1

Grapheme–Phoneme Knowledge Is Essential for Learning to Read Words in English

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Currently there is much interest in the question of how children learn to read, particularly as a result of debates about whether instruction should follow phonics or whole-language prescriptions. The purpose of my chapter is to sidestep the instructional issue, to focus on the learner rather than the teacher, and to clarify how alphabetic processes are central in learning to read words as indicated by theory and evidence. Research on this topic is too extensive to cover fully in this chapter. I have dealt with this problem by mentioning limited evidence to support my claims with the belief that this evidence is representative of and not contradicted by the larger pool of evidence. (For a more complete picture, see Adams', 1990, book, *Beginning to Read*.)

In my chapter, I argue that grapheme–phoneme knowledge, also referred to as *alphabetic knowledge*, is essential for literacy acquisition to reach a mature state. It is important to include spelling as well as reading in this picture, because learning to read and learning to spell words in English depend on processes that are tightly interconnected (Ehri, 1997). As the chapter unfolds, the nature of this connection becomes apparent.

Processes Versus Methods

In considering how children learn to read words, one can focus on methods of teaching reading, or one can focus on processes that develop as beginners learn to read. In this chapter, I focus on processes rather than methods. It is important to be clear about this. I see too many instances where processes are confused with methods and an argument erupts that is unresolvable because the parties are talking about two different things.

Let me give you an example. What does the term *sight word learning* mean to you? What kind of mental image does this term evoke? Teachers who say "I object to it," or "I support it," or "I do it everyday with my students" are referring to a method of instruction. They probably envision students speeding through a set of flash cards as fast as they can, practicing how to read single words.

A very different reaction to this term is to think of sight word learning as a process, as something that all beginners go through to attain skill in reading. Holding this meaning, one envisions the mind of the reader and perhaps imagines a mental dictionary lodged somewhere in the left hemisphere. The dictionary holds all the written words and spoken words that are familiar to the reader. The dictionary is linked to the reader's eyes such that when the eyes light on words that exist in the dictionary, the pronunciations and meanings of the words are immediately activated in memory.

It is important to realize that reading processes can be described separately from reading methods, and that no particular instructional method is entailed by any process. When I talk about sight word learning as a process, I am not suggesting anything about the activities that teachers should impose on students to help them learn sight words. Many different activities might do the job.

Also, it is important to realize that, by singling out word reading processes and talking about their development, I am not suggesting that the processes should be taught in isolation. Likewise, I am not arguing against teaching them in context. The point is that I am not making any declarations about how to teach the processes.

What I want to do is set aside questions about instruction, and try to achieve a clearer view of the reading processes that instruction is intended to develop in students. In doing this, I am not suggesting that instruction is unimportant; quite the opposite. Explicit, directed instruction is essential for enabling most children to acquire enough proficiency with the alphabetic system to become skilled readers and writers of English. The reason for focusing on processes separate from instruction is to clarify what the target of instruction is, where instruction should be aimed, and how instruction should be evaluated for its effectiveness. In my view, teachers need to understand the processes that their instruction is aimed at teaching and the behaviors that indicate whether students are progressing along the lines expected in learning to read. Teachers need this knowledge to evaluate and improve the effectiveness of their instructional efforts.

Basic Processes to Explain

Learning to read involves two basic processes. These processes are captured in the simple view of reading (Gough & Tunmer, 1986; Hoover & Gough, 1990). One process involves learning to decipher the print; the other involves

comprehending the meaning of the print. When children attain reading skill, they learn to perform both of these processes in a way that allows their attention to focus on the meaning of the text while the mechanics of reading, including deciphering, operate unobtrusively and out of awareness for the most part. How do beginners achieve this mature state of reading? Can simple practice of reading text lead to mature forms of reading, just as practice of learning to speak leads to mature speaking abilities? Is there anything special about reading that might be hard to learn and might not be acquired through practice? To answer these questions, we need to clarify the nature of the processes involved in reading and learning to read.

It is important to note that children acquire comprehension skill in the course of learning to speak. Listening comprehension processes are very similar to reading comprehension processes, as Hoover and Gough (1990) showed. However, children do not acquire deciphering skill in the course of learning to speak. This achievement requires special experiences that do not occur in the normal course of conversations between parents and children, or even in sessions where parents read books to their children.

Liberman (1992) argued elegantly and persuasively that humans are equipped for learning to produce and comprehend spoken language easily, but they are not equipped for learning to decode written language easily despite the greater powers of the eye than the ear for processing information. Processing spoken language is not governed by "end" organs such as eyes and ears, but rather is governed by central phonological structures in the brain. Processing speech is not a matter of processing sounds, but instead is a matter of processing combinations of rapidly executed, co-articulated, motoric gestures that are controlled by central processes in the brain. Such processing far exceeds the limits of the ear. The critical phonemic segments that speakers and listeners must process do not lie in the signal itself; rather they lie in the brain and are detected and processed successfully by speakers and listeners because they both possess the same mental equipment.

These facts about speech make it apparent why learning to decipher print is not the "natural" process that learning to speak is. The brain is specialized for processing spoken language, but it has no special central equipment for processing written language. In order for reading and writing skills to develop, what needs to happen is that written language must penetrate and gain a foothold in the central equipment used to process speech. Graphemes must become attached to "deep" phonemes, not simply to "surface" sounds within words. Such penetration and attachment, however, are not straightforward steps, because speech is seamless on the surface, with no breaks signaling phonemic units. Special experiences are needed to engage the brain in deciphering print.

The basic question to be answered is how learners acquire the deciphering skills that give their eyes access to language comprehension processes that

are programmed for mouths and ears rather than eyes. The answer proposed in this chapter is that access is gained through the acquisition of unobtrusively functioning deciphering skills that involve two types of structures, one nested within the other. The larger structure is lexical and consists of specific words as units with orthographic, phonological, and semantic identities. Nested within words are structures consisting of graphemes linked to phonemes.

Before taking up the matter of how deciphering skills are acquired in a way that allows print to symbolize speech at a deep level, it is important to identify what deciphering skills are and how they operate as part of the reading process.

Reading Words in Text

The interactive model of reading adapted from Rumelhart (1977) and displayed in Fig. 1.1 enables us to describe how words are processed during the act of reading. The center box represents a central processor that receives information from the eyes and interprets it. The boxes around the center depict the various information sources that are stored in readers' memory and are used to recognize and interpret text. Readers' knowledge of language enables them to recognize sentences and their meanings. Readers have factual, experiential, and schematic knowledge about the world. This enables them to understand ideas and to fill in parts of a text where meanings are assumed to be known and thus are not stated explicitly. Readers use their metacognitive knowledge to monitor the quality of their comprehension, to verify that the information makes sense and meets specific purposes, and to detect when repairs are necessary. Memory for a text is constructed as readers use these knowledge sources to comprehend the sentences and paragraphs in that text. Readers' understanding of the text is stored in memory, accessed to understand subsequent text, and revised to accommodate new information.

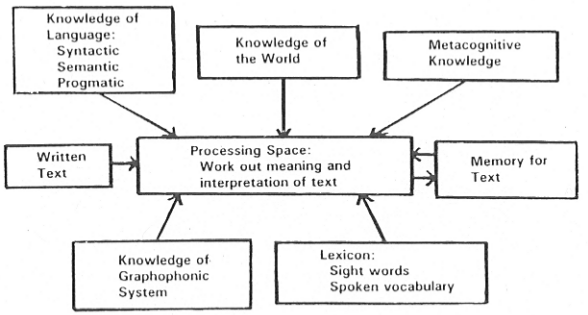

FIG. 1.1. Interactive model of text reading, depicting the sources of knowledge.

At the bottom of Fig. 1.1 are depicted two knowledge sources that enable readers to process letters and words in the text, referred to as *deciphering skills*. Readers' knowledge of the graphophonic system enables them to convert letters into sounds in order to decode unfamiliar words. *Lexical knowledge* refers to something like a dictionary of words that readers hold in memory, including the written forms of words known by sight. All of the knowledge sources in Fig. 1.1 operate together to facilitate text comprehension.

Let us take a closer look at how readers read words as they process text. We can identify at least five different ways (Ehri, 1991, 1994). Readers might read words:

1. By assembling letters into a blend of sounds, referred to as *decoding*.
2. By pronouncing and blending familiar spelling patterns, a more advanced form of decoding.
3. By retrieving sight words from memory.
4. By analogizing to words already known by sight.
5. By using context cues to predict words.

In each case, the processes differ. As readers attain skill, they learn to read words in all five ways.

One way to read words is to determine the sounds of letters and blend them into pronunciations that approximate real words. This is a strategy that enables readers to read words they have never before seen. To use this strategy, readers must know how letters typically symbolize sounds in words, not only single letters but digraphs such as *th*, *sh*, *ea*, *ow*. This is a slower way of reading words than sight word reading (Ehri & Wilce, 1983; Perfetti & Hogaboam, 1975). In reading English, this strategy works sometimes but not always, because many spellings have variable or irregular pronunciations.

