CHAPTER 35

Incorporating Recent Advances in Understanding Word-Reading Skills into Specific Learning Disability Diagnoses

The Case of Orthographic Mapping

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BACKGROUND

In the spring of 1988, I took a graduate course in neuropsychology from Larry Lewandowski at Syracuse University. After describing the inadequate nature of the neuropsychological tests available at the time, he stated that the best tool we had for conducting a neuropsychological evaluation was between our ears. He indicated that the more we knew about the functioning of the brain, the better equipped we would be to select and interpret cognitive and neuropsychological tests and subtests to address the questions we would want to answer. This chapter is written in the spirit of Lewandowski's comment. It may differ from other chapters in this volume, in that only a portion of it is devoted to some critical "nuts-and-bolts" issues of diagnosing specific learning disabilities (SLD) in reading. However, it provides important background information for understanding the very nature and causes of word-level reading difficulties. Such a knowledge base will help practitioners conduct more informed evaluations and make more valid decisions regarding SLD in word-level reading.

Why a Special Chapter on Word-Level Reading?

The reason for this rather in-depth chapter on the nature of word-level reading problems is quite simple: Approximately 80–85% of students diagnosed with SLD have reading disabilities, and the vast majority of these students have word-level reading issues (Fletcher, Lyon, Fuchs, & Barnes, 2018; Lerner & Johns, 2012). The term *word-level reading disabilities* refers to SLD in basic reading and/or reading fluency. Far and away the most common type of SLD, word-level reading disabilities can occur alone or may be comorbid with SLD in reading comprehension, writing, or math. Given the sheer magnitude of SLD in reading, and the vast empirical research that has been conducted to investigate such problems, it seems judicious to examine word-reading difficulties in a fair degree of depth.

The Psychology of Reading

The late Robert Crowder was a cognitive psychologist at Yale University. In his book *The Psychology of Reading* (1981), he mentions an interesting in-sight regarding the relationship between the field of psychology and research on reading. He said that the cognitive revolution from the 1950s to 1970s involved studying perception, input, storage, and retrieval. Various stimuli were used to examine these phenomena, including letters of the alphabet, written words, sentences, and paragraphs. By the 1970s, it became recognized that the field of cognitive psychology had unwittingly amassed hundreds of studies on reading. The goal had been to understand complex cognitive processes; the reading-related stimuli were only the raw materials for studying those cognitive processes (Crowder, 1981).

An examination of the departmental affiliations in the empirical research reports on reading acquisition and reading disabilities indicates that the lion's share of scientifically oriented research articles come from departments of psychology around the globe. Reading research is, however, a highly interdisciplinary pursuit: It is shared by such fields as speech pathology, linguistics, special education, general education, literacy, neurology, and pediatrics. Nonetheless, the field of psychology has arguably made the largest volume of contributions to the hundreds of scientifically oriented reports on reading acquisition and reading disorders that appear every year (Kilpatrick, 2015).

Reading Research versus Classroom Practice

Most unfortunately, this large and heavily grant-funded body of research has not made inroads into the teaching of reading in our nation's K–12 schools. It has been pointed out by numerous sources that "a chasm exists between classroom instructional practices and the research knowledge-base on literacy development" (American Federation of Teachers, 1999, p. 7; see also Joshi, Binks, Graham, et al., 2009; Joshi, Binks, Hougen, et al., 2009b; Kilpatrick, 2015; Moats, 1994, 2009; Seidenberg, 2017). One attempt to close this gap between research and practice was the implementation of *response to intervention (RTI)*. RTI was prompted by federal grant initiatives on reading that yielded highly encouraging findings in terms of preventing and correcting reading problems (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998; National Reading Panel, 2000; Torgesen et al., 2001; Vellutino et al., 1996). The original intent of RTI was to scale up that research, so that all at-risk and struggling readers in the United States would benefit from these highly effective approaches. Most unfortunately, however, the implementation of RTI focused on the processes, frameworks, universal screenings, and progress monitoring for RTI, while the actual instructional and intervention practices that were so highly successful in those seminal studies were never adequately communicated (Kilpatrick, 2015; Seidenberg, 2017). Teachers have been charged with using "research-based" or "evidence-based" instructional practices, without knowing what those practices were (Seidenberg, 2017). As a result, a recent federal report indicated that RTI is having little or no impact on the students it is designed to serve (Balu et al., 2015).

