1361a.

483

Questions people ask about the role of phonological processes in learning to read

DONALD SHANKWEILER[1,2] and ANNE E. FOWLER[2]*
[1] *University of Connecticut, Storrs, CT, USA;* [2] *Haskins Laboratories, New Haven, Connecticut, USA*

Abstract. A growing reliance on research to guide decisions about reading instruction has resulted in a swing toward approaches that emphasize phoneme awareness and the relations between speech and alphabetic writing. Because this is a time of innovation and experimentation in the schools, and because the new emphasis has not won universal acceptance, there is a need to address recurring questions about the role of phonology in reading acquisition. These questions concern: (1) the relevance of phoneme awareness instruction to reading; (2) the consequences of the complexity of English spelling for decisions about explicit instruction in the alphabetic code; and (3) the causes and symptoms of reading difficulties and implications for remediation. In this paper, we offer our answers to such questions and discuss the research bases for them.

Key words: Applying reading research, Learning/teaching issues, Phonological abilities, Reading difficulties, Reading instruction

A growing awareness of the numbers of children who leave American schools without having acquired functional reading skills fuels the search for solutions to the reading problem. Improving reading skills has become a national priority and almost a national obsession. Issues concerning how reading should best be taught, especially at the beginning level, are regularly aired in the press and in legislative chambers. There, as in the latest round of research reviews and recommendations by panels of experts, the tide has turned from approaches that discourage explicit teaching of the connections between speech units and print to those that incorporate systematic instruction in the alphabetic code as an essential component of the reading curriculum.

Pendulum swings in teaching practices are, of course, not new. What is new is the extent to which research from the science of reading is being taken seriously as a guide for decisions about how reading should best be taught. Evidence accumulated over the past 30 years has led to a near consensus among researchers that early awareness of the phonemic principle of alphabetic writing plays a central role in becoming a skilled reader of English

---

* Anne Fowler, who died on March 27, 2004, was co-director of the Early Reading Success Initiative at Haskins Laboratories, a school outreach program that seeks to bring the best research to the aid of classroom teachers.

and other alphabetic systems (National Reading Panel, 2000; Snow, Burns & Griffin, 1998). This consensus has led many who are in a position to influence and redirect school policy to call for curriculum reform and changes in reading assessment. Textbook publishers, state departments of education, and purveyors of professional development courses are rushing to translate research findings for classroom teaching and remedial practice. Others are making superficial changes in terminology to conform to the growing emphasis on the phonological basis of reading, with little change in actual content or practice. Still others have resisted these trends, challenging the recommendations of the review bodies. Clearly, this is a time of experimentation and change; it is a hopeful time, but also a confusing time in which long-held beliefs are being called into question.

Translating research findings into classroom practice presents many challenges. Not surprisingly, attempts to do this have resulted in diverse interpretations of the evidence, especially since teachers are not trained to evaluate research. In view of this, it seemed to us the right time to take stock of recurring questions about the role of speech-based processes in reading in light of the pertinent research. In this paper we discuss ten questions that we frequently encounter in the course of discussions with teachers, colleagues, administrators, legislators and others concerned with reading instruction, assessment, and remediation. We know that other researchers are being asked similar questions. Some of the questions likely reflect misapprehension of the research findings; others draw unwarranted conclusions from the findings. We offer the best answers we can, based on our interpretations of the research evidence. We make no claim to impartiality, but we have tried to examine the evidence fairly. We hope that our reflections will be helpful to other researchers who, increasingly, are being called upon to speak to practical concerns. Our purpose is not to offer another comprehensive review of the reading research literature, a task that has been ably carried out by others (see Rayner, Foorman, Perfetti, Pesetsky & Seidenberg, 2001; Share, 1995; Stanovich, 2000). Rather, by adopting a compact question and answer format, we have tried to make the paper accessible and useful to a variety of people who need to be informed about what research can offer regarding reading instruction and the reasons for differences in response to it. We hope also that the paper can help to provide a critical framework for evaluating competing claims about reading and its problems.

In the discussion that follows, we present our list of questions about reading and reading pedagogy that continue to fuel the ongoing debate about learning to read in English-speaking schools. To facilitate discussion, we have organized the questions into three groups, taking up, in turn: the significance of phoneme awareness, instruction in the alphabetic code, and the

role of phonological skills in reading acquisition and reading difficulty. First, however, we offer some remarks about the fundamentals of alphabetic writing that shape the task of the would-be reader.

1. Phonology, the alphabetic principle, and the reader

In our view, the primary function of a writing system is to give unambiguous expression to all the words of a language (see DeFrancis, 1989; Klima, 1972). Words form the primary link between language and the world, the intersection of form and meaning. We usually think of them as units of meaning, but words are also (phonological) units of speech. Words can be further decomposed into still smaller units of meaning (morphemes) and speech (syllables and consonant and vowel phonemes).

Spoken words are patterned sequences of articulatory movements and resulting sound. Looking across languages, we see that writing systems represent speech in different ways, often reflecting differences in the artic-ulation and sound pattern (i.e., *phonology*) of individual languages. Japanese, for example, with but 100 meaningless syllables that can be combined to create thousands of multisyllabic words, is well served by a *syllabary*, an orthography based on syllables. Chinese, on the other hand, has far too many syllables for a syllabary to be a practical form of writing. Moreover, individual syllables in Chinese often constitute meaningful words; the same syllable can represent as many as 20 different words. Avoiding the ambiguity created by such a degree of homophony, Chinese writing, a *logography*, is based on the meaning elements, or morphemes, that make up individual words.

The *alphabetic* form of writing, such as we use in English, was the last to be invented (Gelb, 1963). Based primarily on the articulatory and sound struc-ture of words rather than their meanings, alphabetic writing systems represent words by using letters to correspond to phonemes – consonant and vowel units abstracted from speech. This is referred to as the *alphabetic principle*.

From linguistics we learn that phonemes function as elementary building blocks of spoken words, acquiring meaning only through combination. All words of a language are created from combinations drawn from a few dozen phonemes, with exact numbers and identity of phonemes differing across languages. Since vast numbers of combinations can be created from the set of phonemes available, the number of meanings that can be trans-mitted is virtually unlimited. A central function of phonemic structure, then, is to make large vocabularies possible (A.M. Liberman, 1999). An alphabetic orthography places this structural feature of spoken language at the disposal of a reader-writer. Anyone who knows the alphabetic code

need not rely on rote memory to recognize written words. Capitalizing on the phonemic basis of word construction, alphabetic systems employ only two dozen letters (give or take a few) to write the myriad words of the language. *Phoneme awareness*, the discovery that the words of the language come apart into sequences of recurring phoneme segments, was the critical insight that made invention and use of alphabetic writing possible (Mattingly, 1992).

1.1. *Questions concerning the relevance of phoneme awareness instruction*

Unfortunately, the economy and convenience of alphabetic writing comes at a price. In the history of our species, phoneme awareness did not develop hand in hand with the ability to speak and understand the spoken language. We can infer that the discovery of phonemic structure and the discovery of the possibility of alphabetic writing was a cognitive leap for our forebears because, in comparison to speech, alphabetic writing is a recent development (Gelb, 1963). If we ask, with Alvin Liberman (1999), why we humans do not get phoneme awareness for free as a benefit of learning the spoken language, he answers that we don't get it because we don't need it for that purpose. Because our species has evolved to speak, children do not have to be taught their native language any more than they have to be taught to walk and run. The complex computations that take an experienced listener from sound pattern to word (or sentence) meaning are performed automatically and unconsciously. But in reading (English or another alphabetically-written language) an arbitrary code intervenes between the written symbols and the words they represent. The preschool child's rapid mastery of the spoken language does not automatically confer the awareness of phonemic structure necessary to penetrate the written language code (Liberman, Shankweiler & Liberman, 1989; Rayner et al., 2001). But every new learner who would grasp the alphabetic principle must somehow make the discovery that words come apart into phoneme units. Difficulty in attaining phoneme awareness is arguably the price we pay for having evolved to speak (and understand speech) rather than to write and read. In this section we consider questions that challenge the central importance of phoneme awareness.

1.1.1. *Is the significance of the phoneme overrated?*
The special relevance of the phoneme for reading acquisition is that this unit is literally the key to the alphabetic code (I. Liberman & A. Liberman, 1992). Byrne (1996) points out that a would-be reader who wrongly hypothesized one of the larger word chunks as the base could never unlock the secret of how words are spelled. At least a rudimentary awareness that spoken words are decomposable into recurring (phoneme) segments is needed for a learner

to grasp the all-important truth that letters represent phonemes. Lacking this awareness, the learner is unlikely to stumble on the systematicities of written representations, so spellings will appear arbitrary and therefore learnable only by rote. Armed with phoneme awareness, the learner needs but minimal exposure to letter-sound correspondences to penetrate the code and develop the ability to identify written words, even those that are seen for the first time (Ball & Blachman, 1991; Brady et al., 1994; Byrne, 1998; Fowler, 1991; Gough & Hillinger, 1980; Liberman, Shankweiler, Fischer & Carter, 1974).

Although phoneme awareness rarely arises spontaneously, it has been shown that sensitivity to larger phonological units (including words, rhymes, and syllables) occurs earlier and probably more naturally than awareness of phonemes (e.g., Bertelson & De Gelder, 1989; Bowey & Francis, 1991; Gipstein, Brady & Fowler, 2001; Liberman et al., 1974; Treiman, 1985). However, sensitivity to larger phonological units relates to awareness of individual phonemes has not been firmly established (see Special Issue of *Journal of Experimental Child Psychology*, May 2002). It seems that many children who readily pick up rhyme and alliteration have little difficulty acquiring phoneme awareness once they have received instruction. However, sensitivity to these larger phonological segments will not lead automatically to phoneme awareness even in adults. In nearly all cases, a catalyst is needed to draw the learner's attention to the phoneme level. For example, illiterate adults studied by Bertelson and colleagues found it virtually impossible to isolate individual phonemes within a word. This was so even though some had skill in rhyming (Bertelson & de Gelder, 1989). Similarly, literate readers of Chinese logograms not exposed to the alphabet have also proven unable to segment words into phonemes (Read, Zhang, Nie & Ding, 1986). Consistent with these accounts, kindergartners' ability to rhyme or to segment words into syllables has limited utility in predicting later reading success (Bowey, 2000; Stanovich, Cunningham & Cramer, 1984).

