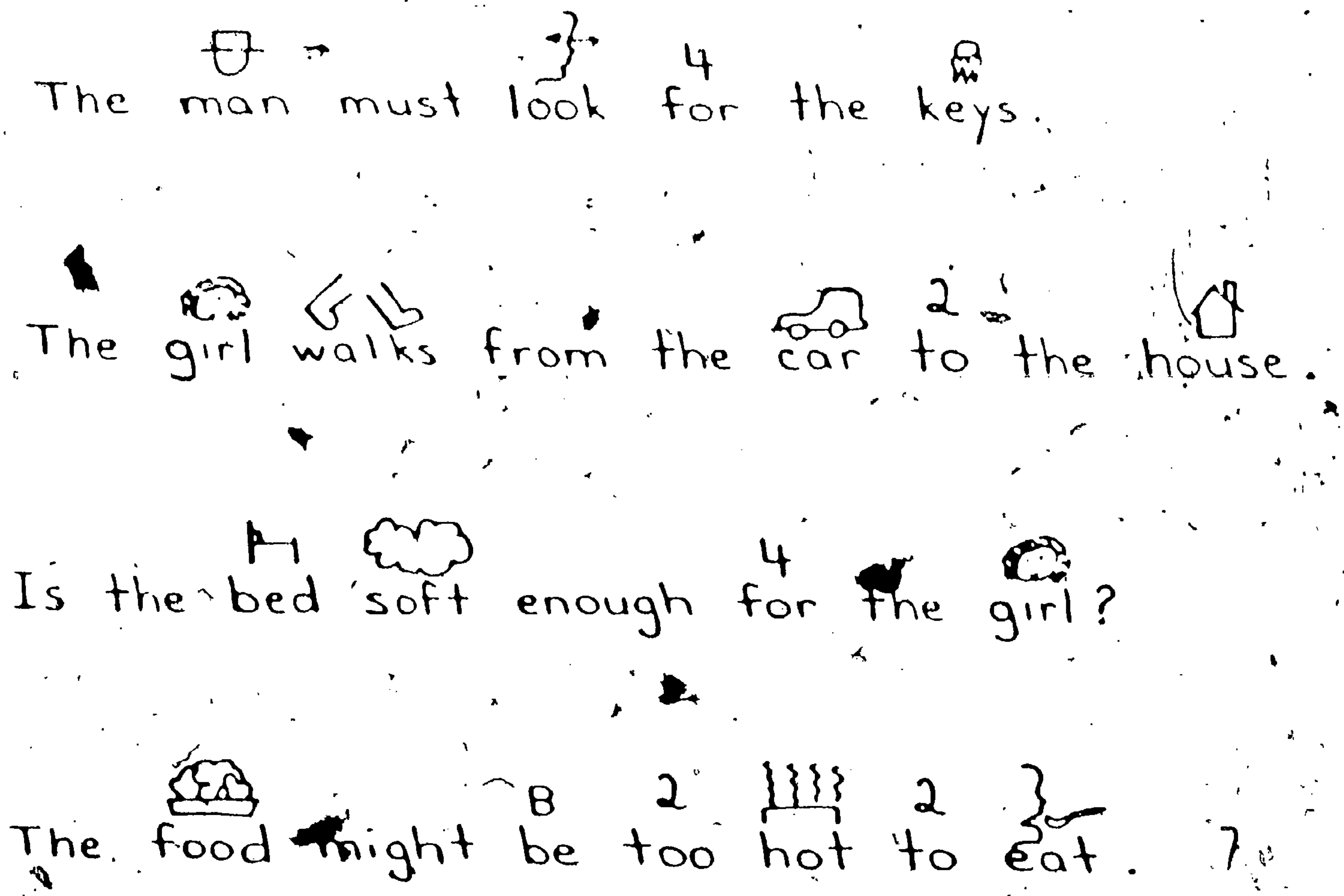

Figure 8-1. Examples of sentences read during training.

the isolation group read the words in non-meaningful lists and then heard the sentences. Context subjects were told by the experimenter that the words they would read "go together to say something to you, so as you are reading, think about what the words are saying." Isolation subjects were told, "First you'll read the words. Then I will tell you how the same words can go together to say something to you."

Subjects read through each sentence or list twice in succession on each of four trials. If target or supplementary words were misread, the experimenter pronounced the word, pointed out how letters mapped sounds and which letters were silent, and had children pronounce the word correctly. On the first trial, the three sentences for each target word were presented together in succession. On subsequent trials, the same sentences reappeared but in mixed order with at least two other target-word sentences intervening.

During Trial 1, after each sentence was read or heard, a discussion of its meaning commenced. A picture or object was presented, and the child was given a question or directive which required applying the meaning of the sentence to the picture or object. To illustrate, for the target word "very," children read or heard "The girl looks at the very fat pig," then saw a picture of a girl looking at two pig pictures. The experimenter's directive was, "Show me the one." For the word "should," children read or heard, "The dog should not sit on the car," then saw a picture taken from a book about Clifford, the big red dog, in which Clifford is crouched next to a small smashed car. The experimenter's question was, "How come?" On subsequent trials after reading or hearing each sentence, children were asked to remember the picture they saw before and the same question was asked. The picture was presented after their answer or if they could not remember it.

Posttests

Spelling production. Each target word was pronounced, children repeated it and then wrote it out.

Spelling recognition. Children were shown four possible spellings of each target word. To make misspellings attractive, they were selected from those produced by first graders in a pilot task. The correct spelling appeared in the 2nd, 3rd, or 4th position on the card. The experimenter pronounced the word, subjects repeated it and pointed to their choice.

Target and supplementary word identification. Children attempted to read aloud 43 of the supplementary words which had accompanied the target words during training. Each appeared on a card without its pictograph. Next, they read aloud the 10 target words listed in a column. They were told to proceed rapidly but to avoid mistakes and to skip any unknown words. Their latency on the list was timed with a stopwatch. The target words were presented again, this time individually on cards, and children pronounced each without any time pressure.

Sentence production. Children read each target word on a card, they were corrected by the experimenter if necessary, and then they attempted to show they knew what the word meant by embedding it in a meaningful sentence, either one of the training sentences or one of their own creation. Sentence productions were classified as complete (full sentences containing reference-denoting words and making good sense), questionable (sentences with odd meanings; sentences abbreviated with pronouns and general verbs such as "do;" incomplete sentences consisting of phrases), or unacceptable (anomalous or ungrammatical sentences; no response). The reliability of these classifications was verified by a second rater who classified 93% of the sentences identically.

Multiple choice cloze. This task was given to 6 pairs of subjects who were required to read sentences and select which of four target words belonged in a blank space. The task proved unsatisfactory. It was time-consuming to administer. Some first graders never learned to respond readily. Rather than glance over the four word choices and select the correct one, they would stop and read each word aloud, thereby disrupting the syntax of the sentence, or they would proceed by trial and error through the word choices, embedding each in the sentence. Difficulties were not limited to one group. Thus, this task was dropped and replaced by the sentence anagram task for 13 subject pairs.

Sentence anagram. This task was intended to assess subjects' knowledge of the grammatical role of target and pictograph words. Subjects were shown sets of 5-8 words in mixed up order, each word printed on a small cardboard square, and they were told to figure out how the words go together to make sense. It was expected that since context subjects had experienced all the words in sentences, they would be able to form sentences more accurately and faster than isolation subjects. There were 10 sentences, one for each target word. The remaining words were drawn from the supplementary words taught during training. Each was printed with its pictograph. All of the sentences differed from those used during training.

Before constructing these sentences, subjects practiced to criterion on four non-target word sentences. For each construction, subjects were shown the words in mixed up order with the target word always near the end. First they identified orally all the words, and then on signal they tried to rearrange the squares to form a meaningful sentence. This latter response was timed with a stopwatch. If subjects were unsuccessful, the experimenter prompted a second attempt by lining up the first two words in the sentence. The sentence anagram task was always given after the word detection task.

Word detection. This task was intended to measure subjects' awareness of target words as functional units with syntactic and semantic identities. Twenty sentences 8-14 words in length were written, two sentences burying each target word at least four words from the beginning and four words from the end of the sentence. (All sentences were different from those presented during training.) In

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half of the sentences, the boundary sounds of the target word overlapped with adjacent word sounds (i.e., "The green garden frog gave vegetables to the hungry rabbit."). In the other half, the sounds were different (i.e., "The rich grandfather gave dollar bills to the needy children."). The sentences were tape recorded. Intonation patterns were prescribed for each sentence so that minimal stress and pitch were assigned to target words. The order of the sentences was random except that recurrences of the same target word were always at least five sentences away. Each sentence was repeated once in succession on the tape.

Before responding to each sentence, children were shown four target words to read. If any errors ocurred, the experimenter corrected them and had children reread the four words. Then they listened to the sentence and reported whether they heard any of the printed words and if so which one. If unsuccessful, they reread the words and listened to the sentence again. They were allowed 5 seconds to respond. Prior to beginning the task, they received practice with two non-target-word sentences.