It appears that school psychologists, like teachers, are not likely to be incorporating the findings from the reading research into their professional practice. A study published in *School Psychology Review* indicated that school psychologists, by and large, are not familiar with some of the most important findings from empirical studies of reading acquisition and reading difficulties/disabilities (Nelson & Machek, 2007). The present chapter is intended to provide information about some important recent advances related to word-level reading difficulties that practitioners should consider when evaluating and diagnosing students who display such difficulties.

READING WORDS VERSUS LEARNING WORDS

One of the most plausible reasons for the limited effects of RTI appears to be that educators continue to teach reading the way they have always taught it, but now they do so within an RTI framework (Kilpatrick, 2015; Seidenberg, 2017). There is no evidence that the highly effective general and remedial instructional techniques used in the federal grant initiatives that prompted RTI have been widely incorporated into our schools, while there is evidence that they are not (e.g., Joshi et al., 2009). This would account for the null results found in the recent federal report (Balu et al., 2015). An important problem related to this is that neither of the two dominant reading approaches used in schools over the last 40 years properly distinguishes between *reading* words and *learning* words. They focus on the former without adequately addressing the latter. This is problematic because the most highly successful outcomes in the reading research literature appear to have facilitated the ability to learn and remember words, not just to read and identify them (Kilpatrick, 2015).

The most common approach to teaching reading in the United States in recent decades has been the three-cueing-systems approach. This approach was made popular by the whole language movement in the 1980s and 1990s and now forms the foundation of balanced instruction, Reading Recovery, and the Leveled Literacy Intervention (commonly known as LLI). The three-cueing-systems model teaches students to read words and sentences by using three types of cues: (1) the *context* of the sentence or passage; (2) the *linguistic* features of the words (grammar and syntax), and (3) the *grapho-phonic* features (i.e., letters and sounds) of the word (Goodman, 1996). The second most common approach to reading instruction has been phonics. The phonics approach encourages students to use knowledge of letter–sound relationships to "sound out" unfamiliar words. The phonics approach has been shown to yield superior results to the three-cueing-systems approach, particularly for weak readers (Bond & Dykstra, 1967; Brady, 2011; Ehri, Nunes, Stahl, & Willows, 2001; National Reading Panel, 2000; Moats, in press; Share, 1995).

The problem with both of these approaches is that they focus on developing students' abilities to *identify* words. This is not the same as *learning* those words. A word can be read or identified without actually being learned or remembered. When this happens, a word that has been correctly identified via phonic decoding or contextual guessing may not be remembered when encountered in the next paragraph, and most likely not remembered when encountered the next day. By contrast, skilled readers are very adept at remembering the words they read. From second grade on, skilled readers learn newly encountered words after only one to four exposures (Cunningham, 2006; Reitsma, 1983; Share, 2004b; see more below). From then on, those newly learned words are recognized as familiar when they are encountered, and that recognition is instantaneous and effortless (Ehri, 2005). There is no need to sound out such words, nor is any guessing involved. Currently, there does not appear to be an instructional methodology used in schools that takes account of the empirical research that has occurred on printed-word learning (but see Kilpatrick, 2016). Yet, as mentioned, it appears that the studies that displayed highly successful intervention results all helped students develop the ability to learn words rather than simply read words.

It must be pointed out here that most children will learn to read, "no matter how unhelpful the instruction" (Liberman & Liberman, 1990, p. 54). For approximately two-thirds of students, this distinction between reading/identifying words and learning/remembering words is of very little consequence. These students acquire the ability to learn words as a result of being exposed to literacy activities. The situation is quite different for struggling readers. For them, the distinction between reading words and learning words is of great significance. A large portion of the bottom third of readers are not able to learn words efficiently, regardless of which of the two dominant teaching approaches they receive.