Certainly, the phoneme is the most critical segment for grasping the alphabetic principle and learning to use it. At the same time, the English writing system represents other levels of linguistic structure. The *morpheme*, the minimal unit of meaning, is of particular significance (Nagy, Anderson, Schommer, Scott & Stallman, 1989). For example, English writing frequently uses different spellings to signal different meanings (*in/inn, two/too*) and one spelling (e.g. *-ed*) to represent a single morpheme despite differences in pronunciation (as in *worked, played* and *shouted*). Attainment of phoneme awareness is no guarantee that a learner will immediately discover how the writing system encodes morphemes. This is evident in the following excerpt from the writing of a phonemically astute first grader describing a sea dragon:

    it livdin Thea sea it sleept in thea kave

This example also illustrates that successful readers and writers must be sensitive to grammatical structure to appropriately use capitalization and punctuation to mark off syntactic boundaries. Indeed, reader-writers who would become proficient must become aware of several levels of linguistic structure in addition to the phoneme – word, syllable, morpheme, sentence, phrase – and must acquire knowledge of the writing conventions used to represent these language structures.

Research on aspects of linguistic awareness beyond the phoneme allows three conclusions. First, children, including those who have difficulties with reading, will more readily pick up on regularities that refer to units that are larger (syllables, onset/rimes) or more semantically salient (morphemes, words) than are phonemes (Byrne, 1996; Elbro & Arnbak, 1996; Fowler & Liberman, 1995; Gipstein et al., 2001). Second, difficulties with various aspects of linguistic awareness tend to be correlated; students who have difficulty gaining access to phonemes tend also to lack sensitivity to other units (Rubin, Patterson & Kantor, 1991; Shankweiler et al., 1995). Third, whereas the influence of phoneme awareness differences on reading skill decreases somewhat with age and experience, the influence of morpheme awareness on reading and spelling tends to increase (Carlisle, 1995; Mann & Singson, in press).

> **Conclusion:** The significance of phoneme awareness is not overrated. Because it enables learners to penetrate the code that relates speech to print, phoneme awareness is key to reading an alphabetic system. Other forms of linguistic awareness can also be helpful to a learner, especially one who is beyond the earliest stages.

1.1.2. *Is phoneme awareness training really necessary?*

Children typically managed to learn to read long before phoneme awareness training was introduced, consistent with the popular notion that children will learn by whatever method is used to teach reading. This notion is certainly false if it is meant to apply to all children irrespective of their circumstances. Many children growing up in favorable environments with strong support for reading activities at home can adapt to a variety of instructional approaches. In poor inner city neighborhoods, however, failure to learn is too often the norm. For children in these environments, teaching appears to be critical to success. But, in any environment, individual differences are important. Even in relatively prosperous, stable communities, a sizeable minority (as many as 20–30%) may leave school with reading and writing handicaps. For these children, too, training in phoneme awareness can facilitate the process of learning to read. As we discuss in later sections, appropriate teaching, espe-

cially in the early grades, can reduce the incidence and severity of reading difficulties in both advantaged and disadvantaged youngsters.

Even those questioners who may accept the importance of phoneme awareness may question the need for making the explicit teaching of it a part of the general reading curriculum. For one thing, phoneme awareness is often equated in people's minds with phonics. Children taught by centuries' old, traditional alphabetic phonics were frequently reminded that words come apart into segments that can be matched up with letters. But prevailing practice over most of the past century has favored whole-word approaches to reading instruction. What is distinctive about an approach built around phoneme awareness is (1) the stress on helping the beginner to appreciate, prior to alphabet training with letters, that spoken words can be divided into smaller recurring units, and (2) the steps that are taken to avoid misleading the beginner (as traditional phonics does) that each individual letter can be separately pronounced, stressing that pronounceable units generally consist of combinations of letters.

A spate of findings shows just how unnatural the discovery of phonemes can be. Studies of young children (Bentin, Hammer & Cahan, 1991; Byrne, 1998; Liberman et al., 1974), illiterate adults (Morais, Alegria, Bertelson & Cary, 1979), and adults literate in nonalphabetic languages (Read, Zhang, Nie & Ding, 1986) have led to a consensus that explicit awareness of the phonemic structure of words will not come about simply as a child gains maturity and experience with the spoken language. Most children need to have phoneme structure pointed out to them in order to make sense of the mappings between phoneme segments and corresponding letters.

Research testifies both to the failure of youngsters to spontaneously discover the phoneme segments, and to the benefits of explicit instruction focused on the internal structure of the spoken word. Byrne (1992, 1998) and his associates have conducted numerous experiments in which young preliterate children were first taught to recognize pairs of words until they were highly accurate (e.g., *fun* and *bun*) and then tested to see whether what they learned would generalize to new words that shared some of their phonemes. For example, after achieving 100% accuracy on *fun* and *bun*, the children were shown *bat* and *fat* and asked, "Which one says *fat*?" Prereaders typically responded at chance. The outcome of these studies suggests that few beginners will infer the alphabetic principle unaided, even when provided with data in the form of word pairs that provide sufficient information to allow the inference. But children do learn to apprehend phonemic structure by activities that direct their attention to it. When the same print exposure was coupled with explicit instruction in phoneme awareness (demonstrating, for example, that the spoken words, *fat* and *fun*, begin with the same phoneme),

Byrne and his colleagues find that most children can succeed in generalizing a spelling pattern to new instances. It is exactly *because* phoneme awareness does not develop spontaneously that it must be taught.

Other findings leave little room for doubt that phoneme awareness plays a causal role in helping beginning readers make sense of the alphabetic code. For example, Ball and Blachman (1991) showed that teaching kindergarteners letter-sound correspondences without also teaching phoneme awareness skills was largely ineffective in promoting word recognition. However, when the children's attention was drawn to the internal structure of spoken words using segmentation activities, they readily grasped the alphabetic principle, accurately reading and spelling words they had not seen before. Children successfully instructed in phoneme awareness activities have an advantage in reading that persists at least through the elementary grades (Bradley & Bryant, 1983; 1991; Byrne, Fielding-Barnsley & Ashley, 2000; Lundberg, 1994).

Would-be readers differ in how much explicit teaching they require to achieve phoneme awareness. Some children need just a nudge (perhaps merely a pairing of letters and sounds) to gain awareness and to grasp the alphabetic principle, but many children need intensive instruction (Adams, 1990; National Reading Panel, 2000). In our experience, most classrooms include at least a few children who will struggle without explicit guidance from their teachers.

> **Conclusion:** Because phoneme awareness is necessary and will rarely develop spontaneously, instruction must be available to all beginning readers.

1.1.3. *Is phonemic awareness more a consequence of reading skill than a prerequisite?*

Some findings indicate that phoneme awareness may develop as a consequence of exposure to reading and writing. Especially persuasive is research showing that adult illiterates and readers of a nonalphabetic script lack awareness of phonemes (Lukatela, Carello, Shankweiler & Liberman, 1995; Morais et al., 1979, 1991; Read et al., 1986). These findings have helped to cement the link between awareness and reading in an alphabetic system, but seemed to call into question the presumption that the chief direction of causal influence is from awareness to reading rather than the reverse (Morais, 1991). However, viewing the larger body evidence makes it clear that causation runs in both directions: there is reciprocity in the relation between phoneme awareness and reading. For most children, rudimentary partial awareness of phonological segments helps children grasp the alpha-

betic principle, and, in turn, experience with spellings gained in reading and writing strengthens and refines awareness (Ehri, 1992; Perfetti, Beck, Bell & Hughes, 1987).

It is important to appreciate, however, that experience with print and even instruction in letter-sound relations does not automatically promote phoneme awareness (Ball & Blachman, 1991). As discussed earlier, many children will achieve awareness only after instruction explicitly directs their attention to the internal structure of spoken words (Blachman, 2000; Brady, Fowler, Stone & Winbury, 1994; Byrne, 1998; Fowler, Conway Palumbo, Swainson & Gavalis, 2001; Seymour & Elder, 1986). Although phoneme awareness is probably most often acquired in the course of instruction in reading, it can also be fostered by language play outside the context of reading and writing, by games such as "I spy" (Mann, 1991). This was demonstrated by an elegantly designed study by Lundberg, Frost and Petersen (1988), in which a large sample of kindergartners and first graders made substantial gains in phoneme awareness when the instruction was delivered independently of the orthography, using activities limited to spoken-word materials. This research makes an important contribution to understanding the diverse origins of phonological awareness, and it presents a definitive challenge to the view that awareness and reading are inseparable. The awareness training provided by Lundberg and his associates had beneficial effects on children's reading and spelling in later years (Lundberg, 1994). The practical import of this body of research is that phoneme awareness will be sharpened and refined by all experiences – both with oral and written language – that direct the learner's attention to the internal structure of words.

As we noted, once rudimentary phoneme awareness is attained, experience with print may further strengthen and refine it. In time, however, awareness of the parts of spoken words tends to merge with knowledge of their spellings. In some people, this seems to result in difficulty with consciously separating the two knowledge sources. Literate adults can find it difficult to focus attention on the phonemic structure of spoken words, finding it easier to call to mind a word's spelling than its phonemic elements (Ehri & Wilce, 1980), thereby unwittingly substituting knowledge of spelling for knowledge of phonemic structure. For example, people will assert that there are three phonemes in *box*, but four (or five) in *socks*, despite the fact that both have the same three final phonemes following the initial consonant (Tunmer & Rohl, 1991). It seems that once literacy is well established, some adults are no longer able to break up spoken words into their phonemic parts (Scarborough, Ehri, Olson & Fowler, 1998).

The tendency for phoneme awareness to become dulled in adults needs to be actively countered in the training of reading teachers. At present, many

teachers (and would-be teachers) of reading have only a tenuous awareness of phonemic structure (Moats, 1994; Scarborough et al., 1998). And yet, teachers must be able to impart trustworthy knowledge of phonemic structure to work effectively and flexibly with the many children who require explicit tutelage. We agree that this is an area in which teachers would benefit from guidance and support (Brady & Moats, 1997).