Whereas beginning readers decode words by attacking individual letters, more advanced readers process chunks of letters when they decode words. They learn how letter chunks are pronounced from their experiences reading and writing different words that share common letter patterns. When they see new words containing these patterns, they can pronounce the patterns as units without having to subdivide them into graphophonic units. Table 1.1 contains a list of common chunks found at the ends of single-syllable words in English (Stahl, Osborn, & Lehr, 1990), as well as a list of common affixes occurring in words (Becker, Dixon, & Anderson-Inman, 1980). Studies show that words having common letter patterns are easier to decode by readers who are familiar with the patterns (Bowey & Hansen, 1994; Juel, 1983; Laxon, Coltheart, & Keating, 1988; Treiman, Goswami, & Bruck, 1990).

A very different way to read words is by sight. Consider the list of words in Table 1.2 taken from Adams and Huggins' (1985) test of sight word

TABLE 1.1
Common Spelling Patterns in Words

Common Endings (Rime Spellings) of Single-Syllable Words						
-ack	*-all*	*-ain*	*-ack*	*-ale*	*-ame*	*-an*
-ank	*-ap*	*-ash*	*-at*	*-ate*	*-aw*	*-ay*
-eat	*-ell*	*-est*				
-ice	*-ick*	*-ide*	*-ight*	*-ill*	*-in*	*-ine*
-ing	*-ink*	*-ip*	*-ir*			
-ock	*-oke*	*-op*	*-ore*	-or		
-uck	*-ug*	*-ump*	*-unk*			
Common Affixes						
-al	*-able*	*-ate*	*-ant*			
-ed	*-en*	*-er*	*-ent*			
-ize	*-ist*	*-ing*	*-ive*	*-ite*	*-ion*	*-ic*
-ful	*-ly*	*-less*	*-ment*	*-ness*	*-ous*	
com-	*con-*	*de-*	*dis-*	*ex-*	*im-*	*in-*
or-	*pre-*	*pro-*	*re-*	*un-*		

reading. You can probably read them easily. Why do we take this as evidence for sight word reading? Because these words cannot be read accurately by decoding letters into sounds. They have unusual spellings that do not conform to the conventional spelling system. Readers have to remember how to read these words in order to read them accurately. Adams and Huggins selected these words to show that sight word reading is a very different way to read words than is decoding. However, it is important to note that sight word reading is not limited to strangely spelled, difficult-to-decode words. With sufficient practice, all words acquire status as sight words.

When readers read words by sight, they access information stored in memory from previous experiences reading the words (Ehri, 1992). This process is used to read words that have been read several times before. Sight of the written word activates its spelling, pronunciation, and meaning immediately in memory, without any decoding steps required. Reitsma's (1983) evidence suggests that even first graders can retain sight words in memory, after reading the words as few as four times. You can tell when readers are reading words by sight because they read the words as whole units, with no

TABLE 1.2
Words From Adams and Huggins' (1985) Test of Sight Word Reading

none	*island*	*busy*	*bouquet*	*rhythm*
calf	*depot*	*yacht*	*fiance*	*heights*
break	*react*	*suede*	*guitar*	
prove	*sugar*	*tongue*	*chauffeur*	

pauses between sounds, and they read the words within one second of seeing them (Ehri & Wilce, 1983).

There is one property of sight word reading that distinguishes it from the other ways of reading words. This property makes sight word reading especially valuable for text reading. When sight words are known well enough, readers can recognize their pronunciations and meanings *automatically* (LaBerge & Samuels, 1974). That is, they can read these words without expending any attention or effort decoding the words. They recognize these words instantly, even when they try to ignore them.

To experience automatic word recognition, look at Fig. 1.2. Move across the rows from left to right and say the name of each picture as quickly as you can. Ignore the words printed on the pictures. Did you find it impossible to ignore the words? Most readers do. This is evidence that your mind is processing the words automatically, despite your intention to ignore the words.

In psychological research, this is known as the Stroop phenomenon. Studies using the picture–word interference task have shown that not only the pronunciations but also the meanings of words are recognized automatically (Ehri, 1977; Golinkoff & Rosinski, 1976; Rosinski, Golinkoff, & Kukish, 1975) and that readers as young as the end of first grade can read familiar words automatically (Guttentag & Haith, 1978). It turns out that automat-

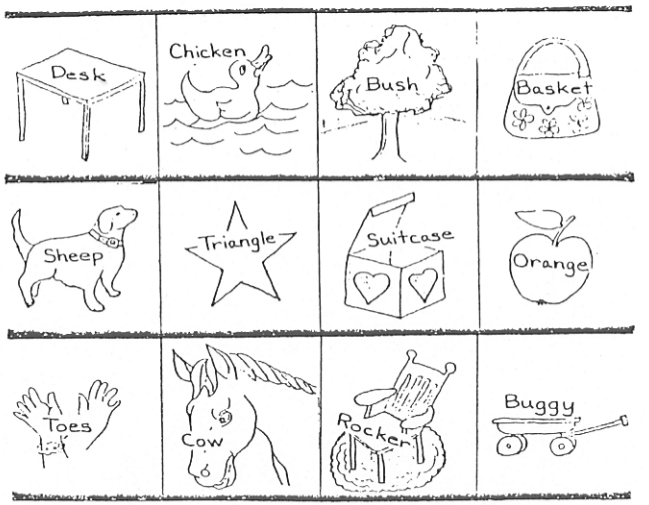

FIG. 1.2. Picture-naming task to demonstrate that words are processed automatically despite the reader's intention to ignore them. From "Learning to Read and Spell Words" by L. Ehri, *Journal of Reading Behavior, 19*, 5–11. Copyright 1987 by National Reading Conference. Reprinted by permission.

icity of word reading is the secret of efficient text reading. We consider this matter shortly.

Another way to read words is by analogy (Baron, 1977; Bowey & Hansen, 1994; Cunningham, 1976; Gaskins, et al., 1988; Glushko, 1979, 1981; Goswami, 1986, 1988; Laxon et al., 1988; Marsh, Freidman, Welch, & Desberg, 1981). Readers may read a new word by recognizing how its spelling is similar to a word they already know as a sight word. They access the similar sight word in memory and then adjust the pronunciation to accommodate the new word, for example, reading *fountain* by analogy to *mountain*, or *brother* by analogy to *mother*. Goswami (1990) found that beginning readers can use their knowledge of rhyming words to read words by analogy. However, having some decoding skill appears to be required for beginners to analogize by accessing sight words in memory (Ehri & Robbins, 1992).

One final way to read words is by using context cues such as pictures and the preceding text to make predictions about upcoming words. As portrayed in the interactive model in Fig. 1.1, readers can use their knowledge about language, their knowledge of the world, and their memory for the text already read to guess the identities of some words as they read text. Some words are easier to predict than others. For example, function words such as *to* and *the* are easier than content words such as *farmer*, *truck*, and *corn*. This way of reading words is evident in the miscues that readers produce when they read text aloud. When words are misread, the words substituted often fit the sentence structure and meaning, indicating that context influenced how the words were read (Biemiller, 1970; Clay, 1968; Goodman, 1976; Weber, 1970).

Predicting words based on context cues, however, does not account for the way that readers read most words in text (Stanovich, 1980). Studies of the predictability of words in text indicate that, on average, 25% to 30% of the words can be guessed correctly. However, the most important content words that carry the most meaning are the least predictable, with only 10% guessed correctly (Gough & Walsh, 1991). Thus, for readers to guess words effectively, they must know most of the surrounding words in a text. To read these accurately, readers must use processes other than contextual guessing.

Having identified the various ways to read words, let us consider how words are processed during text reading. First, consider eye movements. How do you think readers' eyes move when they read a line of print? Do the eyes sweep across the page like a video camera, or do they move in jerks, moving and stopping, moving and stopping? If you observe someone read a page of text, you will discover that the eyes move in fairly regular jerks, stopping to fixate on words and then jumping to the next fixation point. Studies reveal that the eyes fixate on practically every word in a text, sometimes more than once (McConkie & Zola, 1981; Rayner & Pollatsek, 1989). Few words are skipped, usually only high-frequency function words such as *the*. Even words that can be predicted with 100% accuracy are not

skipped. This indicates that the eyes are picking up and processing each word during text reading. According to the interactive model of reading in Fig. 1.1, multiple processes operate in parallel in readers' heads as they read text, and their minds coordinate all of these processes. The eyes light on one word after another. The mind picks them up. The reader's attention and interpretative powers are focused on determining what events, information, and ideas are being represented—what the text means.

Of the various ways to read words identified here, there is one way that enables text reading to operate the most efficiently. If readers can recognize words automatically, then word reading can be executed unconsciously. Each of the other ways of reading words requires conscious attention, however slight. If readers attempt to decode the word, or to find an analogous word in memory, or to use context to predict what the word might be, their attention is shifted at least momentarily to the word itself to solve the puzzle regarding the word's identity, regardless of how easy it is to decode the word or to guess it. This suggests that being able to read words by sight automatically is the key to skilled reading of text. This allows readers to process words in text quickly, without attention directed at the word itself.