Results

To verify that context and isolation groups did not differ in any important way, matched pair t-tests were performed on eight pretest scores. Mean values are reported in Table 8-1. Differences were

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Insert Table 8-1 about here

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insignificant on all but one test. Children assigned to the isolation group were unexpectedly more accurate in naming alphabet letters than subjects in the context group, $t(19) = 2.94$, $p < .01$. However, inspection of scores revealed that the mean difference was very small, less than one letter ($\bar{X} = 0.65$ letters). Of the 20 pairs, scores of only four differed by more than one letter, with three being the largest discrepancy. Pairs did not differ significantly on the other measures considered more relevant for learning words: word identification and spelling; letter-sound knowledge; letter-aided sound memory. And pairs were identical in their ability to read the target words. Nevertheless, to check for effects of this bias in subsequent analyses, posttest comparisions favoring the list group were verified on a subgroup of 10 pairs who did not differ in their knowledge of letter names. (See results below.)

Effects of word training were assessed with several posttests designed to measure different aspects of printed word learning. Knowledge of the orthographic identities of words was measured in a spelling production and a spelling recognition task. The extent to which spellings were amalgamated to pronunciations was assessed by measuring subjects' accuracy and latency in reading a list of target words. Knowledge of the syntactic/semantic identities of words was

Table 8-1

Mean Scores on the Pretests and Posttests as a Function

of Printed Word Learning Condition

Pretests	Context	Isolation	t-value[a]	Maximum Score
Word identification				
Target	2.2	2.2	.00 n.s.	10
Other	43.1	43.4	- .42 n.s.	75
Letter name errors	1.15	0.50	2.94 **	25
Latency	23.4	23.4	- .05 n.s.	(sec.)
Familiar word spell.	55%	2%	.58 n.s.	100%
Letters	85%	85%	.00 n.s.	100%
Letter-sound knowledge	18.9	18.9	- .05 n.s.	25
Sound learning (Trial 3)	1.4	1.5	- .31 n.s.	4
Posttests				
Spelling - Words	2.25	3.15	-2.44 *	10
Letters	29.9	33.8	-3.01 **	47
Spelling recognition	7.1	8.5	-2.65 **	10
Word identification				
Target timed	7.2	8.2	-1.96 *	10
Target untimed	8.2	9.4	-3.09 **	10
Latency (sec./word)	2.83	1.80	-2.52 **	-
Supplementary	38.3	40.4	-3.05 **	43
Gain (pre to post)	+11.8	+13.6	-2.00 **	-
Sentences - Complete	7.6	5.2	3.47 **	10
Questionable	1.3	2.9	-3.04 **	10
Word detection	15.5	13.2	2.14 **	20
Anagram	7.0	7.1	-.10 n.s.	10
Mean latency[b]	2.66	2.84	-.82 n.s.	

[a]Asterisks denote a significance difference on matched-pair t-test: *$p < .05$, ** $p < .01$. A nonsignificant difference is n.s. Two-tailed tests were used for pretests, one-tailed for posttests.

[b]Mean number of seconds per word calculated only for sentences taking the child less than 30 sec. to construct. Only 13 pairs of subjects were given the anagram task.

measured in three tasks: one where subjects embedded the target words in meaningful sentences; one where subjects listened for the presence of target words in spoken sentences; and one where subjects unscrambled words to form sentences. The dependent measures were the number of correct responses and/or the number of seconds to respond. List readers' scores were subtracted from their sentence reader mates' scores and these differences were subjected to matched-pair t-tests.

Results confirmed hypotheses. Mean values are given in Table 8-1. Whereas children who read function words in meaningful sentences learned more about their syntactic/semantic identities, children who read the words in unstructured lists learned more about their orthographic identities and about their spellings as symbols for sounds. As revealed in Table 8-1, context learners received significantly higher scores in the word detection and sentence production tasks. In creating sentences, contexts subjects supplied more semantically coherent and complete environments for target words whereas isolation subjects gave more abbreviated or partial sentences or sentences with questionable meanings. However, isolation subjects outperformed context subjects in spelling the target words, recognizing correct spellings, and reading the words quickly and accurately. Furthermore, they learned to read more of the supplementary words without pictographs than context subjects.

There was one task which failed to yield the predicted difference. Sentence readers did not outperform list readers on the anagram task. Both groups unscrambled about the same number of sentences correctly, and their mean latencies (seconds per word) on sentence constructions consuming less than 30 seconds were not significantly different. (See Table 8-1.) One factor boosting the performance of list readers, and hence limiting the sensitivity of this measure to word training effects, may have been that subjects had already learned to read some of the supplementary words prior to the experiment ($\bar{X}$ of list readers = 27 words correct out of 43 on the pretest). Thus, their ability to construct sentences was not solely a function of their word training experiences in this experiment.

To verify the superiority of list readers on the spelling and word reading tasks with letter naming skill differences removed, matched-pair t-tests were conducted on 10 pairs whose members scored identically on this pretest. The differences were still significant at $p < .05$ except in the spelling production task where the difference in number of words spelled correctly was significant at $p < .10$. This confirms the pattern reported above. These findings are consistent with those in our homonym word learning study (Ehri & Roberts, 1979). They reveal that reading for meaning facilitates the process of attaching syntactic/semantic identities to printed words whereas decoding experiences with lists of words promotes learning their orthographic and phonological identities.

To examine the course of word learning of the two groups, their oral reading errors were tallied. On each trial, children read 30 sentences of lists, each twice in succession. On the first trial, the

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three sentences or lists for each target word were presented together. On subsequent trials, they were mixed up. The experimenter responded to any errors by pronouncing the word and then pointing out letter-sound correspondences. Since list reading subjects did not have any meaningful contexts to help them identify target words, they might be expected to make more errors than sentence reading subjects. This is what happened. Results are displayed in Figure 8-2. An analysis of variance on the number of word errors during the first and second readings over trials for each group revealed a main effect of trials, $F(3,57) = 66.29$, $p > .01$, a main effect of repetition, $F(1,19) = 52.50$, $p < .01$, and interactions between trials by repetition, $F(3,57) = 48.57$, $p < .01$, and between training condition by trials by repetition, $F(3,57) = 4.78$, $p < .01$. As evident in Figure 82, list reading subjects made more errors than sentence reading subjects.

Insert Figure 8-2 about here

These results reveal that one of the reasons why list readers acquired more information about orthographic identities was that the inadequacy of their knowledge was exposed so that the experimenter could intervene and help correct it. In the case of sentence readers, the presence of meaningful contexts had the effect of propping up performance/but at the expense of learning orthographic identities completely enough to be able to read the words outside of contexts. This effect of sentence contexts is similar to the effect of pictures on printed word learning reported by Samuels (1967, 1970). Gagne (1962) identifies other instances of this phenomenon where performance is propped up but at the expense of learning.

In the present study, pictographs accompanied non-target words to enhance the ease of word identification during training. Despite these prompts, subjects in the sentence reading as well as list reading groups learned to recognize several of these words from their orthographic forms alone. Scores rose from a mean of 26.7 words recognized on the pretest to a mean of 39.3 recognized on the posttest (maximum = 43), a gain of 12.6 words. It suggests that first graders were not ignoring graphic cues and responding only to picture prompts. Perhaps the experimenter's method of pointing out letter-sound relations contributed to the gain. For some pictographs where multiple labels were possible, it was necessary to notice letters to produce the correct word. These results show that the presence of pictures does not preclude acquisition of information about printed words.

One factor possibly boosting the performances of list readers in the tasks measuring knowledge of syntactic/semantic identities of function words was that some of them were observed attempting to create meaningful phrases out of the word lists. For example, one list reader after pronouncing "the while children" asked, "The wild children?" After completing a few training trials, some list readers indicated that they recognized the spoken sentence as being comprised