> **Conclusion:** A reciprocal causal relationship has been demonstrated between learning to read and becoming phonemically aware. Even so, the subsequent influence of literacy experience does not mitigate the importance of teaching phoneme awareness to kindergartners. Teachers preparing to work with beginning readers may also need to have their phoneme awareness skills refreshed.

1.1.4. Do children who fail to demonstrate phoneme awareness in kindergarten become poor readers?

Given the significance of the phoneme for alphabetic literacy, it is not surprising that success in kindergarten on phoneme awareness indicators bodes well for later reading achievement. Surveying a host of studies examining the correlation between kindergarten phoneme awareness and reading outcomes, Scarborough (1998) reports a mean r of 0.46. However, it does not follow that kindergartners who lack phoneme awareness are necessarily headed for reading failure. Numerous studies indicate that systematic instruction can instil rudimentary phoneme awareness in most children who are initially lacking awareness, including many at special risk for reading disability (Ball & Blachman, 1991; Blachman, 2000; Byrne, Fielding-Barnsely & Ashley, 2000). Therefore, kindergartners who fall short on phoneme awareness should not automatically be deemed unready for school when their failure may simply indicate lack of instruction.

Developmental factors explain in part why measured phoneme awareness in kindergarten is of only limited value as a predictor. Studies find that most pre-readers fail on phoneme counting, phoneme deletion or phoneme manipulation tasks, showing that they lack full awareness of phonemic structure (Bowey, 2000). Clearly, an awareness of phoneme segments, as such, is not typical of four and five-year olds. Phoneme awareness is the culmination of incremental growth in appreciation of sub-word phonological structure, beginning with such properties of words that are often represented by groups of phonemes such as rhyme and alliteration. Awareness of these sublexical structures often begins to develop in the preschool years, but in most children it does not eventuate in full phoneme awareness without explicit guidance (Fowler, 1991).

Children who fail to benefit from phoneme awareness instruction, or are slow to show gains, are at risk for later reading problems. Byrne et al. (2000) studied the predictive value for first grade reading of three kindergarten measures: Initial level of phoneme awareness, final level of phoneme awareness (after instruction), and length of time required to reach the benchmark. It was the last, the rate of response to instruction, that proved the best predictor. A similar finding was obtained in a recent kindergarten training study by Fowler et al. (2001). In that study too, response to instruction was a better predictor of achievement at the end of the year than was initial or final score on phoneme awareness. These findings indicate that instruction is important both to instil phoneme awareness and to identify children who need more intensive help.

> **Conclusion:** Most, though not all, kindergartners who lack phoneme awareness can gain it readily with instruction and make normal progress in learning to read.

1.2. *Questions about instruction in the alphabetic code*

Given the current rush in many schools to embrace phoneme awareness training, there is a danger that such training could be seen as sufficient by itself to insure that children will learn to read successfully (Blachman, 1997). This would be a serious misinterpretation of research findings. Although phoneme awareness is an essential component of skill in word recognition, it is not sufficient to inoculate children against later reading difficulties. In addition to phoneme awareness, research discussed in 1.1.2 and 1.1.3 indicates that explicit, systematic instruction in the code relating spellings to pronunciations is necessary for most children, as well as teaching designed to promote fluency and comprehension (Snow et al., 1998). In this section, we discuss questions about the value of teaching letter-sound correspondences, the place of skill in decoding vis a vis sight word recognition, the value of contextual cues for word recognition, and the effects on comprehension of teaching emphasizing word recognition.

1.2.1. *Because English spelling appears so arbitrary with so many inconsistencies, will teaching children letter-sound correspondences really help them develop word recognition skills?*

Alphabetic systems vary in how transparently they link phonemes to graphemes. Unlike Italian or Finnish, English does not have consistent one-to-one grapheme-to-phoneme correspondences. The complexities of English spelling are well known; they have led some influential people (one was George Bernard Shaw) to proclaim the futility of basing the teaching of

reading on the alphabetic code. The argument is that even if code instruction may be relevant for truly alphabetic languages, English spelling contains far too many exceptions to make it anything other than misleading; one-to-one letter-sound correspondences fully identify the correct pronunciation of only 20% of English words. Much of the apparent arbitrariness of English spelling derives from the fact that there are not enough vowel letters to represent all of the vowel sounds. If one moves beyond the level of single letter-phoneme correspondences to examine correspondences in larger sublexical units (syllable, rime, morphological affix), vowel spellings look a good deal more systematic (Gough & Hillinger, 1980; Venezky, 1970, 1999). Importantly, each of these larger units incorporates a vowel; predictability of vowel letter pronunciation improves dramatically, when attention is paid to the letters that follow (Treiman, Mullenix, Bijeljac-Babic & Richmond-Welty, 1995).

Detailed analyses of the correspondences between spoken and written words reveal the full extent of the systematicity of English spelling, and provide information about regularities that apply at the level of intermediate subword units: syllables, morphemes and rimes. For example, in an analysis of 17,602 words most likely to be encountered by beginning readers, Stanback (1992) found that closed syllables (as in *at, met, mop, in* and *up*) make up almost half of all written syllables; their spellings correctly predict the vowel pronunciation in 95% of words. In view of this, it is appropriate that many reading programs start with these so-called short vowel patterns. Another equally predictable, but less common, syllable type consists of *-le* following a consonant (as in *table*). Open syllables, as in *I, me, enemy* or *cargo*, constitute 29% of all syllables, and 83% follow predictable patterns. Other common, but somewhat less predictable, patterns include the VCe pattern (as in *take* or *ale*), VV pattern (as in *teak* or *aid*), and Vr pattern (as in *ark,* or *or*).

In a computer-assisted analysis of 24,000 English words, Aronoff and Koch (1996) confirmed the utility of syllable spelling patterns as guides to pronunciation. Even when compared to regularly spelled morphemes (*pre-, -tion*), high-frequency words (*of, the, one*), and common rimes (*-ook, -ight*), information about syllable type was the single most reliable key to vowel pronunciation, with an overall predictability level of 64.9%. Adding information about the other three sublexical units raised the total predictability only modestly, to a total of 70.5%. Considered on their own, rime spellings not composable from individual letter-sound correspondences (*-ight*) predicted the pronunciation of only 3.5% of all syllables; information about morphological prefixes and suffixes, accounted for an additional 32.3%, and high-frequency words another 4.8%.

Conclusion: English spelling is largely systematic, although the systematicities extend beyond single grapheme-phoneme mappings. It is therefore highly worthwhile to teach spelling patterns explicitly.

1.2.2. *Can a large sight-word vocabulary compensate for poor decoding skills?*

Some children, though not many (Shankweiler et al., 1999), manage to accrue a large reading vocabulary in spite of very limited decoding skills. These children succeed in memorizing considerable numbers of words, thereby fooling teachers and parents into thinking they are making good progress. But word identification based on whole-word patterns becomes progressively more difficult as the number of similarly written words (e.g., *thought/though/through*) increases dramatically in the mid-elementary grades (Gough & Hillinger, 1980).

Evidence exists that reliance on memorization alone is not a good strategy in the long run. Byrne, Freebody, and Gates (1992) found that among second graders, poor decoders with good sight word skills comprehended text better than those good decoders with poor sight-word skills. By fourth grade, however, the tables had turned: those who acquired decoding skills early went on to gain better comprehension skills, surpassing in both decoding and comprehension the children who failed to establish good decoding skills initially. (See also Connelly, Johnston, & Thompson, 2001.)

Research by Ehri (1992, 1997) suggests that accurate sight word recognition in fact depends on well-established decoding skills. Striking demonstrations of this dependency are presented by Gough and Walsh (1991) and Tunmer and Chapman (1998), who studied the relation between children's scores on reading regularly-spelled words and their reading of words with exceptional spellings. Although success with regular words was no guarantee of success with exception words, no child succeeded with exception words who could not also read regular words. Clearly, regular words are a stepping stone to reading exception words.

An important manifestation of reading skill is the ability to recognize systematicities between groups of letters and units of speech (phoneme, syllable, word). A skilled reader of English recognizes multi-letter correspondences, such as between the *ough* of *tough, rough, enough*, and a shared phonological part of these words, the rime /ʌf/. Because experienced readers read in units larger than single letters (Rayner, 1986), it has often been recommended that multi-letter correspondences be introduced from the start.

An issue of current debate concerns the utility of high-frequency syllable rimes (*-at, -id, -op*) as a stepping stone to decoding, potentially eliminating the need for full phoneme segmentation. Goswami and Bryant (1992)

proposed such an instructional sequence, pointing to data that showed a strong relationship between children's skill in rhyming and their ability to make analogies between the spelling patterns of words in reading. For example, some children in that research could read *sack*, having been taught *pack*. The potential utility is considerable, as evident in analyses demonstrating that 500 primer-level words can be spelled with just 37 rime patterns (Wylie & Durrell, 1970).

Introducing beginning readers, and older struggling readers, to onset-rime patterns has potential benefits, in part because it focuses on units that are more salient to young children than are single phonemes (Bowey, 2002; Hulme, Hatcher, Nation, Brown, Adams & Stuart, 2002). But there is no support for the idea that children can learn to read with rimes alone without also apprehending the alphabetic principle. Moreover, there is evidence that rimes may be most successfully acquired and applied when they are initially built up from the component phoneme-grapheme correspondences (Bowey & Francis, 1991; Ehri, 1992; Treiman, 1993). Cheney and Cohen (2000) recommend directing children's attention to the internal phonemes of the word from the beginning, pointing out that approximately two-thirds of the most common 37 rimes identified by Wylie and Durrrell (1970) are entirely consistent with phoneme-letter pairing.

Research is continuing on the question of whether, when, and for whom, instruction focusing on spellings of onset-rime units is helpful. However, we already know that teaching onset-rime patterns cannot substitute for instruction at the phoneme level. Readers must learn to decode the thousands of words not accommodated by onset-rime alone. Just as it is ultimately futile to read by whole words, reading based on onset-rime units fails to support the reader beyond the early stages.

> **Conclusion:** A large sight word vocabulary cannot fully compensate for poor decoding skills. Word chunks such as onset and rime may be useful stepping stones, but they too cannot replace phoneme-level analysis.