Although sight word reading is the most efficient way to read words in text, readers may not know all of the words by sight, so the other four means of reading words must be available to identify unknown words. However, this is not their only contribution. Perfetti (1985) proposed an interactive model in which sight word reading is *supported* by the other ways of reading words. Imagine that a skilled reader is reading a text. Most of the words are known by sight. Sight word reading is a fast-acting process, faster than all the other forms of word reading, so this is how the words are identified. As each sight word is fixated, its meaning and pronunciation are triggered in memory quickly and automatically. However, the other word reading processes do not lie dormant; their contribution is not to *identify* words in the text, but rather to *confirm* the identity already determined. Confirmatory processes are thought to happen automatically as well. Knowledge of the graphophonic system confirms that the word's pronunciation fits the spelling on the page. Knowledge of syntax confirms that the word fits into the structure of the sentence. World knowledge and text memory confirm that the meaning of the word is consistent with the text's meaning up to that point. Having confirmation from multiple sources, that is, redundancy operating during text reading, is a highly important feature. It serves to maintain highly accurate reading, to make the reader sensitive to errors, and to provide a means of self-correction when errors disrupt comprehension.

Sensitivity to redundancy in text may explain miscue differences distinguishing good from poor beginning readers. Both good and poor readers have been observed to substitute the same proportion of syntactically appropriate words when they misread words in texts, indicating that both good

and poor readers are influenced by context to the same extent (Biemiller, 1970). However, good readers are much more likely to self-correct their errors than are poor readers (Clay, 1969), supporting the idea that confirmatory processes operate to a greater extent in good readers than in poor readers.

Let me remind you that in order for readers to be able to read text easily and make sense of it, a large proportion of the words must be familiar and easily read. The rule of thumb is that if students can read at least 98% of the words in a text, the text is considered easy. If students can read 90% to 95% of the words, the text is at their instructional level. If students fall much below 90%, the text becomes frustrating for them (Johns, 1991). These high values underscore the importance of readers' acquiring large sight vocabularies as well as acquiring the various strategies for figuring out unfamiliar words.

Although several ways to read words in and out of context can be distinguished, the type of word reading that most directly supports text reading is sight word reading, at least in English. Moreover, I suggest that establishing sight words in memory is the way that written language gains a foothold in the central mechanisms that regulate speech. This allows readers to use their knowledge of speech to process written language.

SIGHT WORD LEARNING REQUIRES ALPHABETIC KNOWLEDGE

Sight words are words that readers have read accurately on earlier occasions. They read the words by remembering how they read them previously. The term *sight* indicates that sight of the word activates that word in memory, including information about its spelling, pronunciation, typical role in sentences, and meaning (Ehri, 1992). To explain sight word reading, we must specify how readers are able to look at printed words they have read before and recognize those specific words while bypassing thousands of other words, including those with very similiar spellings or meanings. Moreover, we must specify how readers are able to store and remember new words easily after reading them only a few times (Reitsma, 1983). The kind of process we have found to be at the heart of sight word learning is a *connection-forming* process: Connections are formed that link the written forms of words to their pronunciations and meanings. This information is stored in the reader's mental dictionary or lexicon.

What kinds of connections are formed to store sight words in memory? You are probably familiar with the traditional view, which holds that readers memorize associations between the visual shapes of words and their meanings. For example, if you outlined the borders of the following words, each would exhibit a distinctive shape:

dog *green* *tent* *on* *ate*

However, in my research I have found that this view is incorrect (Ehri, 1992).

Consider the feat that skilled readers perform when they read words by sight. They are able to recognize in an instant any one of many thousands of words. They recognize one unique word and bypass many other similarly spelled words. For example, consider all the words that must be overlooked to read the word "stick" accurately: not only *stink*, *slick*, and *slink*, which have similar shapes as well as letters, but also *sting*, *sling*, *string*, as well as *sick*, *sing*, and *sink*. Moreover, skilled readers can remember how to read new sight words with very little practice. Memorizing arbitrary associations between the shapes and meanings of words cannot explain how skilled readers do what they do. Sight word reading must involve remembering letters in the words. These are the distinctive cues that make one word different from all the others.

Findings of my research indicate that readers learn sight words by forming connections between graphemes in the spellings and phonemes underlying the pronunciations of individual words. The connections are formed out of readers' general knowledge of grapheme–phoneme correspondences that recur in many words. Graphemes are the functional letter units symbolizing phonemes. Phonemes are the smallest units of "sound" in words. Readers look at the spelling of a particular word, they pronounce the word, and they apply their graphophonic knowledge to analyze how letters symbolize individual phonemes detectable in the word's pronunciation. This secures the sight word in memory (Ehri, 1980, 1984, 1987, 1991, 1992, 1994; Ehri & Saltmarsh, 1995; Ehri & Wilce, 1979, 1980, 1983, 1986, 1987a).

Figure 1.3 reveals how beginning readers might analyze several different words to secure them as sight words in memory. In this figure, capital letters designate the spellings of words, lower-case letters between slashes indicate phonemes, and lines linking letters to phonemes indicate connections. Notice that in some spellings, more than one letter combines to form the grapheme that is linked to a phoneme (e.g., *sh*, *ch*, *th*). Notice that sounds consisting of a vocalic consonant plus schwa, /əl/ or /ər/, may be treated as one graphophonic unit (Treiman, 1993). Alternatively, beginners may be taught to separate these into two units in order to conform to the principle that all syllables must have a vowel (Gaskins, Ehri, Cress, O'Hara, & Donnelly, 1996). Notice that although the grapheme *g* is known to symbolize either /j/ or /g/ in words, in the word *giggle*, the letter *g* gets remembered as the phoneme /g/, not /j/, because the pronunciation of the word specifies /g/. In this way, the spelling is bonded to the word's pronunciation and meaning. The bonded unit is stored in memory as that word. The next time the reader sees the word, he or she can retrieve the word from memory to read it. Perfetti (1992) described a similar process for representing words in memory.

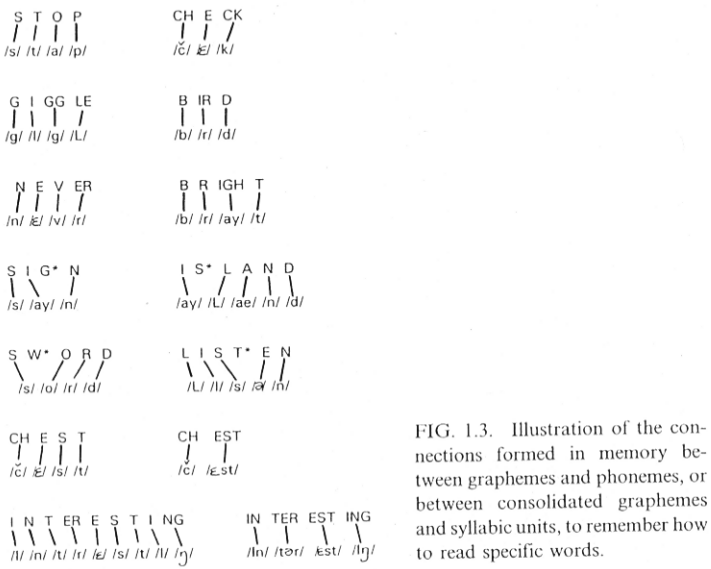

FIG. 1.3. Illustration of the connections formed in memory between graphemes and phonemes, or between consolidated graphemes and syllabic units, to remember how to read specific words.

Note what graphophonic knowledge readers must possess to secure complete representations of sight words in memory. Readers need sufficient familiarity with letter shapes. They need to know how to distinguish the functional graphemic units that typically symbolize phonemes in words. They need to know how to segment pronunciations into constituent phonemes that match up to the graphemes they see in spellings. It is in performing this graphophonic analysis for individual words that the spellings of words penetrate and become attached to readers' knowledge of spoken words in a way that links written language to the central mechanisms governing spoken language.

In analyzing words graphophonically, readers attempt to achieve an optimum match by searching pronunciations for distinguishable phonemes that graphemes suggest are present in the word. For example, we observed fourth graders segment words such as *pitch* into four phonemes corresponding to the graphemes *p-i-t-ch,* but they segmented *rich* into three phonemes matched to the graphemes *r-i-ch* (Ehri & Wilce, 1980). A phoneme corresponding to *t* can be found in articulating these words, but it is not distinguished without a spelling to suggest it.

The process of forming connections allows readers to remember how to read not only words containing conventional letter–sound correspondences such as *stop*, but also words that have less regular spellings. Connections that might be formed to remember irregular words are illustrated in Fig 1.3. Note that the same types of connections are evident. It turns out that most

of the letters in irregular words conform to grapheme-phoneme conventions, for example, all but *s* in *island*, all but *w* in *sword*, all but *t* in *listen*, all but *g* in *sign*. In remembering letters that do not correspond to phonemes, readers may remember them as extra visual forms, may flag them as silent in memory, or may remember a special spelling pronunciation that includes the silent letter, for example, remembering *listen* as *lis-ten* or *chocolate* as *choc-o-late* (Drake & Ehri, 1984; Ehri, 1984; Ehri & Wilce, 1982).