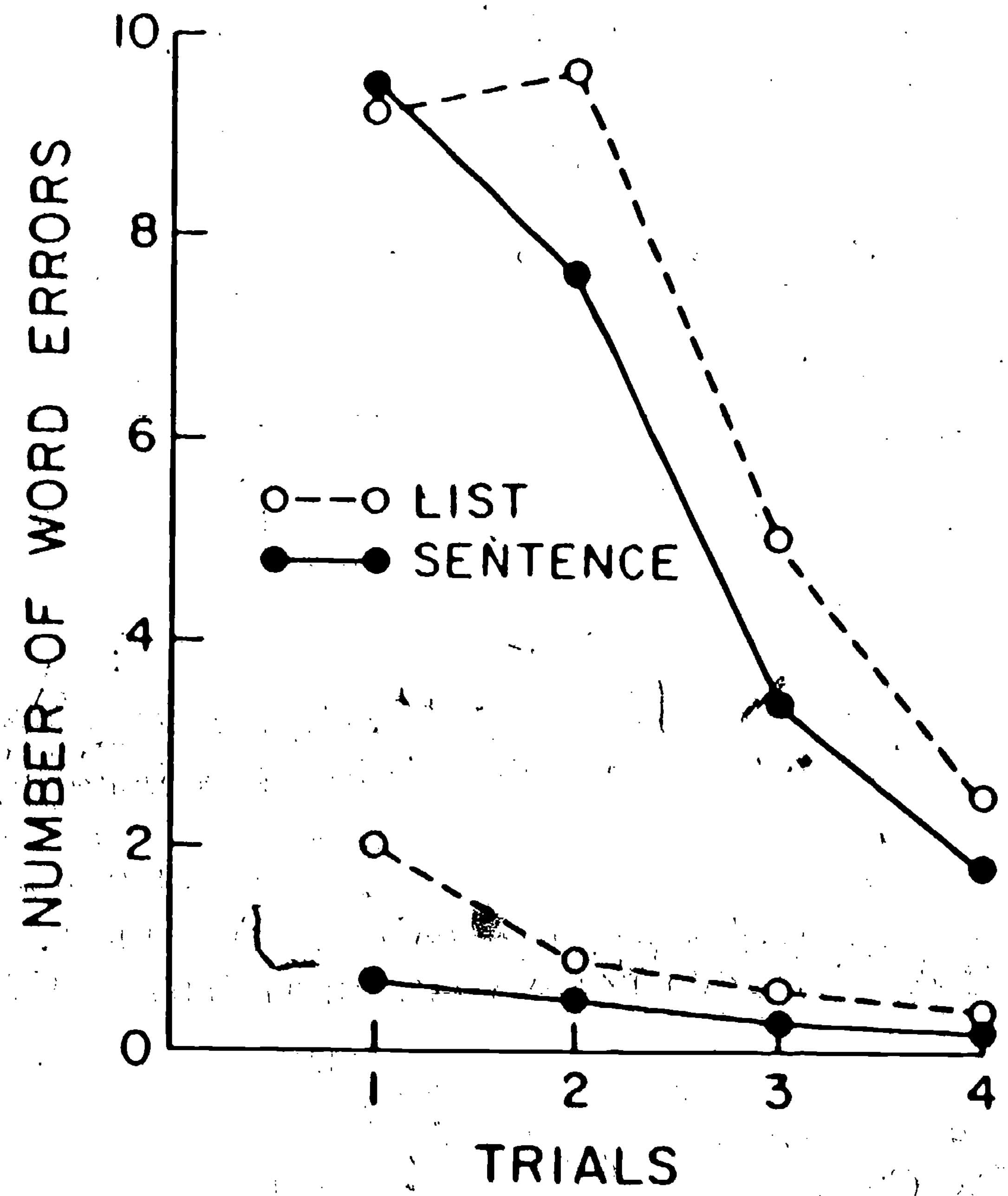

Figure 8-2. Mean number of target word identification errors made by sentence and list groups on the first and second reading over trials.

of the words they had just read. One child remarked, "Hey, that card had all the words." Some subjects spontaneously produced the sentence themselves or answered the meaning question immediately after they read the word list before the experimenter had a chance to speak. Although their efforts were not always successful, these responses indicate that list readers were attempting to find meanings for words.

Posttest performance patterns favoring sentence or list readers were checked across the 10 function words to verify that differences were not acounted for by a small subset but rather held for the majority of the words. The number of successful responses for each word was calculated separately for sentence and list readers on the following measures: complete sentences produced, words detected, words spelled correctly, words read accurately (untimed). Differences were subjected to matched pair *t*-tests. In all cases, they were significant ($p < .05$). This confirms that training effects generalized across words as well as subject pairs. In the sentence production task, performance differences favoring the sentence readers were especially great for the words "while" and "which" which several list readers misinterpreted as "wild" and "witch." In the spelling task, as might be expected, the words hardest for subjects were the most irregularly spelled words, "should," "might," and "enough," which none of the sentence readers wrote out accurately. Words displaying the weakest training effects overall were "very" and "from," the two most commonly recognized target words on the pretest.

The possibility that effects of training were greater for the less proficient beginning readers was examined also. Reading proficiency was determined by word identification pretest scores. It turned out that two groups could be distinguished, 10 pairs of subjects who knew 0 or 1 target words and who read 18-41 out of 75 other words (the low readers), and 10 pairs who knew between 2 and 6 target words and 46-68 other words (the high readers). Scores of the two groups on the target and supplementary word posttest measures were subjected to analyses of variance. The independent variables were reader ability (high vs. low) and training condition (sentence vs. list reading). Of interest was the presence of an interaction between these two variables. Results were positive in four analyses: word reading accuracy, $F(1,18) = 7.42$, $p < .05$; word reading latency (seconds per word), $F(1,18) = 4.77$, $p < .05$; detection of words in spoken sentences, $F(1,18) = 4.51$, $p < .05$; reading supplementary words, $F(1,18) = 5.17$, $p < .05$. In all four interactions, posttest performance differences between sentence and list readers were larger in the low than the high ability group. Mean values are illustrated in Figure 8-3. Interactions between ability and treatment were not significant in the analyses of spelling and sentence production scores

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Insert Figure 8-3 about here

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and also in the analysis of target word reading errors during training ($p > .05$) where patterns were similar for high and low groups.

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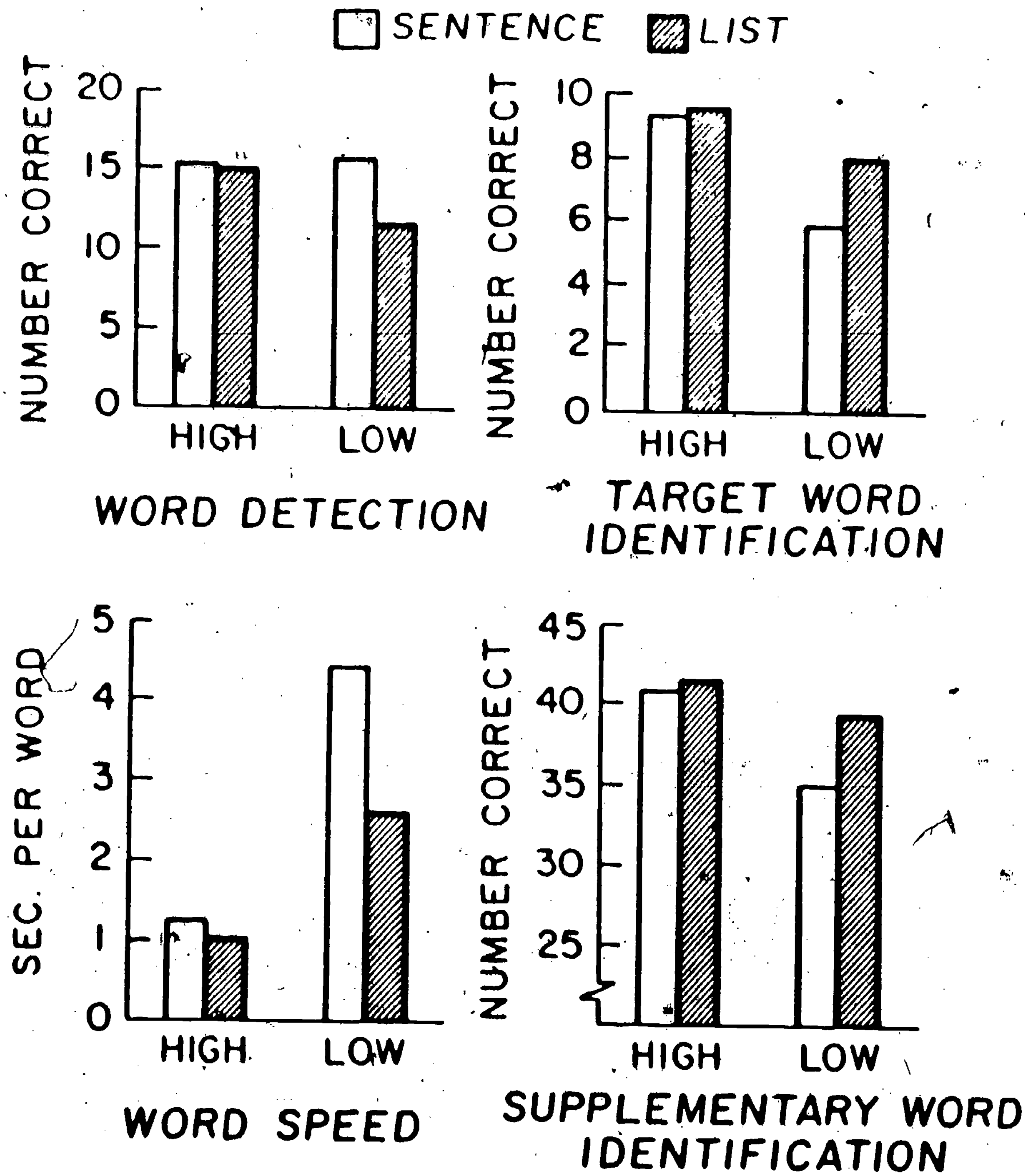

Figure 8-3. Interactions between reader proficiency level (high vs. low) and word training condition (sentence vs. list) on four measures of posttest performance.