1.2.3. *Should learners be encouraged to rely on context more than the code to recognize words?*

The belief that children should rely on context to guess at words, rather than to sound them out is a central tenet of the whole language tradition (Goodman, 1976). It is undeniably true that context greatly affects how a word is incorporated into a sentence schema during the ongoing process of language understanding, whether in reading or listening. But what is at issue is the role of context in word recognition itself. We will argue that good readers do not have to guess in deciding what word it is they are reading.

To see this we must distinguish a word as a phonological entity (a sequence of consonant and vowel phonemes) from its meaning or meanings. Words and meanings are complexly related: more often than not, the same phonological word represents more than one meaning. The word *bug*, for example, can refer to an insect or to an electronic eavesdropping device.

An ingenious set of experiments by David Swinney (1979) showed that when there is more than one possibility, the language processing system takes no chances. In the earliest phases of reading or listening, all known meanings of a word are briefly activated. The language processing system next selects the appropriate meaning by immediately taking account of the context, deactivating the irrelevant meaning or meanings. And yet, because it all happens in a second, the reader is usually unaware that the processing system entertained irrelevant meanings. The essential role of the phonological word in this process is to anchor meaning. Successful use of context to select a word's intended meaning depends on accurate and rapid identification of the phonological word.

But can context help with word recognition when the reader is struggling with print? Although studies that manipulate context show that context can facilitate recognition of a primed word (Van Orden, Pennington & Stone, 1990), its predictive value for guessing the (phonological) word in absence of decoding accuracy is often greatly overestimated. Gough, Alford and Holley-Wilcox (1981) estimate that only one word in four is predictable, on average. Moreover, most of the words that can be predicted are high frequency function words such as pronouns and conjunctions. If one considers only content words, predictability drops to one in eight. And yet it is content words that pose the challenge. The data suggest that context can supplement the word's spelling in reducing uncertainty, but it cannot substitute for code-based processes of word identification. A number of demonstrations make clear that, without knowledge of the code, reliance on context is an inadequate strategy for arriving at a word's identity (see Stanovich, 1986, 2000).

Consistent with this conclusion, unskilled readers with weak decoding skills are the ones most likely to attempt to rely on context, though they do so ineffectively. Skilled readers are better than unskilled, but are less likely to need to guess because their word recognition skills are so well honed as to function autonomously (Nicholson, 1991). Indeed, ability to identify words accurately and rapidly out of context is a hallmark of a skilled reader. Tunmer and Chapman (1998, in press) showed that developing readers whose word-reading skills fall midway between the extremes are the ones who stand to benefit most from context.

> **Conclusion:** Use of context cannot substitute for knowledge of the code for recognizing printed words.

1.2.4. *Does emphasis on the code detract from comprehension, which is the real purpose of reading?*

An often-repeated criticism of code-emphasis instruction is that by focusing on phonic patterns without reference to meaning, children will miss the point of written language as a means of communication. This concern is not entirely unfounded. Explicit instruction in the code cannot end there. It needs to be coordinated with attention to the meaning of the words and text under study. Study of word patterns in isolation must be combined with opportunities to apply these patterns in reading and understanding connected text (Juel & Roeper/Schneider, 1985). At the same time, especially among children who enter school with only limited experience with the language of instruction, code-based reading instruction should not preclude efforts to improve vocabulary, narrative, inference making, and other skills important for comprehension (e.g., Beck, McKeown, Hamilton & Kucan, 1997; Beck, McKeown & Kucan, 2002).

It is useful to think of skill in reading as having two main components: the skill that enables the reader to identify individual words in written form, and the skill that enables the reader to interpret the words and weave them into meaningful patterns that yield comprehension of narrative or other kinds of texts (Gough & Tunmer, 1986). It is obvious that the second skill is not just about reading because we also use it whenever we comprehend language in spoken form. Difficulties in reading can involve either or both of these separable components. It makes no sense to ask which is more important for reading, since both are necessary.

Developing readers need materials that help them master each component of reading. At first, texts they can read independently are necessarily simple, but most beginning readers can understand more difficult text when it is read to them, or when they are doing supported reading. More advanced texts are valuable for promoting vocabulary growth and narrative comprehension. These should be used in parallel with simpler texts aimed at building word recognition skill. Hence, the beginning second grader may independently read *Hop on Pop*, with its controlled vocabulary and simple sentences, for the sheer pleasure of being successful, while the same day discussing *Charlotte's Web* for its more advanced vocabulary and narrative elements. It is probably not until fourth grade that most children acquire the requisite word recognition skills to enable them to successfully read any material they can comprehend through listening. In Jeanne Chall's terms, it is at this point that most students progress from "learning to read" to "reading to learn" (1996). However, this transition can take place only if general comprehension and vocabulary skills have proceeded apace with word reading skill.

Even among children with strong knowledge of the code, experience indicates that many will not achieve full text comprehension without some guidance along the way in comprehension strategies. By the same token, few children can move from supported reading of connected text to automatic word recognition without some guidance in relating the structure of spoken words to their corresponding spellings. For promoting ease of word recognition, the evidence seems to favor direct instruction, supporting the superiority of explicit code-based teaching that emphasizes phoneme segmentation and spelling patterns over implicit, text-based approaches (Blachman, Tangel, Ball, Black & McGraw, 1999; Foorman, Francis, Fletcher, Schatschneider & Mehta, 1998; Torgesen et al., 1999; National Reading Panel, 2000).

Skill in word recognition and reading comprehension, though separable in principle, tend to be well correlated, especially in beginning readers (Shankweiler et al., 1999). This is readily understandable because comprehension depends on accurate word recognition. Failure to acquire word recognition skills in the first grade greatly reduces a child's chances of developing serviceable reading comprehension skills in later grades. The Connecticut Longitudinal Study of children from kindergarten to adulthood documents the persisting effects of early learning, finding that first grade decoding skill still accounts for a quarter of the variation in comprehension in the ninth grade (Foorman, Francis, S. Shaywitz, B. Shaywitz & Fletcher, 1997; Shaywitz, Fletcher, Holahan et al., 1999).

Although instances of accurate printed word recognition coupled with poor text comprehension tend to attract interest, such cases are relatively unusual in studies of children with learning problems (Catts & Hogan, 2002; Shankweiler et al., 1999; Spear-Swerling, 2001). One group that does fit this profile are children whose native language is not English and who have received inadequate English instruction in school. When given good code instruction, English Language Learners typically learn to identify words, but often read with poor comprehension unless oral language skills and vocabulary have also received intensive focus. A much rarer group comprise children with hyperlexia – a condition in which good word decoding occurs in the context of poor comprehension (Aram & Healy, 1987). Here too, the comprehension problems are not restricted to reading. Children with hyperlexia tend to have poor comprehension of spoken language; their verbal IQ is typically well below average and some have also been identified as having autistic-like qualities. Students with a less severe disparity who teachers have identified as "word callers" tend to be less than automatic in word recognition, with word-level skills still consuming much of their cognitive resources. These children may comprehend well when helped to read more fluently, through rereading or through use of simpler text.

Few educators would disagree that reading instruction must be tailored to individual student needs (Juel & Minden-Cupp, 2000). Less widely appreciated, however, is the need for suitably analytic diagnostic assessments to serve that end. Indeed, most high-stakes tests (including those used in our own state of Connecticut) are designed such that it is impossible to distinguish between weak listening comprehension, weak word recognition, or a combination of the two (M.S. Mulligan, unpublished PhD dissertation [2002]; Spear-Swerling, 2001).

> **Conclusion:** Emphasis on the code promotes comprehension by fostering skill in word recognition. Code emphasis needs to be supplemented by instruction aimed at enhancing general language skills. Assessment tools should be adequately diagnostic to guide teachers in addressing individual needs.

1.3. Questions about the sources of reading difficulties

Many of the efforts of researchers and reading specialists alike are directed toward the substantial minority of school children who are deemed capable of learning but for whom early conventional reading instruction does not suffice. The hallmark of such reading difficulties is poor word recognition, a problem that directly reflects their difficulties with phoneme awareness and their consequent failure to learn effective word decoding routines (Rack, Snowling & Olson, 1992; Shankweiler et al., 1995, 1999; Share, 1995; Stanovich & Siegel, 1994; Vellutino et al., 1996). In English-speaking places, it is estimated that approximately 20% of all students emerge from the early grades without a firm grasp of the alphabetic principle, though this number can vary both as a consequence of instructional opportunities and the method used to determine "weakness" (Fletcher et al., 1994). Even with well-directed intensive instruction, approximately 5 to 7% of children continue to exhibit significant reading difficulties (Torgesen, 2000). The educational and vocational outlook for these children is not favorable – indeed the dominant symptom picture in older poor readers is remarkably similar to that typifying younger ones still in elementary school (Bruck, 1998; Fowler & Scarborough, 1993; Pennington, Van Orden, Smith, Green & Haith, 1990). Reading difficulties are influenced by environmental circumstances, such as poverty and large numbers of classmates with reading difficulties (e.g., Bowey, 1995). Reading difficulties are also influenced by biogenetic factors, as revealed by genetic studies and neurophysiological approaches. In the following paragraphs we address three questions about factors that can hamper effective efforts at prevention and remediation.

1.3.1. *Are problems with phoneme awareness the root cause of reading difficulties?*

Although problems with phoneme awareness do indeed loom large in reading disability, it would be an oversimplification to see them as the root cause. In our view, a more accurate way to describe the association would be that problems with awareness are one manifestation of an underlying deficiency in the phonological part of the language system (Liberman, Shankweiler, Camp, Blachman & Werfelman, 1980). To evaluate this idea, we must look again at the developmental foundations of reading.

In acquiring the vocabulary of their spoken language, children have to learn and retain phonological representations for thousands of words. There is evidence that in the earliest years, when children are able to say only a few words, their representations tend to be relatively undifferentiated, being organized syllabically rather than phonemically (Nittrouer, Studdert-Kennedy & McGowan, 1989). As children continue to learn new words, they must differentiate increasing numbers of words that are close in sound pattern (like *bill, pill* or *see, she*). Apparently, the pressure to learn new vocabulary leads children's word representations to become more fully specified phonemically (Studdert-Kennedy, 1986).