ASSESSMENT CONCERNS REGARDING WORD-LEVEL READING

In the same way that conventional approaches to reading instruction do not adequately distinguish between reading words and learning words, neither do most standardized tests that involve isolated-word reading. Nationally normed, word-level reading assessments evaluate students' ability to read words. They do not directly evaluate their ability to learn words. Additionally, such assessments confound two different aspects of word reading: identification and recognition (Kilpatrick, 2015). *Word identification* refers to the ability to correctly read a given word, regardless of its prior familiarity. *Word recognition* presumes that a word is already familiar (Aaron et al., 1999; Harn, Stoolmiller, & Chard, 2008; Kilpatrick, 2015). Yet the terms *word identification* and *word recognition* are typically used interchangeably. Some subtests that assess isolated-word reading in reading and achievement batteries are called word identification subtests (e.g., in the Woodcock–Johnson Tests of Achievement), while others are called word recognition subtests (in the Kaufman Test of Educational Achievement). This is despite the fact that these subtests use identical or nearly identical formats. The synonymous use of these terms appears to compromise precision in understanding and addressing two different reading-related skills or processes.

Some of the words on standardized word identification subtests are already familiar to any given student. The pool of words that a student already knows has been referred to as an *orthographic lexicon* or a *sight word vocabulary* (Ehri, 2014; Van den Broeck & Geudens, 2012). Such words are instantly recognized on those subtests; no sounding out or guessing is needed. The size of a given student's orthographic lexicon/sight word vocabulary appears to result from the interaction between the student's ability to remember words and the student's reading experience. The latter factor (reading experience) allows him or her to be exposed to more and more words to be learned.

In addition to tapping into a student's orthographic lexicon, standard word identification subtests evaluate another skill. This second skill involves a student's ability to figure out a word, on the spot, that he or she did not previously know. Students can correctly determine unfamiliar words in isolation by using one or more strategies. One strategy involves guessing based on the first letter and the length of the word. For example, a student may say "lunch" when presented with *laugh,* or "expect" when presented with *expert.* Such guessing will often yield a correct response. A correct response does not mean that the student knows the word. It means that the student made a good guess. A second strategy that can be used to determine a previously unfamiliar word involves reading by analogy (Ehri, 2005). If a student is familiar with the word *since,* he or she can use knowledge of that word when encountering a word like *prince.* A third strategy is what researchers call *phonological recoding* (Share, 1995), which educators call *phonic decoding.*

A fourth strategy for determining an unfamiliar word without the aid of context is called *set for variability* (Kearns, Rogers, Koriakin, & Al Ghanem, 2016; Tunmer & Chapman, 1998, 2012). Essentially, set for variability refers to one's ability to correctly determine a mispronounced word. This applies to reading when a student correctly determines a word despite having mispronounced it, either because it is an irregular word or because it was simply misread. Students with stronger oral vocabularies make better use of set for variability than students with more limited oral vocabularies (Tunmer & Chapman, 2012).

Thus, on standard, context-free word identification subtests from normative achievement batteries, students can read unfamiliar words via four different strategies. This means that on our most popular word-reading subtests, two different aspects related to word-level reading are inherently confounded: the size of the sight vocabulary and the ability to figure out unfamiliar words without the aid of context. While subtests of nonsense-word reading may help us understand a student's ability to sound out an unfamiliar word, we have more difficulty assessing the sight vocabulary. Yet the size and growth of the sight vocabulary are what may give us some clues about a student's efficiency in learning/remembering words.

Language Skills May Confound Word-Reading Assessment and SLD Diagnosis

The advantage that vocabulary skills provide in making use of set for variability implies that the scores on word-reading subtests for those with higher vocabulary skills might tend toward an overestimation of their raw word-level reading capabilities. This has no bearing on the classical IQ–achievement discrepancy; indeed, the scoring pattern is in the wrong direction (i.e., it minimizes any discrepancy between IQ and achievement). However, this phenomenon appears to have implications for identifying readers who are poor at learning words and who may benefit from additional general educational remedial reading help, or even in some cases students who may qualify as SLD. Such students have been called *compensators* (Kilpatrick, 2014, 2015, 2016). A study of compensators indicates that they often dislike and avoid reading, despite average word identification subtest scores on normed tests (Kilpatrick, 2014). It seems that their strong verbal skills combined with even rudimentary phonic decoding skills allow them to correctly identify previously unfamiliar words on word-reading tests via set for variability.

Consider the possible impact of set for variability on interpreting the word identification subtest scores of two third-grade boys. The first student has a verbal IQ (VIQ) of 90, and the other has a VIQ of 113. They both have equal phonic decoding skills, as reflected by standard score of 83 on a test of nonsense-word reading. Let us say they happen to have prior familiarity with the same number of words on the word identification subtest. They also both received a scaled score of 11 on the Blending Words subtest of the Comprehensive Test of Phonological Processing—Second Edition (CTOPP-2; Wagner, Torgesen, Rashotte, & Pearson, 2013), but a 7 on the Elision subtest.