Analyses conducted on pretest measures revealed no significant ability by treatment interactions ($p > .05$), indicating that interactions detected on posttests arose as a result of training.

The word detection task was designed to include two types of contexts for function words, one where boundary words overlapped with adjacent words and one where boundary sounds were different. We expected that words "buried" in sentences might be harder to detect. However, matched-pair t-tests revealed that subjects identified about the same number of words correctly regardless of acoustic overlap, $\bar{X}$ = 7.1 non-distinct vs. 7.2 distinct words correct, $t(39) = -.31$, $p > .05$. These results reveal that word analysis in this task is not conducted on an acoustic or phonetic basis but involves a deeper level of linguistic analysis.

One of the claims of identity amalgamation theory is that printed word learning entails a number of separable aspects. In the present study, evidence was sought regarding the extent of independence among these components. Intercorrelations among the target word posttest measures revealed significant relationships among the spelling production (letters correct) and word decoding (accuracy and speed) measures ($r = -.44$ to $-.56$; $r = +.46$ to $+.69$, $p < .01$). Likewise, sentence production and word detection scores were significantly correlated ($r = .47$, $p < .01$). However, correlations between the orthographic-phonological measures (first set) and the syntactic/-semantic measures (second set) were low and non-significant (r's ranging from $-.05$ to $+.23$, $p > .05$) except in one case where border-line significance was apparent, between spelling production (correct letters) and word detection ($r = .32$, $p < .05$). These findings suggest that processes of establishing orthographic images in memory and amalgamating these to phonological identities develop together. However, they are not closely tied to the process of learning the syntactic/semantic identities of words, at least not in the case of function words. That is to say, children may learn about the syntactic/semantic identities of function words as a consequence of their reading experiences whether or not they also learn enough to spell the words and to pronounce them accurately when they are seen in isolation. Such disparities may be more apt to occur with words where each component of the process has its own source of difficulty. In the case of function words studied here, meanings were opaque, spellings entailed silent letter patterns, and there were discrepancies in pronunciations mapped by the same letters across words (i.e., whil<u>e</u> - whi<u>c</u>h - mi<u>ght</u>; b<u>o</u>th - fr<u>o</u>m; sh<u>ou</u>ld - en<u>ough</u>). To what extent the components of printed word learning develop separately or together may vary depending upon factors such as these.

Discussion

Findings of the present study are consistent with our previous homonym study (Ehri & Roberts, 1979) and offer further support for word identity amalgamation theory. This conceptualization provides a useful way of describing the various aspects of printed word learning and the impact of word training experiences. According to present findings, beginners who practice reading and interpreting words in meaningful sentences learn more about their syntactic/semantic identities whereas children who read the words as isolated units learn more about their spellings and how the orthographic forms symbolize pronunciations. The advantage of reading words in sentences is that meanings are activated when the orthographic forms are seen. In isolation, it may be hard for readers to determine meanings, particularly for context-dependent words. The disadvantage of reading words in sentences is that less attention is paid to word spellings and how letters map sounds. This is particularly true for function words which can be guessed more easily and which tend to be skipped over during reading (Hatch, Polin, & Part, 1974). Also, because of contexts, readers make fewer errors, thus preventing a bystander from detecting and correcting inadequate word knowledge. Having readers practice words in isolation overcomes these problems. Successful decoding of single words requires attention to letters as they map sounds, and insufficient knowledge is immediately exposed for correction.

Results of the present study are consistent with previous findings suggesting that function words present special problems for beginning readers (Ehri, 1975; 1976; 1979). Results confirm that the syntactic/semantic identities of these words are not obvious to children as a consequence of acquiring spoken competence with English. The experience of learning to read the words in sentence contexts may be necessary to develop children's awareness of these words as separate units with functional significance in their language.

One or another of several factors may explain why list readers learned the orthographic and phonological identities of printed words better than sentence readers. During training, list readers had to depend upon graphic cues to identify words whereas sentence readers had context cues as well. Also, list readers made more errors in reading words than sentence readers, and so they received more corrective feedback regarding letter-sound relations from the experimenter. One might wonder whether list readers would have outperformed sentence readers if the experimenter had corrected errors by merely pronouncing the words. The answer appears to be affirmative. Ehri and Roberts (1979) used this procedure and obtained the same pattern of results. Actually, though the letter-sound corrective procedure was used less often, it probably benefitted sentence readers more than list readers since the former were the ones less apt to process graphic cues completely.

In the present study, effects of training experiences were found to exert a greater impact upon word learning among less proficient beginning readers. This finding is open to two interpretations. It may be that lower ability readers are influenced more by their experiences because unlike better readers they either lack or do not spontaneously invoke the skills or strategies which would enable them to compensate for deficiencies in instruction. Alternatively, it may be that in contrast to high ability readers, low readers were familiar with few if any target words prior to the experiment and so their knowledge of the target words was acquired solely as a consequence of their experiences in the experiment.) For this reason, training effects were more substantial. Present findings cannot settle the matter since both characteristics (i.e., basic reading skills as well as pre-experimental familiarity with target words) distinguished the high and low ability groups.

It is interesting to note the parallel between results of the present study and Samuels' (1967) findings with pictures as contexts for word learning. Like sentences, pictures appear to slow down the process of learning to pronounce words accurately in isolation (although not all studies have detected this effect, cf. Hartley, 1970; Samuels, 1970; Montare, Elman & Cohen, 1977; Samuels, 1977; Arlin, Scott, & Webster, 1978-79). Also, according to Samuels' (1967) data, pictures like sentences appear to retard learning primarily among poorer readers. Samuels explains his results in terms of attentional processes and poorer readers' greater susceptibility to distraction. An alternative explanation more compatible with amalgamation theory is that poorer readers lack the letter-sound skills necessary to decode the words completely and store their orthographic forms in memory when they appear in sentences or along with pictures. Because top-down processing supplies an acceptable word based upon partially completed bottom-up processing (Rummelhart, 1977), the poorer readers fail to notice how all the letters map sounds. Their frequent substitution of "might" and "must" for each other may be an instance of this process. It is interesting to note that in the Singer et al. (1974) study where artificial orthography was used, no interaction between context-no context treatment and reader ability (1st & 2nd graders) was observed, possibly because the relevant letter-sound skills were inadequate and not differentially developed in the two grade levels.

One question of interest in the present study was to what extent the various components of printed word learning develop separately or interdependently. Results indicated that learning spellings and learning pronunciations for printed words emerge together and are more interdependent than learning syntactic/semantic identities of words. A pattern of interdependence between decoding and spelling and some disparity between these skills and semantic processing of words has been described by others. Frith (1978) examined word processing in two groups of 12 year olds who were good at comprehending text and comparable in this respect but who differed in spelling ability. She found that both groups were equally skilled at processing the meanings of printed words but the poor spellers knew fewer orthographic details and were also slower at pronouncing familiar words. Baron (1977) and Baron and Treiman (1980) regard disparities in printed word processing as being quite possible and likely to develop. According to their multiple route theory of printed word learning, one or another or several parallel but independent paths among mental word codes may be established in the lexicon - print to sound, print to meaning, print to sound to meaning - depending upon readers' skills, learning experiences, and how they habitually practice reading words. Although this view appears to regard independence among word identities as more probable than amalgamation theory, both are in agreement that printed word learning has multiple parts which do not necessarily develop together.

Findings of the present study carry implications for reading instruction. Results show that each method of teaching beginners to read printed words - reading words in meaningful sentences, and reading words in isolation on lists - offer unique advantages and disadvantages, and that the method which is best for amalgamating meanings to printed forms may not also be best for learning to decode and to spell words. In deciding which method might be most effective in any instance, an instructor must consider several factors, most importantly, the purpose of instruction (i.e., which aspects of printed words are to be learned), and the particular characteristics of the words themselves (i.e., how obvious their meanings are out of contexts; whether the words are easily guessed and passed over when embedded in contexts). Perhaps the best approach is to provide both types of word reading practice.

Chapter 9: Does Word Training Increase or Decrease Interference in a Stroop Task?[a]

The process of learning to recognize printed words is regarded by many as a central part of learning to read (Gibson & Levin, 1975). The reader's success in recognizing words can be measured in three ways, according to the theory of automatic information processing proposed by LaBerge and Samuels (1974). One can examine how accurately the child can identify printed words. One can determine whether the child can recognize words automatically. This subdivides into two capabilities. One is whether the reader can recognize words without having to attend to components such as letter-sound correspondences. The other is how rapidly the reader can process words. Speed is seen as important because several mental operations or stages are thought to be involved in the transformation from visual to semantic information. As the reader practices recognizing words successfully, movement through these stages speeds up, and the separate stages are gradually integrated or consolidated into single units in memory.