Spellings of words are like maps that lay out the phonological forms of words visually. Readers need to become skilled at computing these mapping relations very quickly when they read words. Knowledge of letter–sound relations provides a powerful mnemonic system that bonds the written forms of specific words to their pronunciations in memory. Once the graphophonic spelling system is known, readers can learn to read words and build a lexicon of sight words easily.

Capabilities That Enable Sight Word Learning in Beginners

There are three graphophonic capabilities that enable beginners to secure complete representations of sight words in memory: knowledge of letter shapes, knowledge of how graphemes typically symbolize phonemes in words, and phonemic segmentation skill. Evidence for the importance of letter knowledge and phonemic segmentation skill in building a sight vocabulary can be found in many studies. For example, Share, Jorm, Maclean, and Matthews (1984) compared the value of 39 characteristics measured in kindergartners at the beginning of school as predictors of word reading skill after 1 and 2 years of instruction. They found that phonemic segmentation and letter-name knowledge were the top predictors of word reading ability, better even than vocabulary knowledge and parent–child book reading experiences, with *r*s ranging from .58 to .68. Several training studies have confirmed that teaching beginners phonemic segmentation, particularly when it is combined with letter knowledge, facilitates the development of word reading skills in beginners (Ball & Blachman, 1991; Bradley & Bryant, 1979, 1985; Lundberg, Frost, & Peterson, 1988; and several others).

It is important to recognize that these skills are strong predictors of beginning reading, not only because they enable sight word reading but also because they are not easily acquired by youngsters. Liberman, Shankweiler, Fischer, and Carter (1974) showed that segmenting words into phonemes is much harder for beginners than is segmenting words into syllables. This is because there are no breaks signaling where one phoneme ends and the next begins in the pronunciations of words. Rather, phonemes overlap and are co-articulated, yielding a seamless stream of sound. Special experiences are needed to help beginners become skilled at recognizing and manipulating phonemes in words. Studies have shown that even adults who have never learned to read an alphabetic orthography have much difficulty identifying

phonemes in speech (Mann, 1986; Morais, Alegria, & Content, 1987; Read, Zhang, Nie, & Ding, 1986).

It is important to recognize that acquiring phonemic awareness requires getting in touch with "deep" phonemes in words rather than surface sounds, as explained previously. According to our theory, graphemes must become attached to these deep phonemes in order for sight words to become well secured in lexical memory. Helping students do this may be facilitated by teaching them how to monitor articulatory gestures, that is, how to use lip and tongue movements to signal phoneme boundaries. For example, the following sequence of movements are involved in saying "top": the tongue touching the roof of the mouth, the mouth opening, and then the lips coming together. Each movement corresponds to a different phoneme. Such awareness and monitoring are taught in the Auditory Conceptualization in Depth Program designed by Lindamood and Lindamood (1975) to remediate reading and spelling difficulties.

It is important to recognize that the aim of phonemic segmentation training is to help learners discover the phonemic segments that allow the spellings of words to become attached to the phonological representations of words in memory. The errors of children who are naive about the spellings of words reveal how phonemic analysis can run off course if left to operate independently of spellings. For example, observations by Henderson (1981), Read (1971, 1975), and Treiman (1993), among others, revealed that some naive learners think that the second sound in *important* is /n/ rather than /m/, that the initial sound in *dress* is the same as the initial sound in *jumper*, that the second consonant in *skate* is /g/, and that the sound between /b/ and /p/ in *bump* consists of one rather than two phonemes. Although children's insights are accurate, discovering these facts about phonetics is not helpful for matching spellings to pronunciations. It is more adaptive to conceptualize the sound structure of words so that it dovetails with graphemes in the spellings of words. It is possible for learners to tinker with the phonological representations of words, but it is not possible to alter spellings that are fixed by the conventional system. According to my theory, the connection-forming process for storing words in memory is facilitated when potential discrepancies between spellings and pronunciations can be reconciled in this way.

Not only phonemic segmentation but also letter learning is difficult for beginners; here, the burden is on memory (Ehri, 1983). Children must remember the shapes, names, and typical sounds of 52 upper- and lower-case letters. These abstract visual forms and labels lack any meaning, making it especially difficult to retain the letter information in memory. Methods of teaching the letters that incorporate meaning into the learning process, that provide mnemonic devices for enhancing memory, and that involve the child in extensive practice should speed up the course of letter learning. An example of letters that are made much easier to learn is found in the Letterland

program (Wendon, 1994). For example, the letter *s* is drawn as a snake, and children learn to refer to it as "Sammy Snake." Both shapes of *h* (*H* and *h*) are drawn to depict "Hairy Hat Man." The alliteration in the labels clarifies the critical sounds to be associated with the letters. The letter shapes are retained more easily in memory because they assume the shapes of the characters. Children can look at a letter, be reminded of the character's shape, recall the character's name, and then find the critical sound at the beginning of the name. In our research, we have found such mnemonics to be effective in teaching letter–sound relations (Ehri, Deffner, & Wilce, 1984).

Children who come to school knowing most of their letters have a substantial head start in learning to read. Knowing the names of letters makes the process of learning letter–sound relations easier, because most of the letters contain relevant sounds in their names. Children who come to school knowing few letters are extremely limited in the progress they can make in learning to read until they learn most of the letters, as becomes apparent later in this discussion.

Phonemic segmentation and letter knowledge are capabilities that benefit sight word learning when children first begin learning to read. In later years, as learners encounter words that are longer and more complex, they need to acquire additional knowledge about the alphabetic system, knowledge involving syllabic and morphemic spelling patterns. This knowledge is needed to extend the development of sight word reading beyond a graphophonic level.

Phases of Development in Sight Word Learning.

In studying the course of development of sight word learning, I have found that different types of connections predominate at different points in development (Ehri, 1991, 1994, 1995). To provide an overview, sight word learning begins as a nonalphabetic process involving memory for connections between selected visual cues and words. However, once learners acquire some knowledge about the alphabetic writing system, sight word learning changes into an alphabetic process involving connections between letters in written words and sounds in their pronunciations. At first, connections are partial, linking salient letters to sounds. When readers acquire full knowledge of the alphabetic system, complete connections can be formed between graphemes in spellings and phonemes in the pronunciations of words. As sight words accumulate in memory in fully analyzed forms, letter patterns recurring in different words become consolidated into multiletter units symbolizing phonological blends. Alphabetic connections linking all of the letters in spellings to their pronunciations enable mature readers to represent thousands of words uniquely in their mental lexicons and to locate the pronunciations and meanings of these words accurately and automatically when seeing them in print (Ehri, 1980, 1984, 1987, 1992; Perfetti, 1992).

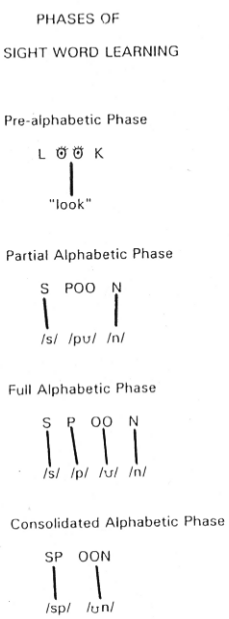

FIG. 1.4. Example of the connections formed to remember how to read words by sight at each phase of development.

To capture the changes that occur in the development of sight word reading, I have distinguished four phases characterized by the involvement of the alphabetic system. This system represents the regularities that underlie the written forms of English words and that all learners must internalize in order to build a fully functioning sight vocabulary. The term *alphabetic* indicates not simply that words consist of letters, but also that the letters function as symbols for phonemes and phoneme blends in the words. The four phases are: pre-alphabetic, partial alphabetic, full alphabetic, and consolidated alphabetic. Each phase is labeled to reflect the predominant type of connection that links the written forms of sight words to their pronunciations and meanings in memory. These are illustrated in Fig. 1.4.

Pre-Alphabetic Phase

During the pre-alphabetic phase, beginners remember how to read sight words by forming connections between selected visual attributes of words and their pronunciations or meanings and storing these associations in memory. Gough and Hillinger (1980) described this as a process of paired associate learning. We called this *visual cue reading* (Ehri & Wilce, 1985). Gough, Juel, and Griffith (1992) showed that pre-alphabetic readers select single salient visual cues to remember words. In one case, a thumbprint appearing

next to a word was found to be the salient cue. When it accompanied the word, children could read the word. When it did not, the word was not recognized. Other examples of salient visual cues that readers might use to form connections are the two round eyes in *look* (see Fig. 1.4), the tail dangling at the end of *dog*, and two humps in the middle of *camel* (Gough, Juel, & Roper/Schneider, 1983).