However, there are large individual differences, such that some children even at school age have representations that may be insufficiently detailed to allow them to readily become aware of shared and minimally contrasting phonemes across pairs of similar (spoken) words. Fowler (1991) and Elbro, Borstrom and Petersen (1998) have maintained that differences among beginning readers in the completeness and stability of phonological representations of vocabulary items is one reason that children differ in phoneme awareness, in readiness to grasp the alphabetic principle, and ultimately in ability to acquire skill in printed word recognition (see also Katz, 1986). Unskilled readers often betray the inaccuracy of their phonological representations by their spellings (Dietrich & Brady, 2001; Treiman, 1993).

A further manifestation of weakness in the phonological system has to do with processing and retaining phonological information, abilities essential for reading. Difficulties in phonological memory are commonplace in children with reading problems (Brady, 1991, 1997; Mann, Liberman & Shankweiler, 1980). They are most evident on tasks that require children to encode and repeat a new word (or nonword), and on tasks that require them to briefly retain or generate word sequences. Slowness and hesitation in retrieval of phonological words (even words of high frequency) is a prominent symptom. The deficit shows up on tasks that tax serial naming and emphasize speed of response (Scarborough, 1998; Wolf, 1991). These limitations in memory processes are associated with difficulties in comprehending

complex sentences, such as sentences containing embedded clauses. Parsing such sentences requires memory to preserve the phonological record of a stretch of words while they are being assimilated to earlier and later arriving material. Even though the memory processing limitations of poor readers can also affect spoken language, their effect on reading is likely to be more severe, because word decoding and sentence integration may compete for the same limited processing resources (Perfetti & Lesgold, 1977; Shankweiler & Crain, 1986; Shankweiler, 1989).

The practical import of this discussion is that there is a danger that people will seize on the idea of phoneme awareness as fully expressing the deficit in reading disabled people, whereas in reality, the problem is a good deal more complex. Individual variations in the abilities essential for reading stem from a complex mix of environmental and biogenetic causes. It has been recognized for about a century that reading disability tends to run in families. In a group of studies reviewed by Scarborough (1998) in which familial history of reading disability was assessed, between 30% and 85% of the reading disabled children had one or more affected family members. Some studies included a comparison group of normal readers; in these the percentage of normal readers with an affected relative was between 3% and 12%.

In recent years, behavior geneticists have had some success in teasing apart the environmental and genetic contributions to reading based on studies of families. Twin studies are the classic way of assessing heritability. Because identical twins share all of their genetic material, and fraternal twins share only half of it (like ordinary siblings), the comparison of the incidence of some trait in the two kinds of twin pairs permits quantitative assessment of the extent to which the trait is carried by the genes, i.e., its heritability. The telling result is a higher incidence of twin pairs where both are affected among identical twins than among fraternal twins. Twin studies of reading disability have consistently yielded evidence of genetic influence, although heritability estimates vary, depending on a number of extraneous factors such as sample size. To cite one example, findings of the Colorado twin study of reading disability (DeFries & Gillis, 1991; Olson, 1994), with a very large sample size, suggest that reading disability is influenced in nearly equal measure by genetic and environmental factors. Genetic factors account for more than half the variance in decoding skills and phoneme awareness. This finding seems to hold not only for reading disability, but across the full range of reading skill.[1]

Cognitive variation underlying reading differences is also reflected in patterns of brain activity generated during reading performances. Studies using functional neuroimaging to examine brain activity evoked during reading-related tasks have shown that reading-disabled and nonimpaired

readers differ most at brain regions that are centrally implicated in decoding letter patterns into speech patterns, in keeping with the large body of behavioral evidence pointing to code-based difficulties in word recognition as the core deficit in reading disability (Pugh et al., 2001; Rumsey, Nace, Donahue, Wise, Maisog & Andreason, 1997; Shaywitz et al., 1998). Moreover, developmental studies of readers at different stages of reading proficiency have shown that increasing skill in word recognition is marked by increases in the level of activity at one of the critical sites that is also implicated in dyslexia, namely, the occipito-temporal region of the left cerebral hemisphere (Shaywitz et al., 2002). Work in progress is examining regional changes in brain activity of children undergoing remedial intervention designed to boost word recognition skills. This research holds promise that cortical markers will distinguish children who respond well to intervention from those who respond poorly (Simos et al., 2002).

> **Conclusion:** Although problems with phonemic awareness are a hallmark of reading disability, they are only one manifestation of broader deficits in processing phonological information that are typically seen in poor readers. These deficits are reflected in genetic patterns and patterns of brain activity.

1.3.2. Do reading comprehension problems of older poor readers reflect persisting difficulties with basic skills?

An influential assessment of literacy problems in the U.S. by George Miller (1988) laid most of the blame on weak comprehension skills. Miller's diagnosis was that the schools, by and large, are doing an adequate job of teaching children what they need to know about the code. He concluded that difficulties in word recognition characterize only a small, well-studied subset of poor readers – those who are rank beginners and/or dyslexic. Rather, he claimed that lack of adequate vocabulary and effective comprehension strategies account for most of the long-term difficulties in reading. Our guess is that these views are widely shared.

As we emphasized earlier, successful reading does depend on effective use of general language skills, as surely as it depends on skilled routines for recognizing printed words and, to be sure, both types of skills are deficient in many poor readers, especially those from low-income communities. This said, for young elementary students with average vocabulary knowledge or better, skill in word recognition is often the first factor limiting reading comprehension (Hoover & Gough, 1990; Shankweiler et al., 1995). Even among poor readers with considerable print experience, research indicates that code-related difficulties continue to be a relevant factor in reading

difficulty. Contrary to the belief expressed above, older poor readers, even those who have managed to acquire fairly good accuracy in word recognition, frequently have difficulty with phoneme awareness tasks and nonword decoding as well as with vocabulary and general comprehension (Bruck, 1998; Shankweiler, Lundquist, Dreyer & Dickinson, 1996). What chiefly distinguishes them from younger poor readers is the ability to recognize in printed form, though perhaps unreliably, a larger body of words. Poor readers at every stage beyond rank beginner are characteristically inefficient in using limited processing resources for tracking narrative and argument because the attentional resources expended in word recognition drain away much of their limited processing capacity. Too little then remains to meet the demands of integrating incoming material with earlier material and with background knowledge (Perfetti, 1985; Perfetti & Lesgold, 1977; Shankweiler, 1989).

In reading connected material for meaning, efficient word recognition and general language comprehension are each necessary but not sufficient. Ordinarily, we would not expect the absolute level of reading comprehension to exceed the level of listening comprehension for the same material. Listening comprehension has been proposed by Gough and associates (Hoover & Gough, 1990) and by Stanovich (1991) as the most direct measure of the general language comprehension abilities that are exploited by reading and listening alike. Confronted with a student, especially an older student, having difficulty comprehending material she needs to read, the reading diagnostician needs an independent measure of listening comprehension with comparably difficult material in order to locate the primary source of the difficulty. If listening comprehension is low, it follows that reading comprehension will be correspondingly low, regardless of the level of skill in decoding words. On the other hand, when listening comprehension is high and reading comprehension is low, poor accuracy and/or speed of word recognition are often present.

> **Conclusion:** Difficulties of most older poor readers involve both word level and comprehension skills, and reflect the critical relation between them.

1.3.3. *If reading difficulties are heritable, does that mean they are not preventable or treatable?*

Genes and environment are in dynamic equilibrium. If either genetic influences change (as they do in a population as a result of mixing due to migration) or environmental influences change (e.g., changes in educational opportunity), the relative impact of genes and environment will change. For example, even for so highly heritable a factor as a person's height, changes in environment can exert a powerful influence (Plomin, DeFries, McClearn

& Rutter, 1997). With regard to the question of prevention and treatability of conditions that have a genetic basis, consider the example of phenylketonuria, a condition caused by a genetic error that makes some normal products of metabolism toxic to the nervous system. If untreated this condition results in progressive deterioration and mental retardation. Yet this result is almost wholly preventable by control of the diet, avoiding foods that contain the offending substance (phenylalanine), and thereby blocking the deleterious effects of the gene. This example helps us to appreciate that because a condition is genetically influenced doesn't mean that it is unpreventable or untreatable.

In the case of reading disability, there is, as noted earlier, a definite risk factor associated with having one or more affected family members. Preschoolers from such families are distinguishable on several language measures from preschoolers in not-at-risk families (Scarborough, 1998). There is evidence that early treatment can enable some, but not all children from these families to escape the worst consequences of reading prob- lems (Byrne, Fielding-Barnsley, Ashley & Larsen, 1997; B.A. Hindson, unpublished dissertation [2001]). Some well-instructed dyslexic individuals eventually acquire good word recognition skills, though they usually remain slow in reading and insecure in spelling, requiring continued reliance on the dictionary and spell checkers (Bruck, 1998). Studies with twin pairs, now underway, will permit monitoring of treatment outcomes in relation to genetic profiles, based on analysis of DNA samples (Olson, Byrne & Samuelsson, 2002).

It is important to recognize that when environmental factors are unfavor- able (if, for example, someone has had poor beginning reading instruction), developmental variation within the normal range may result in a disab- ility that is indistinguishable phenotypically from that found in affected individuals from genetically at risk families. Whatever the source, reading problems, evident early on, tend to persist. In the Connecticut Longitudinal study (Foorman et al., 1997) only about a quarter of the children identified as reading disabled in grade 3 were reading at grade level by grade 9, even though many of these children had received remedial instruction spanning a portion of this period. Findings such as these point to the vital importance of prompt identification of children likely to develop reading problems and timely intervention (Torgesen, 1998). Once children begin to fall behind and to experience the variety of negative consequences associated with reading difficulty, rescue is a great deal more difficult (Stanovich, 1986).

At all events, the data regarding familial incidence of reading disability tell us that while many children from affected families will have special difficulty learning to read, many will not. In order to predict the outcome

for an individual from an affected family, one needs to know which cognitive characteristics prevalent in these families are the most trustworthy predictors of difficulty.

> **Conclusion:** The fact that reading difficulties are to a degree heritable does not preclude the benefits of intervention.

2. Summary and conclusions

We have sought to provide answers, based on available research findings, to some commonly asked questions about the role of phonological processes in learning to read. With regard to phoneme awareness we maintain that this was the insight that made alphabetic writing possible. Because it is literally the key which unlocks the alphabetic code, its significance for reading in an alphabetic system would be hard to overstate. It is critical for teachers and others concerned with teaching beginning readers to appreciate that children rarely discover phoneme segments spontaneously from everyday experience with the spoken language, but most can readily acquire phoneme awareness and word analysis and assembly skills with instruction. Teachers themselves may need to refresh their phoneme awareness.