One particularly interesting task which has been employed to study beginning readers' ability to process printed words automatically is the picture-word interference task. Patterned after the Stroop test (Stroop, 1935), this task requires subjects to name as rapidly as possible a set of 20 pictures depicting common objects or animals. Printed in the middle of each picture is a distracting word labeling some other object or animal. Rosinski, Golinkoff, and Kukish (1975) demonstrated that it takes subjects longer to name pictures when distracting words are present than when nonsense trigrams or when correct labels are printed on the pictures. This word interference effect has been observed among readers as young as first grade. The fact that readers suffer interference from the words despite attempts to ignore them is interpreted as indicating that the words are processed automatically without attention.

In order for printed words to create interference in this task, findings of various studies indicate that readers must be able to decode the words accurately and with a certain amount of speed. Ehri (1976) and Pace and Golinkoff (1976) found that second and third graders who had difficulty recognizing distractor words or who took a long time suffered less interference than children who could read the words easily. It was further shown that minimal interference did not stem from a general inability by poorer readers to process printed words. Pace and Golinkoff (1976) and also Golinkoff and Rosinski (1976) found than when poorer readers were shown pictures printed with distractor words they could recognize easily, they suffered as much interference from the words as good readers. This indicates that it

[a]Published as Ehri, L.C. and Wilce, L. S. Journal of Experimental Child Psychology, 1979, 27, 352-364.

is not subjects' general reading ability but rather their decoding skill with the particular set of distractor words which is the critical determiner of interference.

The present study was intended to explore the relationship between word recognition skill and interference. In previous studies, effects of word recognition accuracy and speed have not been clearly separated in analyses of results or in explanations of interference. Pace and Golinkoff attribute good-poor reader differences sometimes to word decoding ease, sometimes to word decoding immediacy. However, the two are not synonymous. Less skilled readers may recognize fewer printed words correctly than good readers. Or less skilled readers may require more time to decode words they can recognize than good readers (Perfetti & Hogaboam, 1975). It has not been clarified whether both of these types of word difficulties have the same impact on interference in the picture-naming task.

Three experiments were conducted in the present study, one preliminary experiment summarized briefly, and two better designed experiments described in full. Their purpose was to assess the effects of word training on interference patterns in the picture-naming task. Two questions were addressed. Would children who were unfamiliar with the distractor words and were taught to read them more accurately experience greater interference from these words in the picture-naming task following training? Would children who were already familiar with the distractor words and were taught to read them faster also suffer more interference from the words following training? It was reasoned that in both groups, subjects would be learning to recognize more distractor words automatically and so interference should increase.

In the first experiment, second graders were pretested to assess their ability to read the distractor words and to measure the amount of interference these words created in a picture-word task. Two groups of subjects were identified from pretest word recognition scores, those who could read fewer than 16 out of the 20 words, and those who could read almost all of the words. Subjects were then given several learning trials which had the effect of increasing the number of words recognized in the first group and improving word reading speed in the second group. A posttest interference task followed.

Results of this experiment failed to confirm the hypothesis. Among children who were familiar with the words initially and learned to recognize them more rapidly, interference decreased rather than increased on the posttest. No change in interference was detected among subjects who learned to recognize additional distractor words accurately. In attempting to account for results, several features of the experiment were identified as possible sources obscuring a view of word training effects. Pretesting, word training, and posttesting were all conducted in one session rather than distributed over days. Word training ignored meaning and simply entailed teaching children to pronounce printed words. Children were not given any chance to practice and adapt to the picture-word interference task prior to the pretest. A second experiment was designed to rectify these problems. It is described below together with a final experiment which was conducted to verify that changes in interference observed on the posttest were a consequence of word training effects rather than simply a consequence of practice with the picture-word interference task.

Experiment 2

Method

Subjects. The subjects were 30 first graders (mean age 82.3 months), 14 males and 16 females, tested in the spring, and 6 second graders, 4 males and 2 females, tested in the fall (mean age 88.8 months).

Materials. Two sets of 20 short, high-frequency nouns were selected (e.g., "flag," "gun," "horse," "wagon," "apple," "lamp"). Pictures of common objects or animals semantically related to each noun were drawn (i.e., picture of cow for word "horse"). Pictures were arranged in five rows of four objects each. Two different arrangements of the pictures were prepared, one with distractor nouns printed on the pictures, one without any print. One of the picture-word sets was used to familiarize subjects with the picture-word interference task. The other was used on the pretest and the posttest.

The word training materials consisted of 40 cards, 20 printed with single distractor words, and 20 drawn with referents of the distractor words. These cards were mixed together randomly.

Procedures. Each child was pretested, trained, and posttested individually by the experimenter in two or three sessions. On Day 1, all subjects were given the picture-word familiarization task, the pretests, and 2-3 word training trials. Those children who did not learn all the words by trial 2 were given a second day of training. The posttests followed, always on a separate day.

In the familiarization task, the subject first named each of the pictures (no words present). Then he was shown a 20-picture array printed with distractor nouns and was told to label the pictures as quickly as possible and to ignore the words. The purpose of this task was to acquaint the subject with the experience of interference, so that excessive delays due to reactions of surprise would not contaminate performance on the pretest.

The picture-naming pretests and posttests were conducted identically. First, the child was given a warmup picture-naming trial. Then he named the picture arrays twice, once with words printed on them and once without words. He was told to name the pictures as rapidly as possible and to ignore the words. Finally, he read a list of the nouns used as distractors (no pictures present).

He was told to read these as fast as possible and to skip any he did not know. Latencies with each picture set and word list were measured with a stopwatch from the onset of the first word to the onset of the 20th word. The order of presentation of the picture labeling tasks (with and without words) was counter-balanced across subjects, with the same order used on pre- and posttests for any individual child.

Between the pretest and the posttest, each child was given training and practice at recognizing the distractor nouns. A word recognition training trial consisted of having the child identify 40 cards, 20 printed with distractor words and 20 depicting referents of these words. For each printed word, the subject was asked to say the word and then name a function (i.e., "If you had one/some, what would you do with it/them?"). For each picture, he was told to identify it and then give the first letter of its name. Any unfamiliar written word was pronounced for the child, he was asked to spell it, and if unsuccessful to copy it. This training procedure was designed to insure that subjects thought about the meanings of printed words as well as practiced pronouncing them.

All children were given at least three training trials, more if they failed to recognize some of the words correctly during the second trial. Subsequent training was conducted on a second day. If subjects still failed to recognize some words after three more training trials, additional practice was given on these words.

Results

Of central interest in this experiment was the distinction between speed and accuracy word training. The distinction was operationalized by separating children into two groups based on their pretest word recognition scores, those who could identify most of the printed words, and those who failed to identify at least 16 out of 20 words correctly. The former subjects were called old-word/speed learners, those who would be learning to read familiar words faster. The latter group was labeled new-word/accuracy learners, those who would be learning to read unfamiliar distractor words accurately. It is important to note that the speed-accuracy distinction was not built into word training procedures but was based on subjects' pre- and posttest performances. Word learning instruction and practice were conducted identically for both groups, and speed was not even mentioned as an objective. Thus, the groups did not differ in their set for accurate or fast responding in the tasks.

Of the 36 children tested, 16 were classified as old-word/ learners, 20 readers as new-word/accuracy learners. All of the old/word readers were first graders. Six of the new-word subjects were second graders, the remainder were first graders. In the old word group, 14 subjects were given three training trials on the picture and word cards; two subjects saw them 4-5 times. New-word learners received from 3-6 training trials, with most (i.e., 12 out of 20 subjects) undergoing 5 trials.

Word recognition training yielded benefits for all children. Results are given in Table 9-1. Old-word/speed learners were able to read the list of distractor words significantly faster on the posttest than on the pretest, $t(15) = 3.79$, $p < .01$ (mean gain = 3.5 sec.). Likewise, word identification scores of every new-word/accuracy learner

Insert Table 9-1 about here.

improved on the posttest (mean gain = 9.9 words). These findings serve to validate the speed and accuracy labels given to the groups as well as the inference that word training exerted these specific effects on the groups.

Separate analyses of variance were conducted on picture naming latencies for the two groups of readers. Word/print condition and time of testing were the two independent variables of primary interest. Preliminary analyses revealed that neither sex nor presentation order of the picture-word tasks (i.e., clean pictures labeled before versus after distractor-word pictures) produced any main effects on interactions ($p > .05$), so these variables were ignored.