This phase is called pre-alphabetic because, in contrast to subsequent phases, letter–sound relations are not involved in the connections. When pre-alphabetic readers are observed to read print in their environment, such as stop signs and fast-food restaurant signs, they do this by remembering visual cues accompanying the print rather than the written words themselves; for example, the golden arches behind the McDonalds' sign rather than initial *M* in the name. Masonheimer, Drum, and Ehri (1984) selected children who could read environmental print and presented the print with one letter altered; for example, *Pepsi* changed to *Xepsi*. Children failed to notice the change. This occurred not because children ignored letters in the signs (McGee, Lomax, & Head, 1988), but because they did not store the letters in memory as part of the connections that prompted their reading of the signs.

One interesting consequence of the fact that pre-alphabetic connections do not involve ties between letters and sounds is that readers are not held to specific pronunciations of printed words. In studies by Goodman and Altwerger (1981) and Harste, Woodward, and Burke (1982), children were observed to connect print to ideas and to produce variable rather than exact wordings; for example, reading *Crest* as "brush teeth" or "toothpaste," and reading *Dynamints* as "fresh-a-mints." This lack of correspondence at the phonemic level but equivalence at the semantic level indicates that the connections formed in lexical memory at this phase are between salient visual cues and meanings of words. This contrasts with later phases, in which the involvement of letter–sound connections restricts the word accessed in memory to a single pronunciation linked to the word's spelling (Ehri & Wilce, 1987b).

The pre-alphabetic phase is really a phase that occurs by default, as Byrne (1992) pointed out. Young children have a desire to remember how to read words, but they cannot take advantage of systematic relations between letters and sounds. By default, they resort to noticing and remembering visually salient cues. However, in most cases these cues are unreliable, because they recur in several words. Also, they are hard to remember because most are arbitrary; for example, the thumbprint, or the tall posts in *yellow* (Mason, 1980).

Partial Alphabetic Phase

During the next phase, beginners remember how to read sight words by forming partial alphabetic connections between only some of the letters in written words and sounds detected in their pronunciations. Because first and

final letters are especially salient, these are often selected as the cues to be remembered. We called this *phonetic cue reading*. To remember sight words in this way, partial alphabetic readers need to know the relevant letter–sound correspondences and they need to be able to segment initial and final sounds in words. For example, to remember how to read *spoon*, beginners might detect initial /s/ and final /n/ segments in their pronunciation of the word, and recognize that the letters they see, *s* and *n*, symbolize these sounds, as shown in Fig. 1.4. Recognizing these connections is facilitated by the fact that the names of these letters contain the relevant sounds (i.e., "ess" and "en"; Templeton & Bear, 1992; Treiman, 1993). These connections are retained in memory and enable learners to remember how to read *spoon* the next time they see it. The reason why the connections formed are partial rather than complete is that readers lack full knowledge of the spelling system, particularly vowels; also, they do not know how to segment speech into phonemic units that match up with the array of graphemic units.

Ehri and Wilce (1985) showed how readers at these two phases differed in their sight word learning. They found that beginners in the pre-alphabetic phase had an easier time remembering how to read words that had unique visual forms but bore no relationship to sounds (e.g., *WcB* for *elephant*), whereas beginners in the partial alphabetic phase had an easier time remembering how to read words containing salient cues linking letters to sounds (e.g., *LFT* for *elephant*). Cardoso-Martins (1996) recently replicated this study in Brazil with Portuguese-speaking children.

Rack, Hulme, Snowling, and Wightman (1994) confirmed the phenomenon of phonetic cue reading in children. They showed that beginners remembered how to read words better when the spellings provided connections that were phonetically close rather than distant. For example, beginners were taught to read two different spellings of *garden,* either *kdn* or *bdn*. Both /k/ and /b/ differ from /g/, but /k/ is closer phonetically to /g/ because /k/ and /g/ are articulated at the same place in the mouth, in the back. (Say these sounds to yourself to detect similarities and differences.) Results showed that students learned to read *kdn* more easily than *bdn*. Thus, even though both spellings contained incorrect letters, the letter that enabled the formation of a plausible grapho-phonic connction was the one that facilitated sight word learning.

Byrne and Fielding-Barnsley (1989, 1990) studied what type of training was required to move readers from the pre-alphabetic phase to the partial alphabetic phase. They found that students had to be taught to perceive shared sounds in words, to segment initial sounds in the pronunciations of words, and to recognize how letters symbolized initial sounds in words. These three skills had to be acquired in combination to enable beginners to deduce and transfer alphabetic information from training words to transfer words.

There is an advantage to forming connections out of partial phonetic cues rather than visual cues. Ehri and Wilce (1985) and also Mason (1980) found

that phonetic cue readers remembered how to read words much better than did visual cue readers. This is because phonetic cue readers had a system available to support memory. Knowing the alphabetic system greatly facilitates the task of forming and remembering relevant connections between written words and their pronunciations. In contrast, visually based connections are idiosyncratic rather than systematic and are often arbitrary, making them much harder to remember.

Full Alphabetic Phase

During the full alphabetic phase, beginners remember how to read sight words by forming complete connections between letters seen in the written forms of words and phonemes detected in their pronunciations. This is possible because readers understand how most graphemes symbolize phonemes in the conventional spelling system (Venezky, 1970). In applying this knowledge to form connections for sight words, spellings become amalgamated or bonded to pronunciations of words in memory (Ehri, 1992; Perfetti, 1992). For example, in learning to read *spoon,* full phase readers recognize how the five letters correspond to four phonemes in the word, including how *oo* symbolizes /u/ (see Fig. 1.4). I have already described this form of sight word learning previously.

One advantage of representing sight words more completely in memory is that word reading becomes much more accurate. Whereas phonetic cue readers' limited memory for letters may cause them to misread *soon* or *spin* as *spoon*, full alphabetic readers' representations eliminate confusion because their representations are sufficiently complete to distinguish easily among similarly spelled words. This difference in the tendency to confuse similarly spelled words was apparent in a study comparing readers in the partial phase with readers in the full alphabetic phase (Ehri & Wilce, 1987b).

Another characteristic distinguishing full-phase from partial-phase readers is the ability to decode words never read before, by blending letters into a pronunciation. This knowledge enables full-phase readers to form fully connected sight words in memory. In a study by Ehri and Wilce (1987a), beginners who were partial-phase readers were assigned to one or another of two treatments. The experimental group was taught to read words by converting all of the letters to sounds, thus enabling them to process words like readers in the full phase. The control group was given practice associating individual letters to sounds, a treatment that was not expected to advance them beyond the partial phase in their reading. Following training, subjects received a sight word learning task. They were given several trials to practice reading a list of 15 similarly spelled words with corrective feedback on each trial. The full-phase readers mastered the list within three trials, whereas the partial-phase readers read only 40% of the words after seven learning trials.

The difficulty exhibited by partial-phase readers was confusing words having similar letters, for example, *bend* and *blond, drip* and *dump, lap* and *lamp, stab* and *stamp*. These results reveal the great advantage to word reading that occurs at the full alphabetic phase.

Although full-phase readers are able to decode words, this graphophonic assembly strategy for reading words is supplanted by sight word reading for words that are practiced sufficiently often. The advantage of sight word reading over decoding is that sight word reading operates much faster. In a study by Ehri and Wilce (1983), students in first, second, and fourth grades read familiar sight words much faster than simply spelled nonsense words. In fact, good readers were able to read the sight words as rapidly as they could name single digits, indicating that the words were read as single unified wholes rather than as letters identified sequentially. Unitization is taken to indicate that spellings of sight words are fully bonded to their pronunciations in memory.

It is not until beginners are capable of establishing fully connected sight words in memory that they can read new words by analogy to known sight words. In a study by Ehri and Robbins (1992), we found that beginners in the full alphabetic phase were able to read new words by analogy to known words, whereas beginners in the partial alphabetic phase were not. Rather than analogize, partial-phase readers tended to mistake the new words for the known words because of shared letter cues; for example, misreading the new word *save* as the word they had learned to read *cave*. Our explanation is that partial-phase readers do not store their sight words in memory in sufficient letter detail to recognize how they are similar to yet different from similarly spelled new words. In contrast, readers in the full phase possess full representations of sight words plus decoding skill, both of which support an analogy strategy.

Consolidated Alphabetic Phase

The ability of readers in the full alphabetic phase to retain complete information about the spellings of sight words in memory makes it possible for their print lexicons to grow rapidly as they encounter many different words in their reading. As fully connected spellings of more and more words are retained in memory, letter patterns that recur across different words become consolidated. Repeated experience reading a letter sequence that symbolizes the same phoneme blend across different words yields a consolidated unit. Consolidation allows readers to operate with multiletter units that may be morphemes, syllables, or subsyllabic units such as onsets and rimes. These letter patterns become part of a reader's generalized knowledge of the spelling system.

Larger letter units are valuable for sight word reading because they reduce the memory load involved in storing sight words in memory. For example, *-est* might emerge as a consolidated unit in a reader's memory from its occurrence in several sight words known by the reader—*nest, pest, rest, test, vest, west*, and *crest*. Knowing *-est* as a consolidated unit means that the graphemes and phonemes have been analyzed and bonded. Knowing this should ease the task of forming connections to learn the new word, *chest* as a sight word. Whereas full-phase readers would need to form four separate connections linking *ch, e, s*, and *t* to the phonemes /č/, /e/, /s/, /t/, respectively, a consolidated phase reader would need to form only two separate connections, *ch*, and *est*, linked to /č/ and /est/, respectively. Another example of connections formed from consolidated units is shown in Fig. 1.4.