On the word identification subtest, these two students each instantly recognize the same words that are familiar to both of them. The student with the 90 VIQ goes on to correctly identify three unfamiliar words, using his weak phonic decoding skills and subpar set for variability. His word identification score is 83, or 13th percentile. This score is well within the range of weak reading, according to the National Assessment of Educational Progress (2015), which indicates that about 30% of fourth graders read below a basic level. By contrast, using the same rudimentary phonic skills but applying his strong vocabulary skills to yield better set for variability, the student with the 113 VIQ goes on to correctly identify several additional words, yielding a standard score of 92. The former student may receive Tier 2 remedial instruction for his reading skills. Also, depending on the rest of his profile and his school's criteria/cutoffs for SLD, he may even be considered for an SLD designation. By contrast, the second student has an average word identification score. That student would not be considered as having SLD and likely would not even be considered for Tier 2 remedial services. Yet both students have the same raw word-level reading abilities, although the latter student can mask his inadequacies due to strong vocabulary skills. While the classic IQ–achievement discrepancy unfairly favored those with higher IQs, the issue of compensation has the opposite effect.

This illustration is not intended to suggest that the second student should be designated as having SLD. However, it should be acknowledged that such a student is likely to be a struggling reader who, at minimum, should receive Tier 2 remedial instruction. Yet what if one of the school's criteria is that a student must have a standard score of 85 or lower for an SLD diagnosis, and this student received an 87 on word identification? The first student's 83 makes the cut and the second student's does not, although they have a similar-sized orthographic lexicon and the same level of phonic decoding and phonemic awareness. The student with the VIQ of 113 disqualifies himself because he is better at figuring out words, due to his high vocabulary and correspondingly stronger set for variability. But the trajectory for this student is that he will spend more time having to figure out words, while his skilled fellow students will remember the words they read and will not have to keep applying strategies to the same words. Thus, when diagnosing SLD in word-level reading (basic reading and/or reading fluency), we must acknowledge the nature of the inherent problems with the word identification assessments we routinely use to make such diagnoses.

Word-Reading Strategies and the Orthographic Lexicon May Be Confounded

Reading familiar words involves no strategies. Known words are instantly and automatically accessible (Ehri, 2005; Rayner, Pollatsek, Ashby, & Clifton, 2011), even precognitive, so that they are already available before any conscious strategy could be applied. Word-reading strategies, such as the four strategies referred to earlier—to which we could add the use of contextual guessing—are only necessary when encountering unfamiliar words. The confounding phenomenon of evaluating both the recognition of familiar words and the identification of unfamiliar words on the same subtest means that there is no way to know which of the correctly read words were familiar and which were not. Clinical observation may be somewhat useful here by noting whether the student responded to a given word instantly or not. However, such observations cannot be followed up with normative comparisons to determine what constitutes typical performance. This confounding is not without consequence. Known words are read more quickly than unknown words, and the number of known words appears to be the driving force behind reading fluency. That is, reading fluency appears to be primarily a function of the size of a student's orthographic lexicon or sight vocabulary (Ehri, 2005; Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003; Kilpatrick, 2015; Torgesen, 2004b; Torgesen, Rashotte, Alexander, Alexander, & MacPhee, 2003). Students who know all or most all of the words in a given passage read more fluently than students who know fewer of the words in the passage. A student may have 100% accuracy on a passage, but may have poor fluency because he or she had to phonologically recode or guess at a substantial number of the words. While the student correctly *read* those previously unfamiliar words, their unfamiliarity means that these were not words that had been previously learned.

LEARNING WORDS

Having a pool of known words presumes a previous learning history on each and every one of those familiar words. Like other cognitive and linguistic skills, it also presumes that given equal instruction, opportunity, and effort, there will be individual differences in the ease with which students learn and remember written words (Ehri & Saltmarsh, 1995; Share, 2011; Share & Shalev, 2004). But how do students learn words rather than just identify them? At what point does a given word go from being unfamiliar to familiar, and thus instantly and effortlessly accessible? What cognitive, linguistic, and academic skills and processes contribute to our memory for the words we read? Also, why are there such large individual differences in this skill? For example, in a classic study, Ehri and Saltmarsh (1995) discovered that the word-*learning* skills of typically developing first graders were stronger than those of a comparison group of fourth graders with reading disabilities. Share and Shalev (2004) also showed that children with reading disabilities required more exposures to words before they learned them.