Analysis of old-word/speed learners' latencies revealed main effects of print condition, $F(1, 15) = 42.92$, $p < .01$, and time of testing, $F(1, 15) = 11.11$, $p < .01$. The interaction was significant at $p < .10$, with $F(1, 15) = 4.30$, $.05 < p < .10$. From the mean values reported in Table 9-1, it is apparent that latencies were longer with distractor-word pictures than with clean pictures, and latenices were longer on the pretest than the posttest. In order to compare the magnitude of interference on the pre- and posttests, a matched-pair t-test was conducted. Results indicated that the difference between latencies with and without words was signficantly smaller on the posttest, $t(15) = 2.13$, $p < .05$. Out of 16 subjects, 12 or 75% revealed less interference on the posttest than the pretest. These findings are consistent with those observed among speed learners in Experiment 1 which included more subjects. Although there was no main effect of time of testing in the first experiment ($F < 1$), there was a main effect of print condition, $F(1, 27) = 169.06$, $p < .01$, and the interaction was significant, $F(1, 27) = 6.47$, $p < .025$. The matched pair t-test revealed that interference was smaller on the posttest than on the pretest, $t(27) = 2.54$, $p < .02$. Out of 28 old-word/speed subjects, 20 or 71% suffered a decline in interference following word training. Thus, results for speed readers in the two experiments were virtually identical but quite the opposite of the pattern expected. Apparently, training subjects who can read most of the distractor words to read them faster serves to reduce the amount of interference created by the words in the picture-naming task.

Table 9-1

Mean Latencies in Seconds and Mean Words Correct on the Pretest and Posttest for Old-Word/Speed Learners and New-Word/Accuracy Learners in Experiment 2

	Measures	Pretest	Posttest	Mean
Old-Word/ Speed Learners[a] (N = 16)	Pictures Alone (sec.)	17.5	16.8	17.1
	Pictures + Words (sec.)	31.5	27.1	29.3
	Interference	-14.0	-10.3	
	Words Correct (max. =20)	19.1	19.7	
	Word Latencies (sec.)	16.3	12.8	
New-Word/ Accuracy Learners[b] (N = 20)	Pictures Alone (sec.)	21.3	20.3	20.8
	Pictures + Words (sec.)	25.7	30.5	28.1
	Interference	-4.4	-10.2	
	Words Correct (max. = 20)	7.4	17.3	
	Word Latencies (sec.)	47.8	27.5	

[a]For picture naming latencies, MSE (15) = 12.72

[b]For picture-naming latencies, MSE (19) = 22.30

Analysis of variance of the picture-naming latencies among new-word/accuracy learners yielded a main effect of print condition. Pictures with distractor words produced longer latencies than clean pictures, $F(1, 19) = 32.33$, $p < .01$. There was no difference between pre- and posttest latencies, $F(1, 19) = 3.53$, $p > .05$. The interaction between these two factors was significant, $F(1, 19) = 7.69$, $p < .05$. Mean values are given in Table 9-1. A matched pair t-test employed to determine whether posttest interference exceeded pretest interference proved significant, $t(19) = 2.77$, $p < .01$. Out of 20 accuracy learners, there were 16 or 80% who displayed this pattern. These results support the hypothesis that training subjects to recognize a greater number of distractor words serves to increase the amount of interference created by the words in the picture-naming task.

The procedure used in the above analysis to detect shifts in interference was to subtract subjects' latencies in naming clean pictures from their latencies in naming pictures with words and to compare these differences on the pre- and posttests. One might worry that the patterns observed are peculiar to the use of clean pictures as the baseline measure. Since picture-word interference studies vary in the choice of a baseline, with some using nonsense trigrams rather than clean pictures, it is important to demonstrate that performance patterns in the present study are not a function of the particular baseline chosen. Another way to show that interference from distractor words changed following training is to compare pre- and posttest picture-naming speeds with distractor words directly and to ignore baseline latencies. A matched-pair t-test for speed learners revealed that posttest latencies were significantly smaller than pretest latencies, $t(15) = 2.99$, $p < .01$. This verifies the decline in interference for children who learned to read familiar words faster. A matched-pair t-test for accuracy learners revealed that posttest latencies naming word-printed pictures were significantly larger than pretest latencies, $t(19) = 2.49$, $p < .025$. This verifies the increase in interference resulting from accuracy training.

Experiment 3

Contrary to expectations, old-word/speed learners experienced less rather than more interference following word training. This effect was evident in both Experiments 1 and 2. It may be that increased word recognition speed brought about the reduction of interference on the picture-word posttest. However, there is an alternative explanation to be checked. Dyer (1971) observed that interference in a color-word Stroop task declined when subjects practiced the task. In order to be sure that reduced interference was not a consequence of simply repeating the picture-word interference task, a third experiment was conducted. Its purpose was to determine what happens to interference when no word training intervenes between the pre- and posttests. New groups of first graders were selected, and the pretest and posttest procedures employed in Experiment 2 were repeated with them.

Method

The subjects were 30 first graders, 16 girls and 14 boys, mean age 83.4 months. Children were tested in the spring.

The same materials and procedures of Experiment 2 were employed here except that no word training sessions were provided. As before, "pretest" and "posttest" were conducted on separate days.

Results

Of the 30 children tested, 21 were able to recognize at least 16 of the 20 printed distractor words correctly. These were regarded as control subjects for the old-word/speed groups in Experiments 1 and 2, and are referred to as old-word readers in the text below. The remaining subjects recognized fewer than 15 words. These were considered controls for new-word/accuracy learners and are called new-word readers. Analyses of performances of the two groups were conducted separately.

In the analysis of variance of picture-naming latencies for old-word readers, the independent variables were: order of presentation of the picture sheets (clean pictures named before vs. after pictures printed with words); time of testing (first vs. second day); picture print condition (no words vs. printed distractor words). The latter two variables were repeated measures. A preliminary analysis failed to reveal any effects as a function of sex ($p > .05$) so this variable was ignored. One subject was dropped from the main ANOVA to create equal cell sizes.

A main effect of picture print condition emerged, $F(1, 18) = 153.50$, $p < .01$. Results are given in Table 9-2. Pictures printed with words took longer to name than clean pictures. The interaction

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Insert Table 9-2 about here.

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between this variable and time of testing was not significant, $F(1, 18) = 1.61$, $p > .10$. Time of testing exerted no main effect, $F < 1$. In order to determine whether interference declined on the posttest for the old-word readers, a matched-pair t-test was conducted. Results were negative, $t(20) = 1.47$, $p > .05$. This finding suggests that diminished interference observed among speed learners on the posttests in Experiments 1 and 2 can be attributed to effects of word recognition training rather than to practice.

One other effect was detected in the ANOVA of picture-naming latencies for old-word readers. Picture print condition interacted with presentation order, $F(1, 18) = 7.39$, $p < .05$. Apparently the amount of interference was somewhat greater when clean pictures were

Table 9-2

Mean Latencies in Seconds and Mean Words Correct on the Pretest and Posttest for Untrained Readers in Experiment 3

	Measures	Pretest	Posttest	Mean
Old-Word Readers[a] (N = 20)	Pictures Alone (sec.)	18.3	18.8	18.5
	Pictures + Words (sec.)	32.8	31.7	32.2
	Interference	-14.5	-12.9	
	Words Correct (max. = 20)	19.1	19.3	
	Word Latencies (sec.)	15.1	13.0	
New-Word Readers[b] (N = 9)	Pictures Alone (sec.)	20.2	21.1	20.6
	Pictures + Words (sec.)	27.7	27.2	27.5
	Interference	-7.5	-6.1	
	Words Correct (max. = 20)	9.7	10.4	
	Word Latencies (sec.)	30.1	24.7	

[a]For picture-naming latencies, MSE (18) = 7.62

[b]For picture-naming latencies, MSE (8) = 11.68

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named before the word-printed pictures than when they were named after the word-printed pictures. This difference was due primarily to a slowdown in naming the clean pictures when this task followed the distractor-word picture task. Why this should be is not clear. Such an interaction was not detected in the other two experiments.

Analysis of word recognition latencies for old-word readers on the "pre-" and "posttests" revealed that they were faster in reading the list of distractor words the second time around, $t(20) = 3.57$, $p < .01$. (See Table 2.) The difference between these means (i.e., gain of 2.1 seconds) is somewhat less than the gains observed in Experiments 1 and 2 among old-word/speed learners (i.e., 3.8 sec. and 3.5 sec., respectively). A t-test comparing these differences (i.e., Experiment 1 combined with Experiment 2 mean difference versus Experiment 3 mean difference) was significant, $t(63) = 1.78$, $p < .05$, indicating that training in the first two experiments did increase word reading speed beyond that occurring when the word-reading task was simply repeated.

Since the main purpose of Experiment 3 was to obtain control subjects for speed rather than for accuracy learners, fewer accuracy controls were observed ($N = 9$). Analysis of variance of their picture naming latencies revealed only a main effect of print condition, $F(1, 8) = 9.08$, $p < .05$. As reported in Table 9-2, pictures with words were named more slowly than the clean pictures. No other effects were significant ($p > .05$). A matched-pair t-test revealed no change in the amount of interference on the pre- and posttests, $t < 1$.