If a reader knew units such as *est, tion, in*, and *ing* as consolidated units, the task of learning longer sight words such as *question* and *interesting* would be easier. Another contribution of consolidated units to sight word reading is that they speed up the process of accessing words by facilitating letter identification (Juel, 1983; Venezky & Massaro, 1979).

A number of studies have shown that older readers are more sensitive to letter co-occurrence patterns than beginning readers. For example, Leslie and Thimke (1986) gave first and second graders a word-search task and found that students reading at a second-grade level were sensitive to the difference between legally sequenced and illegally sequenced letters in nonwords, whereas first graders were sensitive only to the difference between familiar and unfamiliar real words. This suggests that second grade is when children's sight vocabularies grow large enough to support the consolidation of frequently occurring letter patterns into units.

Also, there is evidence that words containing more familiar letter patterns are read more accurately by students than are words containing unfamiliar patterns even when the words are constructed out of the same grapheme–phoneme correspondences (Treiman, Goswami, & Bruck, 1990). Such effects are more apparent in advanced beginning readers than in novice beginners, indicating the contribution of a larger sight vocabulary to knowledge of common spelling patterns (Bowey & Hansen, 1994).

A study by Juel (1983) showed that knowledge of letter patterns enables more mature readers to read familiar words faster. She found that fifth graders who were shown words that shared letter patterns with many other words were able to read those words faster than words having less common letters. However, this factor made little difference to second graders who were influenced primarily by the decodability of the words. Thus, word reading speed may be facilitated by knowledge of letter patterns sometime after second grade.

To summarize, I have suggested that the development of sight word learning occurs in several phases differing from each other in the involvement

of alphabetic knowledge. The pre-alphabetic phase occurs by default because beginners lack much knowledge or ability to use letters in their sight word reading, so this phase makes little contribution to subsequent phases of development. In contrast, the three alphabetic phases—partial, full, and consolidated—are closely related and extend development from immature to mature forms of sight word learning.

SIGHT WORD LEARNING REQUIRES SPELLING KNOWLEDGE

Most people take it as a given that reading and spelling are different things. However, this can be questioned. The term *spelling* is actually ambiguous. It can function as a verb to refer to the act of spelling a word by writing it; however, it can also function as a noun to refer to the product that is written, the word's spelling, consisting of a sequence of letters. Spellings of words are the targets not only of spelling behavior but also of reading behavior. Talking about spellings of words for reading blurs the separation between reading and spelling.

Another factor muddying the waters is uncertainty about which behaviors count as spelling and which count as reading. One can spell words by writing them. One can also recognize whether spellings are correct or incorrect as the words are being *read*; for example, *rane* versus *rain*. When one writes out words, one usually *reads* the words to verify their correctness. To the extent that spellers do this when they spell, reading as well as spelling contribute to the final spelling product.

Although the ambiguity and overlap might appear hopeless, some basic distinctions can be salvaged. Words have spellings, that is, prescribed sequences of letters. Spellings of words are the targets of three literacy acts:

1. Writing spellings.
2. Reading spellings to determine their pronunciations and meanings.
3. Noticing when spellings are incorrect as they are read.

It turns out that these three literacy acts are very closely related (Ehri, 1997).

There is evidence that when readers read text, they automatically notice when words are misspelled. McConkie and Zola (1981) planted misspellings in text, and they recorded readers' eye movements as they read the text. They found that normal eye movement patterns were disrupted when readers saw words as subtly misspelled as *fracture* and *garden* written *fraoture* and *garben*, even when these words appeared in highly predictable contexts. This is evidence that reading and spelling processes are intertwined during the act of reading.

Correlational findings reveal that the three literacy acts are closely related. I have extracted correlations from various studies in which students were asked to read a list of words, or to write words to dictation, or to distinguish correct from incorrect spellings of words. From Table 1.3 one can see that reading and spelling performances were highly related in these studies. The high values are not explained by more general factors, such as intelligence. For example, in the Greenberg, Ehri, and Perin (1997) study, the partial correlation remained the same when Peabody Picture Vocabulary scores were removed. Note that most of the correlations are above $r = .70$, bringing them close to reliability values that are expected between tests that measure one capability. Such high correlations indicate that similar if not identical processes are measured by these tasks.

Let us consider knowledge sources and processes that are involved in these three acts involving spellings to see what makes them much more similar than different. We can distinguish two types of knowledge that people use to read and spell words (Ehri, 1986). They possess knowledge about the spellings of specific words held in memory as a result of their experiences reading those particular words. Earlier, I portrayed this knowledge as involving graphophonic connections linking spellings to pronunciations. People also possess knowledge about the general alphabetic system. This includes phonemic segmentation and blending, grapheme–phoneme and phoneme–grapheme relations, and spelling patterns that recur in different words. It

TABLE 1.3
Correlations Among Reading Words, Producing Correct Spellings of Words, and Recognizing Misspellings of Words at Various Grade Levels Across Different Studies (from Ehri, 1997)

Studies / *Grade Levels*	*Read: Spell*	*Read: Rec. Missp.*	*Spell: Rec. Missp.*
Juel, Griffith, and Gough (1986) Different words were read, spelled, and recognized.			
First graders	.84	.74	.76
Second graders	.77	.69	.68
Griffith (1987) Same words were read and spelled.			
First graders	.83		
Third graders	.84		
Greenberg, Ehri, and Perin (1997) Different words were read and spelled.			
Third through fifth graders	.86		
Jorm (1981) Same words were read and spelled.			
Fourth through sixth graders	.85		
Griffith (1991) Different words were spelled and recognized.			
Third graders			.80
Ehri and Wilce (1982) Different words were spelled and recognized.			
Seventh graders			.77
College students			.78

does not include memorized rules that people can state verbatim but have little idea how to apply (Beck, 1981). By alphabetic knowledge, I mean *working* knowledge that people actually apply to read and spell.

Typically, beginners are taught grapheme–phoneme correspondences when they begin school. These associations are easier to learn if students already know the names of letters, because most letter names include relevant sounds, for example /t/ in *tee,* and /k/ in *kay.* Read (1971), Treiman (1993), and others showed that beginners make use of letter-name knowledge in their attempts to invent spelling of words. We have shown that beginners use this knowledge also in remembering how to read words (Ehri & Wilce, 1985).

Although letter names take care of 25 associations, there are several more to be learned that are not found in names. Whereas grapheme–phoneme relations are used for reading, phoneme–grapheme relations are used for spelling. It turns out that correspondences for reading are not completely isomorphic with correspondences for spelling. There are about 40 distinctive phonemes in English, but 70 letters or letter combinations to symbolize phonemes. This makes pronouncing spellings easier than writing correct spellings (Cronnell, 1978).

Whereas beginners utilize graphemes and phonemes to read and spell, once students gain more experience with words, they consolidate graphemes and phonemes that recur across different words into multiletter units that are used to read and spell. The earliest units to become consolidated are probably the common affixes and common spelling patterns that were shown in Table 1.1.

This view of systematic alphabetic knowledge is broader than that offered by Venezky (1970) and by Hanna, Hanna, Hodges, and Rudorf (1966). It includes regularities that others regard as irregularities; for example, sounds that are spelled in more than one way, and letter sequences that include silent letters. The feature that makes a letter or letter sequence systematic is its recurrence in several different words. Of course, I am talking about *potential* systematic knowledge here. These sources of regularity are all available for learners to incorporate into their working knowledge of the system. Whether they actually do is another matter.

The other type of knowledge used for reading and spelling consists of information about the spellings of individual words. As I have explained, word-specific knowledge is constructed out of students' knowledge of the general alphabetic system. Knowledge of the system functions as a mnemonic tool, enabling students to retain letter-specific information about individual words in memory.

In English, specific word learning is necessary because variable spellings are possible. For example, *telephone* might be spelled conventionally in several ways, as *teliphone, tellafoan,* or *telufown.* To the extent that learners

see one spelling and process its grapheme–phoneme connections, they remember this spelling and not the alternatives, as has been shown in various studies (Ehri, 1980; Ehri & Wilce, 1986; Reitsma, 1983). Of course, any of these alternatives is much easier to remember than spellings that lie outside the system; for example, spelling *telephone* as *komikeh.* This illustrates how knowledge of the system is central for remembering the written forms of specific words for use in both reading and spelling acts.

It is important to note that my view differs from other views that regard word-specific memory as comprising visual configurations of words or serial lists of letters but not rules and regularities (Kreiner & Gough, 1990). My view is that knowledge of the system is the primary stuff used to build word-specific memory.

Although reading words and spelling words involve very similar processes, it is obvious that we can read words better than we can spell words. The reason is that more bits of information must be remembered for correct spelling than for correct reading. When a student remembers how to read a familiar word, he or she accesses essentially one bit of information from memory, an amalgam consisting of the word's spelling, pronunciation, and meaning. However, when the student remembers how to spell a familiar word, he or she must access *several* bits of information from memory consisting of individual letters in the proper order.