The Nature of Dyslexia

In the reading research literature, significant word-level reading difficulties/disabilities are referred to as *dyslexia* (Fletcher et al., 2018; Hulme & Snowling, 2009; Vellutino, Fletcher, Snowling, & Scanlon, 2004). Although popular understandings of the term *dyslexia* are fraught with 100-year-old misconceptions, from the standpoint of researchers dyslexia simply refers to poor word-level reading despite adequate effort and opportunity, and it cannot be accounted for by blindness, deafness, or severe intellectual impairment (Fletcher et al., 2018; Hulme & Snowling, 2009; Vellutino et al., 2004). For the last three decades, many researchers have conceptualized dyslexia as being the result of a nonword-reading deficit (Rack, Snowling, & Olson, 1992; Share, 1995). In this understanding, word-level reading disabilities are based primarily on poor phonological skills, which make acquiring the alphabetic code of written English very challenging. As a result, sounding out new words is very difficult for those with dyslexia. However, more recently, on empirical, statistical, and design grounds, Van den Broeck and colleagues (Van den Broeck & Geudens, 2012; Van den Broeck, Geudens, & van den Bos, 2010) have shown that poor nonsense-word reading among dyslexic readers appears to be only half the story. Students with word-level reading difficulties also have a weakness in remembering the words they read (Ehri & Saltmarsh, 1995; Share & Shalev, 2004; Van den Broeck & Geudens, 2012; Van den Broeck et al., 2010). In addition to supplementing and extending the notion of dyslexia as a nonword-reading deficit, these findings challenge the older notion that dyslexia can be reliably divided into *phonological* and *surface* subtypes (see more on this below).

Word-Learning Theories

There are several theories designed to explain how words are learned. For simplicity, a distinction is made here between *computational* theories and *cognitive* theories. Computational theories of word learning involve computer programs that simulate both reading words and learning words (Coltheart, 2012; Seidenberg, 2002, 2017). These computational models have yielded rich insights about reading, but they are based only indirectly on behavioral evidence from studies of actual human reading. These models are not considered further in this chapter because the number of trials required for word learning in these models is discrepant with actual data from human readers (surprisingly, typical human readers learn words far more quickly).

Cognitive Theories of Word Learning

The two theories of word learning that have generated the most empirical support are Linnea Ehri's (1992, 2005, 2014; Miles & Ehri, in press) *orthographic mapping theory* and David Share's (1995, 1999, 2011) *self-teaching hypothesis*. Torgesen referred to Ehri's theory of word learning as "the most complete current theory of how children form sight word representations" (Torgesen, 2004a, p. 36). Van den Broeck and Geudens (2012) speak as highly of Share's theory when they say that the "self-teaching model is the most dominant account of the developmental process toward fully specified orthographic representations" (p. 416). This latter quote is not inconsistent with the quote by Torgesen because of the tremendous overlap between these two theories. Indeed, one researcher explicitly says that Share's self-teaching hypothesis "is essentially the same as Ehri's [orthographic mapping] hypothesis" (Apel, 2009, p. 43). While this statement is not technically accurate, it testifies to the large overlap between these models of learning to read.

Both orthographic mapping and the self-teaching model posit a central role for letter–sound knowledge and for phonemic awareness in building the orthographic lexicon. Visual memory plays no role (see below). An important difference between Ehri's and Share's theories is that Ehri's theory provides a specific cognitive mechanism for the process of forming connections between pronunciations and their orthographic representations. Share's theory provides the scenario under which this connection-forming process occurs, without providing specific details about how words are encoded into the orthographic lexicon. Ehri, on the other hand, says little about this learning scenario that Share describes. Rather, her theory presents a more abstract representation of the connection-forming process.

Before this process of orthographic learning is described in detail, a more dominant theory of word learning, even if informal and intuitive, must first be addressed. This is the common view that word learning is based on some form of visual memory process via paired-associate learning. This intuitive theory assumes that learning to read words is a process similar to learning to name familiar objects or people (i.e., visual input, verbal output).