Discussion

To review, three experiments were conducted to clarify word training effects on performance in the picture-word interference task. Results were somewhat surprising. It was expected that word recognition training would serve to increase the amount of interference created by the words in the picture-naming task because subjects would be learning to recognize more of the words automatically. This turned out to be true for subjects who learned to read distractor words which were unfamiliar to them prior to training. However, the opposite effect was observed among subjects who could read all the words initially and who learned to read them faster during training. These results confirm the importance of distinguishing between effects of word recognition accuracy and word recognition speed in the picture-word task. Apparently, training subjects to read distractor words more accurately serves to increase interference whereas training subjects who already know the words to recognize them more rapidly serves to decrease interference.

Although at first glance it may seem that present findings raise doubt about the adequacy of automaticity theory in accounting for interference patterns, this is not so. The reason that results do not square with predictions is not the fault of the model but rather the failure of initial predictions to take full account of the model and to distinguish between training effects involving attention and

ERIC

training effects involving speed. If differential predictions had been created for the two effects, then interference patterns would have come as no surprise. Recall that the concept of automaticity entails two types of changes which occur when readers learn to recognize words automatically. One change is the elimination of attention as a requirement for word recognition. The other change is a gradual reduction in processing time required by the cognitive apparatus in recognizing words. Findings make sense if interpreted in terms of both types of changes, the first type accounting for results with new-word/accuracy learners, the second type for results with old-word/speed learners. In the case of accuracy learners, printed words produced more interference following training because subjects learned to recognize a greater number of distractor words without attention, and so more of the words were inadvertently processed on the posttest than on the pretest. In the case of speed learners, these subjects could recognize most of the words without attention at the outset, and so word training did not produce any changes in attentional demands. What word training did was to speed up or unitize the mental operations required for processing the words. Distractors produced less interference on the posttest than the pretest because the words were able to move through the central processor in less time, thus allowing the pictures to enter sooner and be processed. Given this interpretation, findings do appear to support automaticity theory. They provide evidence for the distinction between attention and speed as separate criteria defining automatic word processing, and they suggest that children learn to recognize words without attention before they achieve maximum speed in processing words.

It is interesting to note that present findings and their interpretation are consistent with a model of the reading task proposed by Perfetti and Lesgold (1977). They portray the process of reading text for meaning as requiring concurrent execution of at least two separate operations: decoding words and interpreting sentence meanings. Both of these operations must be handled by a limited capacity processor which cannot execute both at once and so divides its time between the two operations, with word recognition receiving priority. To the extent that words can be recognized rapidly, they consume less time in the processor, thus permitting sentence operations to be executed more promptly. In the present study, this was the interpretation given to results for speed learners who were simultaneously naming pictures and processing printed words, albeit inadvertently. If the picture-word task can be regarded as analogous to the task of reading text, then present results lend appeal to Perfetti and Lesgold's model.

It is interesting to note that interference patterns observed in the present study can also be detected in the study by Pace and Golinkoff (1976) though they do not focus upon these patterns or test them for significance. Pace and Golinkoff imposed a set of hard-to-read distractor words on pictures and gave these to good and poor readers in the third and fifth grades. From subjects' word recognition performances, it is evident that the good third-grade readers were more accurate in reading the words than the poor third

ERIC

grade readers. In contrast, the good fifth-graders differed from the poor fifth grade readers not in accuracy but in speed. They recognized the same number of distractor words but they took less time to read them than the poor readers (i.e., mean latencies = 14.8 sec. vs. 22.9 sec.). Interestingly, in the picture labeling task, the interference patterns displayed by these two grade levels were opposite. Comparison of picture-naming latencies with and without distractor words reveals that good third graders experienced more interference than poor third graders (i.e., 19.6 sec. vs. 12.7 sec.) whereas good fifth graders evidenced less interference than poor fifth graders (i.e., 11.0 sec. vs. 16.6 sec.). According to the explanation proposed above, interference was greater among good than poor third grade readers because the good readers recognized more of the distractors without attention. Interference was less among good than poor fifth grade readers because the good readers processed the distracting words faster.

Although the automaticity explanation is favored, one might attempt to develop an alternative account for the decline in interference among old-word/speed learners, an account involving the idea that training built up some sort of immunity to the printed words. For example, one might speculate that perhaps word training enabled readers to become more familiar with the visual forms of the words and so made it easier for subjects to ignore or divert their attention from these forms during the picture-naming posttest. Arguments against such suggestions can be offered. First, speed learners practiced reading each distractor word only three times during training. This is hardly sufficient to breed excessive familiarity with printed forms. Second, word training was always conducted on a separate day from the posttest. This precluded the operation of any temporary word inhibiting effect such as semantic satiation (Lambert & Jakobovitz, 1960). Third, it makes no sense to argue that speed subjects learned to ignore words while accuracy subjects did not. The same training procedures were used with both groups. In fact, accuracy learners saw the words more times than speed subjects, yet training made them more, not less sensitive to the words. Thus, the word immunity hypothesis does not seem adequate as an explanation.

Experiments conducted with the picture-word Stroop task by Rosinski and his colleagues and also Ehri (1977) have been directed at demonstrating that word interference arises from semantic sources. For example, Rosinski (1977) showed that sematically related words create substantially more interference than semantically unrelated words. In contrast, the interpretation given to results of the present study has avoided being specific about what aspects of words produce the increase or decline in interference following word training. The question of whether the source is primarily semantic is interesting and awaits investigation.

Some implications of present findings for beginning reading instruction can be offered. Results suggest that there may be value in teaching children to read words not only accurately but also

ERIC

rapidly. To the extent that words are processed effortlessly, attention and other mental resources can be devoted to higher level comprehension and thinking processes. In addition, findings suggest that only a moderate amount of practice may be required for beginners to attain automatic levels of processing. In Experiment 2, most speed learners studied the words only three times, and most accuracy learners only five times. In discussions of automaticity, usually extensive practice is thought to be needed to effect significant change. In sum, findings of the present study suggest that beginning readers can benefit from practice in identifying printed words. The next step is to gather experimental evidence that these benefits include an improvement in reading comprehension.

Chapter 10: Overview Summary

The goal of this research project was to understand more about how beginning readers acquire knowledge of printed words, knowledge of the sort which enables them to spell words fairly accurately and to recognize words correctly and quickly as they are reading text. A theory of printed word learning provided the framework for this research.

The theory has been labeled "word identity amalgamation theory." According to this view, the most important capability to be acquired in learning to read is learning to recognize printed words accurately, rapidly, and also completely in the sense that a word's meaning as well as its pronunciation is apparent when the printed form is seen.

Children already possess substantial linguistic competence with speech when they start learning to read. The major task facing them is learning how to incorporate printed language into this existing knowledge. In English, the most perceptible and dependable units of printed language are words, so it is at a lexical level that children work at assimilating print to their existing linguistic knowledge.

The lexicon is conceptualized as a store of abstract word units having several different facets or identities. Every word has a phonological identity comprised of articulatory, acoustic, and phonemic properties. Every word has a syntactic identity specifying how the word typically functions in sentence contexts. And most words have a semantic identity, something like a dictionary definition. These identities are acquired by children when they learn to speak.

In the course of learning to read, another identity is added to the lexicon, the word's orthographic form, which gets established in memory as a visual image. The term amalgamation refers to processes by which this orthographic identity merges with the word's other identities to form a single unit in lexical memory.

Orthographic images are acquired not as rotely memorized visual figures but as sequences of letters symbolizing sound segments detected in a word's pronunciation. To set up images in memory, the reader must already know how at least some of the letters symbolize sounds and he must notice and process these as he reads the word. To the extent that a word's letters are amalgamated to its sounds, a fairly complete and detailed orthographic image is secured in memory.

In order to become a visual symbol for all of a word's identities, the orthographic form must be amalgamated not just with the word's phonological representation but also with syntactic and semantic information. This occurs as readers practice pronouncing and interpreting printed words while they are reading text for meaning. When orthographic images come to symbolize meanings as well as sounds, their possessors can read and interpret words accurately and quickly, and also they can spell words.

In our first experiments, we wanted to show that orthography can function as a mnemonic device, that it can be used to preserve sounds in memory when it provides an adequate printed symbol for those sounds. We already knew from a previous study that young children have difficulty remembering nonsense syllables. We designed a paired associate sound learning task to explore whether seeing spellings might improve their memory for meaningless sounds.

Beginning readers (first and second graders) were given several trials to learn four oral consonant-vowel-consonant nonsense syllables such as MAV, REL, KIP, QUZ. Recall of these responses was prompted by a variety of stimulus cues in four experiments. What we wanted to determine was whether we could boost or impair memory for the sounds by having children engage in various types of study activities between the test trials. The following types of study activities were compared in one or another experiment:

- Having children look at correct spellings of the response sounds
- Having children look at misspellings of the response sounds
- Having children listen to correct spellings and form visual images in their heads
- Having children rehearse the sounds one extra time
- Having children listen to the sounds broken into component sounds
- Having children listen to oral spellings of the sounds.