What is the nature of the representations that enable students to write out all the letters in words correctly? Results of our research indicate that the spelling-pronunciation-meaning amalgams formed in memory to read words are also useful for spelling words. In several studies, we have taught beginners to read specific words and then have asked them to spell the words. In most cases, transfer from reading to spelling was evident (Ehri, 1997). However, reading did not enable most subjects to spell the words *perfectly.* Typically, students could spell a greater proportion of the letters correctly than they could spell entire words correctly: 70% to 80% of the letters versus 30% to 40% of the words. This suggests that perfect spelling requires more than the amalgams formed from reading practice.

What kinds of letters make spellings especially hard to remember? According to our theory, letters that do not conform to the alphabetic system should be harder to remember. Letter sequences that recur in few other words and are not built out of conventional grapheme–phoneme correspondences should cause problems. When there are many graphemes that might symbolize a phoneme, as in the case of *schwa* vowels, remembering the particular grapheme is harder. Graphemes having no correlates in sound should elude memory; for example, doubled letters and silent letters.

Let us examine some words that have parts known to be difficult to spell. I have listed in Table 1.4 some spelling demons identified by Fry, Polk, and Fountoukidis (1984). What makes these words difficult to spell? According

TABLE 1.4
Spelling Demons With Difficult Parts Underlined
(Taken From Fry et al., 1984)

lieutenant	*sergeant*	*receipt*	*aisle*
unnecessary	*accommodate*	*muscle*	*yacht*
conscientious	*noticeable*	*pneumonia*	*vacuum*

to our theory, students remember best those letters that conform to their knowledge of the alphabetic system, especially letters that can be connected unambiguously to phonemes within words. They have the hardest time remembering letters that lie outside the alphabetic system as they know it. Inspection of these demons reveals that all contain problem letters, including nonconventional graphemes, doubled letters, silent letters, *schwa* vowels (i.e., the nondistinctive vowel pronounced "uh" in unstressed syllables), and uncommon spelling patterns that I have underlined. Notice how variable the spellings of *schwa* vowels can be, as evidenced in these words—*a, e, ou, ea, o, i*—hence, the difficulty of remembering which letter is correct. Kreiner and Gough (1990) showed that spellers make more errors on *schwa* vowels than on unambiguously pronounced vowels.

Waters, Bruck, and Malus-Abramowitz (1988) compared students' ability to spell words that exhibited different kinds of spelling regularities. The children were in third through sixth grades. The hardest words to spell were those having letters that fell outside the system, words such as *aisle* and *yacht*. Less difficult were words whose regularity depended on knowing the spellings of root words and affixes; for example, *sign* related to *signal* and *shortage*. Easier than these were words that might be spelled in alternative, equally legitimate ways, for example, *detail* versus *detale*. The easiest words to spell were completely regular words with few alternative legal spellings. These findings are consistent with our theory.

To summarize, the point of this discussion is to suggest that learning to read words and learning to spell words are very closely related, because growth in both cases requires knowledge of the alphabetic system. Becoming a skilled reader as well as a skilled writer necessitates learning the alphabetic system. This involves at the outset learning graphophonemic relations that provide the foundation for learning a wide variety of spelling patterns.

Spelling Helps Reading and Reading Helps Spelling During Development

Results of several studies indicate that learning to read and learning to spell are reciprocally related, particularly when children first learn to read and write words. To review, according to our theory, students retain word-specific

information in memory when they learn to read words, and this information is available to support spelling performance. Likewise, learning how to produce more complete spellings of words contributes to sight word reading.

We observed transfer from reading to spelling in a study with second graders (Ehri, 1980). Students practiced reading the spellings of eight made-up words until they could read them perfectly. Half of the students read one plausible letter sequence, and half read an alternative sequence. Examples of the pairs of spellings are:

wheople versus *weepel*	*wh* versus *we*
bischun versus *bistion*	*ch* versus no *ch*
ghirp versus *gurp*	*i* versus no *i*

Both forms were pronounced identically. After a 4-minute delay, students wrote from memory the spellings that they had read. They recalled 69% of the words perfectly, indicating that substantial transfer from word reading to word spelling occurred despite alternative ways to spell the words. Even when students misspelled the words, they restricted their letter choices to those they had seen in the words rather than phonemically equivalent alternatives. Adjacent to the word pairs printed here are letters distinguishing the two spellings. We found that students included these letters in their misspellings only if they saw the letters in the words they studied, not if they didn't see the letters. This indicates that word specific knowledge retained from reading experiences influenced second graders' spellings.

Results of another study (Ehri & Wilce, 1986) also revealed the impact of reading words on students' memory for their spellings. In this study, we used words containing medial flaps that are pronounced more like /d/ in American English, but might be spelled with either *d* or *t*. Examples of the words we used are:

huddle, modify, pedigree versus *meteor, glitter, attic.*

Second graders were exposed orally or in writing to 12 words containing these medial flaps. Half of the subjects practiced reading the words; the other half heard and repeated the words but never saw spellings. Subjects practiced the words on one day and then wrote spellings on the next day. Half of the words contained flaps spelled *d* and half contained flaps spelled *t*.

We expected that students who read the words would connect graphemes to phonemes and would remember the flap in each word as /d/ or /t/ according to its spelling, whereas students who only listened to the words would spell the flap phonetically as /d/ in most of the words. This was what we found. Subjects who read the words spelled 84% of the flaps accurately, whereas controls spelled only 64%. By chance we would expect 50% accuracy.

Whereas students in the made-up word (Ehri, 1980) study, spelled words shortly after they read them, students in the flap study spelled words on a different day. Despite the delay, students' spellings still reflected memory for word-specific information, indicating that memory was long term.

In the second flap study, we found that students' memory for complete spellings of the words was weak, only 31%, probably because the words contained problem letters such as doubled consonants. The fact that word-specific effects were nevertheless evident in spellings shows that if students have partial letter information about specific words in memory, they do not ignore this knowledge and invent a spelling. Rather, they access the letters they remember and invent the part they do not remember.

The focus of transfer effects from reading to spelling in these studies involved specific words. In another laboratory study, we manipulated students' knowledge of the alphabetic system by training kindergartners to decode words. We found that this reading treatment boosted their spelling performance (Ehri & Wilce, 1987a). Foorman, Francis, Novy, and Liberman (1991) reported similar findings in a classroom-based study.

To summarize, results of these studies confirm that reading impacts spelling in beginners. When beginners read words, they retain word-specific information in memory and they access this to spell the words. When readers receive reading instruction that improves their general knowledge of the alphabetic system, this benefits their spelling ability as well.

It is clear that reading influences spelling in beginners. Also, there is evidence that spelling influences reading. Morris and Perney (1984) had first graders invent spellings of words before the students had received any formal reading instruction. Most children knew all the letters of the alphabet but they were able to spell few words correctly, only 9%. Students' productions were scored to reflect whether all the sounds were spelled with plausible letters and whether letter choices were conventional. Results revealed a surprisingly high correlation, .68, between spellings invented at the beginning of the school year, and reading achievement scores at the end of the year. The correlation rose to .82 between mid-year spelling scores and year-end reading scores. The likely explanation is that invented spellings reflect children's knowledge of the spelling system that determines how quickly they get off the ground and make progress in learning to read.

We performed a short-term experiment with beginners to examine the effects of spelling training on word reading (Ehri & Wilce, 1987b). In this study, we manipulated learners' knowledge of the general alphabetic system. The students were kindergartners selected because they had limited ability to read words and could not decode. Experimental students were taught to spell words phonetically by segmenting them into phonemes and symbolizing the phonemes with graphemes. Control students practiced isolated phoneme–grapheme associations. Then students were given several trials to learn to

read a set of 12 similarly spelled words. Comparison of performances revealed that spelling-trained students learned to read significantly more words than did control students. Our explanation is that spelling instruction improved students' working knowledge of the alphabetic system. With this knowledge they were able to form more complete grapheme–phoneme connections to remember how to read the words than control students.

In our study, spelling instruction improved students' ability to learn to read a set of words with practice, but it did not improve their ability to decode unfamiliar words, presumably because it did not include lessons in how to assemble and blend graphemes into phonemes. However, Uhry and Shepherd (1993) conducted a spelling training experiment and found that training did improve students' decoding ability. Their findings suggest that spelling instruction can improve decoding ability if it is structured to include blending.

In sum, it is likely that the reason why instruction in spelling contributes to word reading ability is that spelling instruction helps beginners acquire knowledge of the alphabetic system, which benefits processes used in reading.

Reading and Spelling in Normal and Disabled Readers

We have shown that reading and spelling processes are highly related in normally developing readers. What about disabled readers? In two studies examining the relationship between word reading and word spelling abilities in disabled readers separately from normal readers, results verified that reading and spelling performances were strongly correlated in both groups. However, the correlations were not quite as high for disabled readers as they were for normal readers, indicating that the underlying processes may be less interconnected and interdependent in disabled readers.