Though it is a linchpin of beginning reading, phoneme awareness by itself will not yield reading success, especially if later reading instruction is not coordinated with early phoneme awareness training. Children also need to gain experience with regular and irregular spelling-sound correspondences. Other forms of linguistic awareness, pertaining both to word parts (syllables, morphemes) and sentence parts (phrase structure) are also helpful to the learner, especially one who is beyond the earliest stages. Although it is easy to find inconsistencies in the way English is spelled, teachers must appreciate that there is also much that is regular and predictable. To ignore these systematicities is to deprive learners of a valuable aid to learning and memory. Accurate sight-word recognition seems to depend on well-established decoding skills.

A good reader makes use of context to extract meaning from the text, but less likely needs to use it to identify the individual words. The reader who lacks good tools for word recognition is not in a position to make good use of context. The key to developing expertise in reading is acquiring reliable strategies for identifying unfamiliar words, based first on letter-sound knowledge and secondarily on context.

Once rooted, reading difficulties are difficult to cure, but treatment at any age, directed toward instilling the fundamentals, can ameliorate difficulties and result in improvements in word recognition, spelling, and comprehension

when the learner is motivated to learn. The fact that reading difficulties reflect biological predispositions to some extent does not imply that remedial efforts will be futile. Moreover, most of the environmental causes of low literacy are preventable and/or remediable. But to address them fully would require far-reaching changes in our society, changes that would not come about quickly even if there were a collective will. In the meantime, there is a lot that communities can do to improve the way schools approach the teaching of reading and to provide much-needed support for beleaguered teachers. There is evidence that these measures can yield substantial benefits.

Acknowledgements

Note

1. Behavioral genetic evidence for heritability is augmented by gene mapping studies based on DNA samples, which so far implicate genes on chromosomes 6, 15, and 18 (Smith, Brower, Cardon & DeFries, 1998).

References

Adams, M.J. (1990). *Beginning to read: Thinking and learning about print.* Cambridge, MA: MIT Press.

Aram, D. & Healy, J. (1987). Hyperlexia: A review of extraordinary word recognition. In L. K. Obler & D. Fein (Eds.), *The exceptional brain* (pp. 70–102). New York: Guilford Press.

Aronoff, M. & Koch, E. (1996). Context-sensitive regularities in English vowel spelling. *Reading and Writing: An Interdisciplinary Journal, 8,* 261–265.

Ball, E.W. & Blachman, B.A. (1991). Does phoneme awareness training in kindergarten make a difference in early word recognition and developmental spelling? *Reading Research Quarterly, 26,* 49–66.

Beck, I.L., McKeown, M.G., Hamilton, R.L. & Kucan, L. (1997). *Questioning the author: An approach for enhancing student engagement with text.* Newark, DE: International Reading Association.

Beck, I.L., McKeown, M.G. & Kucan, L. (2002). *Bringing words to life: Robust vocabulary instruction.* New York: Guilford Press.

Bentin, S., Hammer, R. & Cahan, S. (1991). The effects of aging and first grade schooling on the development of phonological awareness. *Psychological Science, 2,* 271–274.

Bertelson, P. & de Gelder, B. (1989). Learning about reading from illiterates. In M. Galaburda & M. Albert (Eds.), *From reading to neurons* (pp. 1–23). Cambridge, MA: The MIT Press.

Blachman, B.A. (1997). Early intervention and phonological awareness: A cautionary tale. In B.A. Blachman (Ed.), *Foundations of reading acquisition and dyslexia: Implications for early intervention* (pp. 409–430). Mahwah, NJ: Erlbaum.

Blachman, B.A. (2000). Phonological awareness. In M.L. Kamil, P.B. Mosenthal, P.D. Pearson & R. Barr (Eds.), *Handbook of reading research,* Vol. 3 (pp. 483–502). Mahwah, NJ: Erlbaum.

Blachman, B.A., Tangel, D., Ball, E., Black, R. & McGraw, D. (1999). Development of phonological awareness and word recognition skills: A two-year intervention with low-income, inner-city children. *Reading and Writing: An Interdisciplinary Journal, 11,* 273–293.

Bowey, J.A. (1995). Socioeconomic status differences in preschool phonological sensitivity and first-grade reading achievement. *Journal of Educational Psychology, 87,* 476–487.

Bowey, J.A. (2000). A case for early onset-rime sensitivity training in "at risk" preschool and kindergarten children. In N. Badian (Ed.), *Prediction and prevention of reading failure* (pp. 217–245). Parkton, MD: York Press.

Bowey, J.A. (2002). Reflections on onset-rime and rhyme sensitivity as predictors of beginning word reading. *Journal of Experimental Child Psychology, 82,* 29–40.

Bowey, J.A. & Francis, J. (1991). Phonological analysis as a function of age and exposure to reading instruction. *Applied Psycholinguistics, 12,* 91–121.

Bradley, L. & Bryant, P.E. (1983). Categorising sounds in learning to read: A causal connection. *Nature, 301,* 419–421.

Bradley, L. & Bryant, P.E. (1991). Phonological skills before and after learning to read. In S.A. Brady & D.P. Shankweiler (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 37–45). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brady, S.A. (1991). The role of working memory in reading disability. In S.A. Brady & D.P. Shankweiler (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 129–151). Hillsdale, NJ: Lawrence Erlbaum Associates.

Brady, S.A. (1997). Ability to encode phonological representation: An underlying difficulty of poor readers. In B.A. Blachman (Ed.), *Foundations of reading acquisition and dyslexia: Implications for early intervention* (pp. 21–47). Mahwah, NJ: Erlbaum.

Brady, S., Fowler, A., Stone, B. & Winbury, N. (1994). Training phonological awareness: A study with inner-city kindergarten children. *Annals of Dyslexia, 44,* 26–59.

Brady, S. & Moats, L. (1997). *Informed instruction for reading success: Foundations for teacher preparation.* Baltimore, MD: International Dyslexia Association.

Bruck, M. (1998). Outcomes of adults with childhood histories of dyslexia. In C. Hulme & R.M. Joshi (Eds.), *Reading and spelling: Development and disorders* (pp. 179–200). Mahwah, NJ: Lawrence Erlbaum Associates.

Byrne, B. (1992). Studies in the acquisition procedure for reading: Rationale, hypotheses and data. In P.B. Gough, L.C. Ehri & R. Treiman (Eds.), *Reading Acquisition* (pp. 1–34). Hillsdale, NJ: Lawrence Erlbaum Associates.

Byrne, B. (1996). The learnability of the alphabetic principle: Children's initial hypotheses about how print represents spoken language. *Applied Psycholinguistics, 17,* 401–426.

Byrne, B. (1998). *The foundation of literacy: The child's acquisition of the alphabetic principle.* Hove, UK: Psychology Press.

Byrne, B., Fielding-Barnsley, R. & Ashley, L. (2000). Effects of preschool phoneme identity training after six years: Outcome level distinguished from rate of response. *Journal of Educational Psychology, 92,* 659–667.

Byrne, B., Fielding-Barnsley, R., Ashley, L. & Larsen, K. (1997). Assessing the child's and the environment's contribution to reading acquisition: What we know and what we don't know. In B. Blachman (Ed.), *Foundations of reading acquisition and dyslexia: Implications for early intervention* (pp. 265–285). Mahwah, NJ: Lawrence Erlbaum Associates.

Byrne, B., Freebody, P. & Gates, A. (1992). Longitudinal data on the relations of word-reading strategies to comprehension, reading time, and phonemic awareness. *Reading Research Quarterly, 27,* 140–151.

Carlisle, J.F. (1995). Morphological awareness and early reading achievement. In L.B. Feldman (Ed.), *Morphological aspects of language processing* (pp. 189–209). Hillsdale, NJ: Lawrence Erlbaum Associates.

Catts, H.W. & Hogan, T.P. (2002, June). *The fourth grade slump: Late emerging poor readers.* Paper presented at the annual meeting of the Society for Scientific Study of Reading, Chicago.

Chall, J.S. (1996). *Learning to read: The great debate* (3rd ed.). Fort Worth: Harcourt Brace.

Cheney, W. & Cohen, J.E. (2000). *Focus on phonics.* Bothell, WA: The Wright Group.

Connelly, V., Johnston, R. & Thompson, G.B. (2001). The effects of phonics instruction on the reading comprehension of beginning readers. *Reading and Writing: An Interdisciplinary Journal, 14,* 423–457.

DeFrancis, J. (1989). *Visible speech: The diverse oneness of writing systems.* Honolulu: University of Hawaii Press.

DeFries, J.C. & Gillis, J.J. (1991). Etiology of reading deficits in learning disabilities: Quantitative genetic analysis. In J.E. Obrzut & G.W. Hynd (Eds.), *Neuropsychological foundations of learning disabilities: A handbook of issues, methods and practice* (pp. 29–47). Orlando, FL: Academic Press.

Dietrich, J.A. & Brady, S.A. (2001). Phonological representations of adult poor readers: An investigation of specificity and stability. *Applied Psycholinguistics, 22,* 383–418.

Ehri, L.C. (1992). Reconceptualizing the development of sight word reading and its relationship to recoding. In P.B. Gough, L.C. Ehri & R. Treiman (Eds.), *Reading acquisition* (pp. 65–106). Hillsdale, NJ: Lawrence Erlbaum Associates.

Ehri, L.C. (1997). Sight word learning in normal readers and dyslexics. In B. Blachman (Ed.), *Foundations of reading acquisition and dyslexia: Implications for early intervention* (pp. 163–189). Mahwah, NJ: Lawrence Erlbaum Associates.

Ehri, L.C. & Wilce, L.S. (1980). The influence of orthography on readers' conceptualisation of the phonemic structure of words. *Applied Psycholinguistics, 1,* 371–385.

Elbro, C. & Arnbak, E. (1996). The role of morpheme recognition and morphological awareness in dyslexia. *Annals of Dyslexia, 46,* 209–240.

Elbro, C., Borstrom, I. & Petersen, D.K. (1998). Predicting dyslexia from kindergarten: The importance of distinctness of phonological representations of lexical items. *Reading Research Quarterly, 33,* 36–60.