We found that children remembered the sounds best when their study activities consisted of looking at correct spellings or forming visual images of oral spellings. Performance was poorer in the other conditions. Looking at misspellings made it especially hard to learn the sounds. When we examined the errors made by our learners, it was apparent that their difficulties centered on remembering the responses, not matching them up to stimulus prompts. We interpret these results to indicate that spellings improve memory for sounds because they induce children to form orthographic images, and these images preserve the sounds in memory.

The next thing we wanted to find out was whether this ability might be the mechanism which enables children to store and remember the printed forms of real words. In the above experiments, we sought correlational evidence for this possibility. We divided our first graders into successful and unsuccessful learners based on their ability to use spellings to remember the sounds. Then we counted the number of printed words these two groups were able to read on a word identification test. This test included irregularly spelled words which children had to have seen before in order to recognize. We expected that successful sound learners would be familiar with many printed words whereas children lacking an orthographic memory would know relatively few words. This expectation was confirmed. Subjects fell into two distinct groups. Those with orthographic memories could read most of our words while those without could read very few words.

Although these results fall short of demonstrating a causal relationship, they are at least consistent with the claim that when children learn to read, they acquire an orthographic representational system and this capability enables them to build up a repertoire of visual images for words in lexical memory.

We have undertaken another series of experiments to explore the nature of orthographic images. One question we addressed was whether all the letters in a word's spelling get deposited in memory when the printed form is learned. We reasoned that if orthographic images underlie the word learning process, then silent letters should be as firmly planted in memory as pronounced letters. However, if an alternative view is more accurate, that is, if words are always processed by decoding print to sound, then silent letters should not be very well know.

To test this hypothesis, we designed a memory task to compare the salience of pronounced and silent letters in words. The task had three parts. First, we had second and third graders read all the words to make sure they knew them. Next, we had subjects imagine the orthographic forms of each word and decide whether it contained a particular letter. For example, they imagined the word "kind" and were asked, "Does it have an N?" All of the letters were in noninitial positions. Finally, we surprised subjects with a recall task. Each letter was shown and children were asked to identify the word they had imagined for that letter. We examined two aspects of their performance: their success in locating the letter in the imagined word, and their ability to recall the word when shown the letter prompt. We reasoned that, if both letter types are firmly planted in memory, then performance on the letter-location task should be near ceiling, and silent and pronounced letters should prompt equivalent recall.

The results were not quite as we expected but good enough. In the letter location task, our subjects were aware of almost all the silent letters in words although a few more errors were made in judging silent than pronounced letters. In recalling the words associated with letters, to our surprise, silent letters prompted better recall than pronounced letters. We repeated the experiment with a different design and new words and obtained the same results. From these findings, we conclude that silent letters are as firmly planted in memory as pronounced letters, perhaps more so.

The next question we raised was how are silent letters remembered? According to amalgamation theory, letters are supposed to symbolize sounds to be secured in memory. Perhaps whole visual forms can be retained provided only some of the letters are grounded in sound.

ERIC

In the next study, our aim was to find out how easy it is for second graders to remember visual forms which contain silent or redundant letters. We created two spellings for some pseudowords, an unusual spelling and a more straightforward phonetic spelling, and we compared children's memory for the spellings. We reasoned that if memory has a visual component, then our unusual spellings ought to be remembered. We taught second graders to read 4 regular and 4 unusual spellings as names of pictured animals. Then, following a delay, they wrote these words from memory.

We found that the children remembered original spellings quite well. The unusual visual forms were misspelled more often than the regular forms. However, it was not the case that unusual spellings were forgotten. When he looked at the particular letters retained in misspellings, we found that subjects did not abandon the forms they had seen in favor of straightforward phonetic versions. Rather they tended to retain salient letter patterns. We could tell this because these patterns were produced only by subjects who had seen that original version of the spelling.

These results reveal that both visual and phonetic factors participate in the storage and recall of orthographic forms. However, this study does not really clarify how important sound is in securing visual forms in memory. Our second graders may have remembered the unusual spellings because they recognized these as less frequent but acceptable symbol combinations for the sounds. Or they may have remembered the letters as unpronounced visual elements.

We designed another study to see whether children would be able to remember letters which could not be grounded in sound. We made up some tri-syllabic words such as "rostenlust," where the second unstressed syllable contains a non-distinctive schwa vowel, in this case, "tun." In the spellings we created for these words, we varied the vowel letter symbolizing this schwa vowel. Our purpose was to see whether readers would be able to remember the particular letters. We reasoned that if they could, then they would have to be doing it visually since the sounds were non-distinctive. However, we were wrong. What some children did as they practiced reading the words was to divide them into syllables, to pronounce each syllable with stress, and thus to convert the non-distinctive middle schwa into a distinctive sound symbolized by the letter appearing there. In the case of "rostenlust," they saw the letters T-E-N and said ros-"ten"-lust not ros-"tun"-lust. Thus, our efforts to study visual memory were thwarted by our learners' tendency to create relevant sounds for letters if the sounds weren't already there.

We decided to drop our pursuit of visual memory temporarily and to go after this other possibility. We reasoned that maybe, when people acquire orthographic images and learn how words are spelled, they come to think differently about these words than people who have not learned the printed forms. Maybe as people learn letters in a word's spelling and form letter-sound amalgams, they acquire a new conceptualization of its sound structure, particularly if the spelling includes letters symbolizing additional or different sounds.

To check this out, we searched for words with a discrepancy between print and sound, that is, words having letters which symbolize syllables or phonemes which are deleted or not separately articulated in the pronounciations of these words (i.e., T in "match," ER in "interesting"). We selected fourth graders for our experiment. To assess how they conceptualized the sound structure of these words, we had them divide the words into syllables or phonemes. Afterwards, we had them spell the words.

We predicted that children who knew the spellings would segment the words to include the extra sounds symbolized in the spellings whereas children who did not know the spellings would not include the extra sounds in their segmentations. Also, we expected that extra segments would be allocated for words spelled with these extra letters but not for parallel words lacking these letters. For example, "pitch" is spelled with an extra T but "rich" is not.

Results of this study as well as an experiment with pseudowords confirmed our expectations. Apparently, learning spellings may cause readers to reconceptualize the sound structure to include sounds symbolized by extra letters. These results are interesting theoretically because they suggest one way that silent letters may be secured in memory. Also they are consistent with our view that letter-sound amalgamation underlies the word learning process. An interesting implication of these findings might be mentioned. They explain one way that dialect speakers may learn the standard English pronunciatin for some words, through spellings which clarify which sounds are supposed to be there.

We conducted two studies to determine whether beginning readers would be able to read and spell words better if they received instruction and practice in the formation of orthographic images of these words. First and second graders learned how to imagine the spellings of several words and received feedback on the adequacy of their images. In the control condition, words were viewed and read but never imagined. We expected that image training would help learners form more complete orthograhic representations of words in memory and this in turn would enable them to read the words more accurately and rapidly as well as spell the words. However, results fell short of expectations. Although image training improved children's ability to spell the words they learned, their word reading skills remained unaffected.

In the aforementioned studies, our focus was upon the processes involved in getting orthographic images into memory. In the next studies, we examined whether different kinds of experiences learning to read words would influence the storage of orthographic images. Also, we were interested in the effects of learning conditions on acquisition of the semantic identities of printed words. We

ERIC

expected differences in both cases depending upon whether children were taught to read the words in isolation on flash cards or as part of meaningful sentences. We predicted that isolated word readers might learn more about the orthographic forms of words whereas sentence readers might learn more about their meanings.

Expectations were confirmed in two experiments, one in which children were taught to read homonyms (i.e., hall, haul; which, witch), another involving functions words (i.e., might, which, enough). Both groups of children learned to read all the words accurately. However, flash card subjects could read them faster and they included more correct letters in their spellings, whereas sentence readers were more accurate in identifying the meanings of the words. These findings point out the importance of teaching sight vocabulary words by having children read the words in stories rather than on flash cards. This is necessary to insure that meanings of words which are ambiguous or lack clear referents are activated correctly and attached to printed words in memory.

Results of these studies contrast with results of the image training studies in an interestng way. Apparently, the nature of a child's reading experiences with words influences how well he can spell the words, with isolated word reading yielding better spellings than context word reading experiences. However, the nature of a child's experiences learning the spellings of words does not influence how well he will be able to read those words. This suggests that in learning a specified set of words, reading benefits spelling but spelling does not benefit reading.

In a final study, we searched for evidence that a beginner's word reading skill would influence how distracting these words would be in a task where the reader tried unsuccessfully to ignore the words. We wanted to find out whether, if children were taught to read a set of words more accurately and/or more rapidly, the words would become more distracting or less distracting. The task required subjects to name a series of line drawings of familiar objects. We measured the time it took them to name the pictures with and without the words printed over the pictures. We found that the words became more distracting among children who did not know the words initially and learned to read them accurately whereas the words became less distracting among children who already knew the words and learned to read them faster. Results are interpreted to show how different levels of word reading skill influence how the mind divides its time in processing information.

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