Do We Remember Words Based on Visual Memory?

When we look at a chair and say "chair," or when we see the printed word *chair* and say "chair," the naming activity intuitively appears to be similar, if not identical. In both cases, visual input is used to access a phonological code, which is our memory of the pronunciation of the spoken word *chair*. There are, however, multiple, independent lines of evidence demonstrating that word reading is not based on a visual memory process similar to naming objects in our environment. These various lines of evidence have been presented in detail elsewhere (Kilpatrick, 2015), which are summarized below and in Table 35.1.

First, in 1886, James Cattell tested naming speed for objects versus printed words. He did so using a newly developed millisecond-level timing device. Adults read words like *chair* and *tree,* and Cattell compared their reaction times, measured to 1/1,000th of a second, to visual presentations of a chair or a tree. To his surprise, Cattell found that the reaction times to the printed words were consistently faster than to the actual objects. Thus, by the late 1800s, there already existed evidence challenging our intuitive notion that visual memory and orthographic memory (i.e., printed-word recognition) represent the same process.

Second, in the preface to his 1979 book *Dyslexia,* researcher Frank Vellutino says he began the decade of the 1970s assuming the common view that word reading is based on some sort of visual memory process. By the time he wrote his book, however, he had abandoned that view, based on studies he and others conducted in the 1970s that failed to find the expected visual memory deficiencies in dyslexic readers (Vellutino, 1979).

TABLE 35.1. Summary of Reasons Why We Know Words Are Not Remembered via Visual Memory

1. Reaction times to printed words (e.g., *chair* or *tree*) are faster than reaction times to objects (e.g., a picture of a chair or tree), suggesting that visual memory and orthographic memory are different processes.
2. Persons with poor word-level reading tend to have average visual memories.
3. Despite the finding that their visual memory is equivalent to that of hearing individuals, those who are deaf struggle with remembering the words they read.
4. There is a moderate to strong correlation between word reading and phonological skills, but a very weak correlation between word reading and visual memory.
5. Words are instantly recognized despite their visual presentation (uppercase, lowercase, differing fonts, handwriting styles, etc.), as long as the letters are legible.
6. Neuroimaging studies indicate that there is very little overlap in the areas of the brain responsible for visual memory versus memory for written words.
7. We routinely have "visual memory" failures in forgetting the names of familiar people or even objects, but we have no such failures with remembering familiar words.

Third, if reading were based on visual memory, it becomes very difficult to explain why students who are deaf tend to graduate from high school at about a third-grade reading level (Lederberg, Schick, & Spencer, 2013; Leybaert, 2000). Individuals who are deaf have visual memory skills comparable to those of hearing individuals, so if visual memory were the basis for printed word memory, students who are deaf would learn to read at a rate comparable to that of their hearing peers.

Fourth, the correlation between visual skills and word reading tends to be very low, while the correlation between word reading and phonological processes is substantially higher (Vellutino, 1979; Vellutino et al., 1996; Wagner & Torgesen, 1987). It is difficult to understand why this would be the case if visual skills play a substantial role in word learning.

Fifth, studies done to disrupt readers' visual memories of words have been inconsistent with the visual memory hypothesis. As long as readers are acclimated to unusual forms of print (e.g., strange or ornate fonts or a specific individual's handwriting), readers have instant access to words written in those differing ways, despite having no prior exposure to that unusual visual presentation for any given word (Adams, 1990). One example of this involved disrupting a visual presentation of words using mixed type (e.g., wOrDs WrItTeN LiKe tHiS), which virtually guarantees that the reader has no prior exposure to or visual memory of words printed that way (Adams, 1990). Adams (1990) described studies in which words were presented on a computer screen for 1/20th of a second, in either uppercase, lowercase, or mixed case, followed by a mask (e.g., #####). During debriefing after the study, some research participants indicated that they were unaware of these different presentations, and others even insisted that they had all been presented in lowercase letters only.