Fletcher, J.M., Shaywitz, S.E., Shankweiler, D.P., Katz, L., Liberman, I.Y., Stuebing, K.K., Francis, D.J., Fowler, A.E. & Shaywitz, B.A. (1994). Cognitive Profiles of Reading disability: Comparisons of discrepancy and low-achievement definitions. *Journal of Educational Psychology, 86,* 6–23.

Foorman, B.R., Francis, D.J., Fletcher, J.M., Schatschneider, C. & Mehta, P. (1998). The role of instruction in learning to read: Preventing reading failure in at-risk children. *Journal of Educational Psychology, 90,* 37–55.

Foorman, B.R, Francis, D.J., Shaywitz, S.E., Shaywitz, B.A. & Fletcher, J.M. (1997). The case for early reading interventions. In B. Blachman (Ed.), *Foundations of reading acquisition and dyslexia: Implications for early intervention* (pp. 243–264). Mahwah, NJ: Lawrence Erlbaum Associates.

Fowler, A.E. (1991). How early phonological development might set the stage for phoneme awareness. In S.A. Brady & D.P. Shankweiler (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 97–117). Hillsdale, NJ: Lawrence Erlbaum Associates.

Fowler, A.E., Conway Palumbo, L., Swainson, B.A. & Gavalis, D. (2001, June). *Acquisition of sight word and analytic word knowledge in kindergarten.* Poster presented at the annual meeting of the Society for the Scientific Study of Reading, Boulder, CO.

Fowler, A.E. & Liberman, I. (1995). The role of phonology and orthography in morphological awareness. In L. Feldman (Ed.), *Morphological aspects of language processing* (pp. 157–188). Hillsdale, NJ: Erlbaum Associates.

Fowler, A.E. & Scarborough, H.S. (1993). *Should reading-disabled adults be distinguished from other adults seeking literacy instruction? A review of theory and research* (NCAL Publication TR93-7). Philadelphia, PA: National Center on Adult Literacy.

Gelb, I.J. (1963). *A study of writing* (2nd ed.). Chicago: University of Chicago Press.

Gipstein, M., Brady, S. & Fowler, A. (2001). Questioning the role of syllables and rimes in early phonological awareness. In M. Masland (Ed.), *Early identification and remediation of reading disability, Second Edition* (pp. 179–216). Parkton, MD: York Press.

Goodman, K.S. (1976). Reading: A psycholinguistic guessing game. In H. Singer & R.B. Rudel (Eds.), *Theoretical models and processes of reading* (pp. 497–508). Newark: DE: International Reading Association.

Goswami, U. & Bryant, P. (1992). Rhyme, analogy, and children's reading. In P.B. Gough, L.C. Ehri & R. Treiman (Eds.), *Reading acquisition* (pp. 49–63). Hillsdale, NJ: Lawrence Erlbaum Associates.

Gough, P.B., Alford, J.A. & Holley-Wilcox, P. (1981). Words and contexts. In O.J.L. Tzeng & H. Singer (Eds.), *Perception of print: Reading research in experimental psychology* (pp. 85–102). Hillsdale, NJ: Lawrence Erlbaum Associates.

Gough, P.B. & Hillinger, M.L. (1980). Learning to read: An unnatural act. *Bulletin of the Orton Society, 30,* 179–196.

Gough, P.B. & Tunmer, W.E. (1986). Decoding, reading, and reading disability. *RASE: Remedial & Special Education, 7,* 6–10.

Gough, P.B. & Walsh, M.A. (1991). Chinese, Phoenicians, and the orthographic cipher. In S.A. Brady & D.P. Shankweiler (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 199–209). Hillsdale, NJ: Lawrence Erlbaum Associates.

Hoover, W.A. & Gough, P.B. (1990). The simple view of reading. *Reading and Writing: An Interdisciplinary Journal, 2,* 127–160.

Hulme, C., Hatcher, P.J., Nation, K., Brown, A., Adams, J. & Stuart, G. (2002). Phoneme awareness is a better predictor of early reading skill than onset-rime awareness. *Journal of Experimental Child Psychology, 82,* 2–28.

Juel, C. & Minden-Cupp, C. (2000). Learning to read words: Linguistic units and instructional strategies. *Reading Research Quarterly, 35,* 458–492.

Juel, C. & Roper/Schneider, D. (1985). The influence of basal readers on first grade reading. *Reading Research Quarterly, 20,* 134–152.

Katz, R.B. (1986). Phonological deficiencies in children with reading disability: Evidence from an object-naming task. *Cognition, 22*, 225–257.

Klima, E. (1972). How alphabets might reflect language. In J.F. Kavanagh & I.G. Mattingly (Eds.), *Language by ear and by eye: The relationships between speech and reading* (pp. 57–80). Cambridge, MA: MIT Press.

Liberman, A.M. (1999). The reading researcher and the reading teacher need the right theory of speech. *Scientific Studies of Reading, 3*, 95–111.

Liberman, I.Y., Shankweiler, D. & Liberman, A.M. (1989). The alphabetic principle and learning to read. In D. Shankweiler & I. Y. Liberman (Eds.), *Phonology and reading disability: Solving the reading puzzle* (pp. 1–33). Ann Arbor: University of Michigan Press.

Liberman, I.Y. & Liberman, A.M. (1992). Whole language versus code emphasis: Underlying assumptions and their implications for reading instruction. In P.B. Gough, L.C. Ehri & R. Treiman (Eds.), *Reading acquisition* (pp. 343–366). Hillsdale, NJ: Lawrence Erlbaum Associates.

Liberman, I.Y., Shankweiler, D., Camp, L., Blachman, B. & Werfelman, M. (1980). Steps toward literacy. In P.J. Levinson & C. Sloan (Eds.), *Auditory processing and language: Clinical and research perspectives* (pp. 189–215). New York: Grune and Stratton.

Liberman, I.Y., Shankweiler, D., Fischer, F.W. & Carter, B. (1974). Explicit syllable and phoneme segmentation in the young child. *Journal of Experimental Child Psychology, 18*, 201–212.

Lukatela, K., Carello, C., Shankweiler, D. & Liberman, I.Y. (1995). Phonological awareness in illiterates: Observations from Serbo-Croatian. *Applied Psycholinguistics, 16*, 463–487.

Lundberg, I. (1994). Reading difficulties can be predicted and prevented: A Scandinavian perspective on phonological awareness and reading. In C. Hulme & M. Snowling (Eds.), *Reading development and dyslexia* (pp. 180–199). San Diego: Singular Publishing Group.

Lundberg, I., Frost, J. & Petersen, O-P. (1988). Effects of an extensive program for stimulating phonological awareness in preschool children. *Reading Research Quarterly, 23*, 263–284.

Mann, V.A. (1991). Are we taking too narrow a view of the conditions for development of phonological awareness? In S.A. Brady & D.P. Shankweiler (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 55–64). Hillsdale, NJ: Lawrence Erlbaum Associates.

Mann, V.A., Liberman, I.Y. & Shankweiler, D. (1980). Children's memory for sentences and word strings in relation to reading ability. *Memory & Cognition, 8*, 329–335.

Mann, V.A. & Singson, M. (in press). The little suffix that could: Linking morphological knowledge to English decoding ability. To appear in E. Assink & D. Sandra (Eds.), *Reading complex words.* Amsterdam: Kluwer.

Mattingly, I.G. (1992). Linguistic awareness and orthographic form. In R. Frost & L. Katz (Eds.), *Orthography, phonology, morphology, and meaning. Advances in psychology* (vol. 94, pp. 11–26). Amsterdam: Elsevier Science Publishers.

Miller, G.A. (1988). The challenge of universal literacy. *Science, 241*, 1293–1299.

Moats, L.C. (1994). The missing foundation in teacher education: Knowledge of the structure of spoken and written language. *Annals of Dyslexia, 44*, 81–102.

Morais, J. (1991). Constraints on the development of phonemic awareness. In S. Brady & D. Shankweiler (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 5–27). Hillsdale, NJ: Lawrence Erlbaum Associates.

Morais, J., Alegria, J., Bertelson, P. & Cary, L. (1979). Does awareness of speech as a sequence of phones arise spontaneously? *Cognition, 7*, 323–331.

Nagy, W.E. Anderson, R., Schommer, M. Scott, J.A. & Stallman, A.C. (1989). Morphological families and word recognition. *Reading Research Quarterly, 24*, 262–282.

National Reading Panel (2000). *Teaching children to read: An evidence-based assessment of the scientific research on reading and its implications for reading instruction.* Washington, DC: National Institute of Child Health and Human Development.

Nicholson, T. (1991). Do children read words better in context or in lists? A classic study revisited. *Journal of Educational Psychology, 83*, 444–450.

Nittrouer, S., Studdert-Kennedy, M. & McGowan, R.S. (1989). The emergence of phonetic segments: Evidence from the spectral structure of fricative-vowel syllables spoken by children and adults. *Journal of Speech & Hearing Research, 32*, 120–132.

Olson, R.K. (1994). Language differences in "specific" reading disability. In M. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 895–916). New York: Academic Press.

Olson, R.K., Byrne B. & Samuelsson, S. (2002). *Preliminary results from an international longitudinal twin study of genetic and environmental influences on early reading development.* Paper presented at annual meeting of the Society for the Scientific Study of Reading, Chicago.

Pennington, B.F., Van Orden, G.C., Smith, S.D., Green, P.A. & Haith, M.M. (1990). Phonological skills and deficits. *Child Development, 61*, 1753–1778.

Perfetti, C.A. (1985). *Reading ability.* London: Oxford University Press.

Perfetti, C.A., Beck, I., Bell, L.C. & Hughes, C. (1987). Phonemic knowledge and learning to read are reciprocal: A longitudinal study of first grade children. Merrill-Palmer Quarterly, *Children's Reading and the Development of Phonological Awareness, 33*, 283–320.

Perfetti, C.A. & Lesgold, A.M. (1977). Discourse comprehension and sources of individual differences. In M.A. Just & P.A. Carpenter (Eds.), *Cognitive processes in comprehension* (pp. 141–183). Hillsdale, NJ: Lawrence Erlbaum Associates.

Plomin, R., DeFries, J.C., McClearn, G.E. & Rutter, M. (1997). *Behavioral genetics* (3rd ed.) New York: W. H. Freeman.