Guthrie (1973) examined 19 normal second-grade readers and 19 older disabled readers matched to normals in reading age. He gave them word reading and spelling recognition tasks involving both words and pseudowords. Correlations between the reading and spelling tasks were all positive and strong, but those among normal readers were substantially higher than those among disabled readers:

	Spell/Read Words	*Spell/Read Pseudowords*
Normal readers	$r = .84$	$r = .91$
Disabled readers	$r = .68$	$r = .60$

In another study, Greenberg, Ehri, and Perin (1997) compared 72 normal readers in third, fourth and fifth grades with 72 adults matched to the normals in reading age. The adults were severely disabled readers enrolled in adult

literacy programs. Greenberg et al. gave tasks to measure spelling production, word reading, and pseudoword reading:

	Spell/Read Words	*Spell/Read Pseudowords*
Normal readers	r = .86	*r* = .62
Disabled readers	*r* = .57	*r* = .41

As in Guthrie's study, all the correlations were postive and significantly greater than zero, but normal readers' values were substantially higher than those of disabled readers. The difference was not attributable to differences in the size of the standard deviations between the two groups.

Our interpretation is that the lower correlations among disabled readers signal the reason for their difficulty learning to read and spell. Their progress is impaired because their word reading and word spelling processes have not become sufficiently integrated. Poorer integration may arise from inadequate detection of "deep" phonemes in words, or deficient knowledge of the alphabetic system. Both of these deficiencies would be expected to impair the process of establishing sight words in memory, by limiting the strength of the bonds formed between spellings and pronunciations and limiting the attachment of spellings to deep phonemes within the central speech processing system.

This explanation received some support in the Greenberg et al. (1997) study. They found that even though the adult disabled readers and child normal readers were matched in their word reading skill, the adults performed much worse on phonemic awareness and nonword decoding tasks, indicating that their knowledge of the alphabetic system and knowledge of deep phonemes were poorer.

Ehri and Saltmarsh (1995) compared normal first-grade readers to older disabled readers in a sight word learning task. They found that the disabled readers took significantly longer to learn to read the words than did normal readers when learning scores were adjusted for reading age. Moreover, reaction times to read the words indicated that the sight words were not as well secured in memory among disabled readers as among normal readers. These findings add support to the view that the connection-forming processes involved in sight word learning are impaired among disabled readers. Whereas normal readers reach the consolidated phase in their sight word learning, disabled readers may remain at the partial alphabetic phase in their development.

CONCLUSION

Theory and evidence presented in this chapter reveal that learning to read is fundamentally an alphabetic process. There is no way that beginners can attain mature levels of reading and writing without acquiring knowledge of

the alphabetic system and utilizing this to build a vocabulary of sight words. Moreover, getting off the ground in learning to read is not easy. Beginners must accomplish some very difficult tasks. They must retain in memory 52 upper- and lower-case letter shapes and learn how these letters operate singly or in combination to symbolize phonemes in words. They must learn how to find the invisible seams in the flow of speech in order to segment words into phonemes. Their knowledge of graphemes and phonemes must be put to use to penetrate the phonological structure of words buried deep in the speech centers of their brains and to attach spellings of words to these representations.

Phonemic awareness and letter knowledge are important determiners of reading acquisition during the first couple of years. However, further growth requires acquisition of alphabetic knowledge that involves multiletter units, or spelling patterns. Learning to read and learning to spell become closely intertwined during development because each draws on the same knowledge sources in memory. Although the same processes operate in poor readers as in good readers, reading and spelling are not as closely intertwined. Word memory remains difficult when the letters or connections that must be remembered lie outside learners' knowledge of the alphabetic system. This may explain the greater difficulty that disabled readers have in learning to read.

My focus has involved describing how alphabetic processes are central in learning to read. I have said little about instruction. However, my reason for going into detail about reading acquisition processes in learners was to lay out a map that teachers might use to guide their efforts. My claim is that teachers need to understand these processes so that they hold a target in mind when they teach students to read, they can tell whether these processes are being acquired by their students, they can identify how particular aspects of their instruction develop these processes, they can tell whether instruction is working as it should, and they can figure out how to modify instruction to improve its effectiveness. What I propose may appear to be a tall order indeed, but this is what effective, intelligent teaching is all about. Effective teachers are not robots who follow teacher manuals blindly and religiously and who turn the burden of effective instruction over to curriculum materials. Rather, effective teachers are intelligent, reasoning, informed problem solvers who undstand what they are doing.

In giving teachers direction in how to think about the processes they need to teach, I would offer the following as fundamental:

1. At the outset of instruction, beginners need to learn all their letters and learn how to use their letter knowledge to penetrate speech processes. Letter learning includes recognizing the shapes of letters as well as recalling and writing letter shapes from memory. It includes learning the names of

letters as well as the most frequent sounds they symbolize. It includes learning how to group letters to form graphemes that symbolize sounds. Facility with letters is essential for learners to operate alphabetically with words. Learners cannot be expected to make adequate progress without acquiring facility with letters.

2. At the same time, beginners need to break the sound barrier and become aware that words contain phonemes with acoustic and articulatory properties. As this awareness is cultivated, it needs to dovetail with knowledge about sounds in letter names and sounds depicted in the spellings of words. Mastery is evidenced when children can generate phonetically complete and graphemically plausible spellings of words they have never seen written.

3. Teachers need to monitor beginners' progress in acquiring letter knowledge and phonemic awareness to make sure that it is occurring for each student. In kindergarten and first-grade classrooms there is tremendous variability among students in this respect. Teachers will need to exert extra effort with students who enter school lacking this knowledge or who find it more difficult to acquire.

4. First-grade teachers need to adopt as a primary goal that of helping students reach the full alphabetic phase in their sight word reading. For students, this means learning the major grapheme–phoneme correspondences, vowel correspondences being most important. This means being able to segment pronunciations of words into phonemes, being able to segment spellings of words into graphemes, recognizing how the two match up, and retaining these connections in memory.

5. To support sight word learning, students need to acquire strategies for reading unfamiliar words by both decoding and analogizing. These strategies should be easier to teach to students once they reach the full alphabetic phase in their sight word reading.

6. Students need to acquire word spelling as well as word reading competencies. At the outset, spelling instruction should focus on helping students invent phonetically complete spellings of words as well as inventing spellings that are graphemically plausible in terms of the conventional system. Learning the spellings of specific words by memorizing word lists should not begin until students understand how the conventional system works graphophonically. Once this point is reached, remembering the spellings of specific words will be much easier, so spelling instruction can shift to this learning activity.

7. In addition to learning the spellings of specific words, another goal of spelling instruction should be to cultivate students' knowledge of the alphabetic system. This should include not only graphophonic correspondences but also knowledge of consolidated units including root words, affixes, and families of related words. The more that students understand about the alphabetic system, the easier time they should have retaining information about individual words in memory for reading as well as for spelling words.

The guidance I offer is directed at teachers who provide literacy instruction during the primary grades. In my view, it is during this period that teachers make their greatest contribution to students' ultimate reading success, by making sure that the alphabetic foundation for learning to read is well established. This view receives support from studies showing that correlations between reading in first grade and reading in later grades is very high (Juel, 1988). Early on, the ground to cover includes teaching phonemic awareness, letter knowledge, decoding, sight word reading, and spelling as well as teaching how these skills are incorporated into text reading and writing. Students will have a better chance of achieving subsequent milestones with the proper foundation in place. Later milestones include achieving speed and automaticity in reading sight words during text reading, and advancing to the consolidated phase in acquiring knowledge and use of the alphabetic system for reading and writing. Teaching beginners to read effectively is not easy, particularly if children are at risk for reading disability. It requires a professionally trained teacher who understands the processes I have discussed here, who knows how to cultivate them through instruction, and who can tell through observation and assessment whether each student is making satisfactory progress.

AUTHOR NOTES

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2

The Role of Analogies in the Development of Word Recognition

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Word recognition in beginning literacy poses a particular set of problems. The most important of these is how written words represent spoken words. Writing systems were invented to communicate the spoken language, and most writing systems do this systematically, by using an alphabet, a syllabary, or a set of logographs (characters, like $ or %) that convey meaning. Because English is an alphabetic language, children who are learning to read English must learn the systematic correspondences between alphabetic letters (or groups of letters) and sounds. This means that learning written language requires some understanding of spoken language. This is not surprising when one considers that writing systems are designed to convey speech.

In this chapter, we consider how the ability to reflect on spoken language might help a child to learn to read English. We investigate the most consistent level at which the English writing system (or orthography) represents sound (phonology), and examine whether English-speaking children use this level in reading acquisition. This entails the use of orthographic analogies in reading. We then contrast the strategies used by children learning to read English with those used by children learning to read other languages. Finally, we discuss the implications of the analogy research for classroom teaching.

ACQUIRING SPOKEN VERSUS WRITTEN LANGUAGE

Consider briefly the immense task that faces an infant who is beginning to acquire spoken language. The infant is faced with the problem of distin-

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