A likely reason for this finding can be found in studies that show that readers have an abstract representation of each of the letters of the alphabet in the memory system, irrespective of case and font (Bowers, 2000; Frost, 1998; Van den Broeck & Geudens, 2012). Within the first 1/10th of a second after a word is seen, it appears that the particular letters perceived are translated into their respective abstract representations. Apparently, the memory system then seeks to determine whether that *specific sequence of letters*—regardless of its visual characteristics—is stored in the orthographic lexicon. Thus orthographic memory appears to be based on familiar sequences of letters,[1] not familiar visual input at the letter or word level. If the memory system detects a familiar letter sequence, the left fusiform gyrus (in the left ventral occipito-temporal area) activates and the word is recognized. If it does not, the activation then moves higher in the temporo-occipital area associated with the letter–sound conversion process (Dehaene & Cohen, 2011; Glezer, Kim, Rule, Jiang, & Riesenhuber, 2015; Simos et al., 2002). This helps understand why case and font appear to make little or no difference in recognizing words, as long as the letters are legible to the reader.

Sixth, neuroimaging studies have indicated that the areas of the brain that are activated during visual memory tasks show limited overlap with the areas activated during the reading of familiar words (Dehaene & Cohen, 2011; Simos et al., 2002). This helps explain Cattell's results from over 125 years ago.

Finally, in addition to these various lines of research evidence, there is another phenomenon readers experience that is inconsistent with the visual memory hypothesis of word reading. It is not uncommon for us to have an apparent "visual memory failure"—that is, a failure to retrieve the phonological code associated with some visual input. For example, this occurs when we encounter a familiar person and yet fail to retrieve his or her name. It also happens when we fail to retrieve the name of an object in our line of sight ("Hand me that thingy over there").[2] By contrast, it appears that this same retrieval failure never occurs with orthographically familiar words. Familiar words are consistently retrieved. Only unfamiliar words or words printed illegibly represent challenges to accurate retrieval. This disparity in retrieval failures of people's names and objects' names, but not written words, is difficult to explain with the intuitive theory that memory for written words is based on visual processes similar to those used in object recognition. Input and storage are not the same thing. We input words visually, but store them orthographically, phonologically, and semantically.

In sum, several independent lines of empirical evidence appear to falsify our highly intuitive notion that printed words are stored and retrieved from long-term memory via some form of visual memory process. But if visual memory is not the mechanism by which we remember words, what is?

ORTHOGRAPHIC LEARNING AND MEMORY

In contrast to visual memory, the notion of remembering words via *orthographic memory* has received substantial empirical support (Ehri, 1992, 2005; Rack, Hulme, Snowling, & Wightman, 1994; Share, 1995, 2011). *Orthography* refers to the proper way to represent written words in a given writing system. In alphabet-based writing systems, orthographic memory refers to a memory for the precise letter order that comprises a written word or word part (Ehri, 2005; Van den Broeck & Geudens, 2012). Because orthographic memory involves a specific letter sequence, there is no particular relevance to the visual features of the printed words, such as size, case, font, or whether a word is in print or handwriting. The necessary feature is that the letters in the sequence are legible. The question arises as to how such a highly efficient and largely automatic memory for specific letter sequences occurs within the cognitive system. Recent clues have come from neuroimaging studies (Dehaene & Cohen, 2011; Glezer et al., 2015; Simos et al., 2002). As mentioned previously, when familiar words are viewed, the left fusiform gyrus is activated. However, when unfamiliar words and nonsense words are viewed, areas in the left superior and medial temporal and occipital areas are activated. One recent study even tracked this shift in areas of activation as words became familiar (Glezer et al., 2015). In this chapter, however, the focus is on a cognitive description of the orthographic learning process. The neuroimaging and other neurophysiological data serve largely to confirm or disconfirm cognitive explanations of reading (Anderson & Reid, 2009). Currently, neuroimaging and other neurophysiological data appear to provide important evidence that confirms the cognitive explanation of written-word learning described below.

The Nature of Orthographic Knowledge

Orthographic knowledge is understood on multiple levels. On one level, it refers to a familiarity with what would be considered permissible and nonpermissible letter sequences in a given written language. For example, in English, words do not begin with *ck* or *mb,* but they may end with those letters (e.g., *back, thumb*). On another level, orthographic skills refer to the pronunciation of common subword sequences or orthographic patterns that do not yield to simple letter-by-letter, grapheme–phoneme conversion regularities (e.g., *-ight, -alk, -tion, -ould*). Finally, orthography can refer to the correct spelling of any given word (e.g., *brain,* not *brane*).