Pugh, K.R., Mencl, W.E., Jenner, A.J., Katz, L., Lee, J.R., Shaywitz, S.E. & Shaywitz, B.A. (2001). Neurobiological studies of reading and reading disability. *Journal of Communication Disorders, 34*, 479–492.

Rack, J.P., Snowling, M.J. & Olson, R.K. (1992). The nonword reading deficit in developmental dyslexia: A review. *Reading Research Quarterly, 27*, 28–53.

Rayner, K. (1986). Eye movements and the perceptual span in beginning and skilled readers. *Journal of Experimental Child Psychology, 41*, 211–236.

Rayner, K., Foorman, B.R. Perfetti, C.A., Pesetsky, D. & Seidenberg, M.S. (2001). How psychological science informs the teaching of reading. *Psychological Science, 2* (Supplement), 31–74.

Read, C., Zhang, Y., Nie, H. & Ding, B. (1986). The ability to manipulate speech sounds depends on knowing alphabetic writing. *Cognition, 24*, 31–34.

Rubin, H. Patterson, P.A. & Kantor, M. (1991). Morphological development and writing ability in children and adults. *Language, Speech and Hearing Services in Schools, 22*, 228–235.

Rumsey, J.M., Nace, K., Donahue, B., Wise, D., Maisog, J.M. & Andreason, P. (1997). A positron emission tomographic study of impaired word recognition and phonological processing in dyslexic men. *Archives of Neurology, 54*, 562–573.

Scarborough, H.S. (1998). Early identification of children at risk for reading disabilities: Phonological awareness and some other promising predictors. In B.K. Shapiro, P.J. Accardo & A.J. Capute (Eds.), *Specific reading disability: A view of the spectrum* (pp. 75–107). Timonium, MD: York Press.

Scarborough, H., Ehri, L.C., Olson, R.C. & Fowler, A.E. (1998). The fate of phonemic awareness beyond the elementary school years. *Scientific Studies of Reading, 2,* 115–142.

Seymour, P.H. & Elder, L. (1986). Beginning reading without phonology. *Cognitive Neuro-psychology, 3,* 1–36.

Shankweiler, D. (1989). How problems of comprehension are related to difficulties in decoding. In D. Shankweiler & I.Y. Liberman (Eds.), *Phonology and reading disability: Solving the reading puzzle* (pp. 35–68). Ann Arbor: University of Michigan Press.

Shankweiler, D. & Crain, S. (1986). Language mechanisms and reading disorder: A modular approach. (Special Issue: The onset of literacy) *Cognition, 24,* 139–168.

Shankweiler, D., Crain, S., Katz, L., Fowler, A.E., Liberman, A.M., Brady, S.A., Thornton, R., Lundquist, E., Dreyer, L., Fletcher, J.M., Stuebing, K.K., Shaywitz, S.E. & Shaywitz, B.A. (1995). Cognitive profiles of reading-disabled children: Comparison of language skills in phonology, morphology, and syntax. *Psychological Science, 6,* 149–156.

Shankweiler, D., Lundquist, E., Dreyer, L.G. & Dickinson, C.C. (1996). Reading and spelling difficulties in high school students: Causes and consequences. *Reading and Writing, An Interdisciplinary Journal, 8,* 267–294.

Shankweiler, D., Lundquist, E., Katz, L., Stuebing, K.K., Fletcher, J.M., Brady, S., Fowler, A., Dreyer, L.G., Marchione, K.E., Shaywitz, S.E. & Shaywitz, B.A. (1999). Comprehension and decoding: Patterns of association in children with reading difficulties. *Scientific Studies of Reading, 3,* 69–94.

Share, D.L. (1995). Phonological recoding and self-teaching: *Sine qua non* of reading acquisition. *Cognition, 55,* 151–218.

Shaywitz, S.E., Fletcher, J.M., Holahan, J.M. et al. (1999). Resistance of dyslexia: The Connecticut Longitudinal Study at adolescence. *Pediatrics, 104,* 1351–1359.

Shaywitz, B.A., Shaywitz, S.E., Pugh, K.R., Mencl, W.E., Fullbright, R.K., Skudlarski, P., Constable, R.T., Marchione, K.E., Fletcher, J.M., Lyon, G.R. & Gore, J.C. (2002). Disruption of posterior brain systems for reading in children with developmental dyslexia. *Biological Psychiatry, 52,* 101–110.

Shaywitz, S.E., Shaywitz, B.A., Pugh, K., Fulbright, R., Constable, R.T., Mencl, W.E., Shankweiler, D., Liberman, A.M., Skudlarski, P., Fletcher, J., Katz, L., Marchione, K.E., Lacadie, C., Gatenby, C. & Gore, J. (1998). Functional disruption in the brain for reading in dyslexia. *Proceedings of the National Academy of Science, 95,* 2636–2641.

Simos, P.G., Fletcher, J.M., Bergman, E., Breier, J.L., Foorman, B.R., Castillo, E.M., Davis, R.N., Fitzgerald, M. & Papanicolaou, A.C. (2002). Dyslexia-specific brain activation profile becomes normal following successful remedialtraining. *Neurology, 58,* 1203–1213.

Smith, S.D., Brower, A.M., Cardon, L.R. & DeFries, J.C. (1998). Genetics of reading disability: Further evidence for a gene on chromosome 6. In B.K. Shapiro, P.J. Accardo & A.J. Capute (Eds.), *Specific reading disability: A view of the spectrum* (pp. 63–74). Timonium, MD: York Press.

Snow, C.E., Burns, M.S. & Griffin, P. (Eds.) (1998) *Preventing reading difficulties in young children.* Washington, DC: National Research Council.

Spear-Swerling, L. (2001, June). *Fourth graders' performance on two different measures of reading comprehension.* Presented at Society for Scientific Study of Reading, Boulder, CO.

Stanback, M.L. (1992). Syllable and rime patterns for teaching reading: Analysis of a frequency-based vocabulary of 17,602 words. *Annals of Dyslexia, 42,* 196–221.

Stanovich, K.E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly, 21,* 360–406.

Stanovich, K.E. (1991). Conceptual and empirical problems with discrepancy definitions of reading disability. *Learning Disability Quarterly, 14,* 269–280.

Stanovich, K.E. (2000). *Progress in understanding reading: Scientific foundations and new frontiers.* New York: Guilford.

Stanovich, K.E., Cunningham, A.E. & Cramer, B.B. (1984). Assessing phonological awareness in kindergarten children: Issues of task comparability. *Journal of Experimental Child Psychology, 38,* 175–190.

Stanovich, K.E. & Siegel, L.S. (1994). Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable-difference model. *Journal of Educational Psychology, 86,* 24–53.

Studdert-Kennedy, M. (1986). The phoneme as a perceptuomotor structure. In J.S. Perkell & D.H. Klatt (Eds.), *Invariance and variability of speech processes* (pp. 58–76). Hillsdale, NJ: Lawrence Erlbaum Associates.

Swinney, D.A. (1979). Lexical access during sentence comprehension: (Re)consideration of context effects. *Journal of Verbal Learning & Verbal Behavior, 18,* 645–659.

Torgesen, J.K. (Spring/Summer 1998). Catch them before they fall. *American Educator, 22,* 32–41.

Torgesen, J.K. (2000). Individual differences in response to early interventions: The lingering problem of treatment resisters. *Learning Disabilities Research and Practice, 15,* 55–64.

Torgesen, J.K., Wagner, R., Rashotte, C., Rose, E., Lindamood, P., Conway, T. & Garvan, C. (1999). Preventing reading failure in young children with phonological processing disabilities: Group and individual responses to instruction. *Journal of Educational Psychology, 91,* 579–593.

Treiman, R. (1985). Onsets and rimes as units of spoken syllables: Evidence from children. *Journal of Experimental Child Psychology, 39,* 161–181.

Treiman, R. (1993). *Beginning to spell: A study of first-grade children.* New York: Oxford University Press.

Treiman, R., Mullenix, J., Bijeljac-Babic, R. & Richmond-Welty, E.D. (1995). The special of rimes in the description, use and acquisition of English orthography. *Journal of Experimental Psychology: General, 124,* 107–136.

Tunmer, W.E. & Chapman, J.W. (1998). Language prediction skill, phonological recoding ability, and beginning reading. In C. Hulme & R.M. Joshi (Eds.), *Reading and spelling: Development and disorders* (pp. 33–67). Mahwah, NJ: Erlbaum.

Tunmer, W.E. & Chapman, J.W. (in press). The relation of metalinguistics abilities, phonological recoding skill and the use of sentence context to beginning reading development: A longitudinal study. To appear in R.M. Joshi (Ed.), *Literacy acquisition, assessment and intervention: The role of phonology, orthography and morphology.* Amsterdam: IOS Press.

Tunmer, W.E. & Rohl, M. (1991). Phonological awareness and reading acquisition. In D. Sawyer & B. Fox (Eds.), *Phonological awareness in reading: the evolution of current perspectives* (pp. 1–29). New York: Springer-Verlag.

Van Orden, G.C., Pennington, B.F. & Stone, G.O. (1990). Word identification in reading and the promise of subsymbolic psycholinguistics. *Psychological Review, 97,* 488–522.

Vellutino, F.R., Scanlon, D.M., Sipay, E.R., Small, S.G., Pratt, A., Chen, R. & Denckla, M.B. (1996). Cognitive profiles of difficult-to-remediate and readily remediated poor readers: Early intervention as a vehicle for distinguishing cognitive and experiential deficits as basic causes of specific reading disability. *Journal of Educational Psychology, 88,* 601–638.

Venezky, R.L. (1970). *The Structure of English Orthography.* The Hague: Mouton.

Venezky, R.L. (1999). *The American Way of Spelling*. New York: Guilford.
Wolf, M. (1991). Naming speed and reading: The contribution of the cognitive neurosciences. *Reading Research Quarterly, 26*, 123–141.
Wylie, R.E. & Durrell, D.D. (1970). *Elementary English, 47*, 787–931.

Address for correspondence: Donald Shankweiler, Haskins Laboratories, 270 Crown St., New Haven CT 06511, USA. Phone: +1-860-486-3522/+1-203-865-6163; Fax: 203-865-8963; E-mail: donald.shankweiler@uconn.edu