Orthography as an Independent Reading-Related Subskill

One issue in this area has been whether orthographic skills represent a separate reading-related subskill in the same way that letter–sound knowledge, nonsense-word reading, phonemic awareness, and rapid automatized naming are considered to be reading-related subskills. Orthographic skills have been commonly assessed in research studies via the word likeness task, the homophone or pseudohomophone task, and exception-word reading (e.g., Olson, Forsberg, Wise, & Rack, 1994).

A word likeness task asks children which of two nonwords is most like a word. For example, given *lmk* and *pif,* the latter is more like a word because it has a common consonant–vowel–consonant (CVC) pattern, while the first item has no vowel. A homophone or pseudohomophone task requires students to identify the correct spelling pattern for a given word, such as which of the following is a flower: *rows, rose,* or *roze*. An exception-word task simply involves having students read words that do not yield correct pronunciations via phonic decoding (e.g., *iron, yacht, rendezvous*).

Before the middle of the last decade, many researchers argued that orthographic skills contribute to word reading above and beyond letter–sound skills and phonemic awareness (e.g., Cunningham, Perry, Stanovich, & Share, 2002; Holmes, 1996). In contrast, other researchers claimed that these orthographic skills are by-products of letter–sound knowledge, phonological skills, and reading experience, and thus are not causal elements in word-reading development (Vellutino, Scanlon, & Tanzman, 1994). This latter view was supported by research in the 1990s showing that orthographic sequences become "unitized" as part of reading development and experience. For example, typical fourth-grade readers and strong second-grade readers read a nonsense word like *nalk* to rhyme with *walk* and *talk,* while weaker-reading second graders read it to rhyme with *talc,* following a more strict application of letter–sound regularities (e.g., Bowey & Underwood, 1996). Presumably, with reading experience, orthographic patterns become familiar to readers.

More recently, there appears to have been a shift in understanding the relationship between orthographic skills and reading development. This shift followed a comprehensive review of the empirical literature by Jennifer Burt (2006). Her review indicated that there were no theoretical or empirical grounds for considering orthographic skills to be a reading-related skill that contributes to the development of reading skills apart from letter–sound skills, phonemic awareness, and reading experience. Rather, orthographic skills appear to represent a point in letter–sound knowledge development that occurs as a result of reading experience and noting patterns that are consistently pronounced (e.g., *-ight, -tion*), even if they are inconsistent with a simple letter-by-letter phonic decoding approach. This view has received further support from longitudinal research. Deacon, Benere, and Castles (2012) found that first-grade reading skills predicted third-grade performance on orthographic skills tasks, while orthographic skills tasks assessed in first grade did not predict third-grade reading skills. Despite this trend in the research, it appears that some authors (e.g., Feifer, 2011, 2014; Mather & Wendling, 2012), while describing subtypes of dyslexia, continue to maintain that orthographic skills independently contribute to reading (for more detail, see below).

HOW ORTHOGRAPHIC LEARNING OCCURS: SELF-TEACHING AND ORTHOGRAPHIC MAPPING

The Self-Teaching Hypothesis

The evidence in support of David Share's self-teaching model of orthographic learning is large and growing (e.g., Bowey & Muller, 2005; Cunningham, 2006; Cunningham et al., 2002; Share, 1999, 2004b, 2011), as is the empirical support for Ehri's orthographic mapping model (e.g., Dixon, Stuart, & Masterson, 2002; Ehri & Saltmarsh, 1995; Laing & Hulme, 1999; Rack et al., 1994). I examine each in turn.

The self-teaching hypothesis begins with a simple and self-evident observation. A skilled adult reader has tens of thousands of written words in his or her orthographic lexicon/sight word vocabulary, yet it is likely that only a few hundred of those words were directly taught by teachers or parents. The essence of the self-teaching model is that children teach themselves most of the words they know, once they have in place adequate or better phonological recoding skills (i.e., phonic decoding; Share, 1995). As students with phonological recoding skills encounter new words, they perform the letter–sound conversion process and phonological blending to identify those words (Share, 1995, 2011). Context and set for variability may assist in the identification of an unfamiliar word, especially irregular or exception words. Regardless, the self-teaching model proposes that the process of tracking through the letter sequence and sounds that constitute a printed word helps establish that letter sequence in long-term memory (Share, 1995).

Numerous studies have shown that from second grade on, an average reader requires only one to four exposures to a new word in order for that word to become established in the orthographic lexicon/sight word vocabulary (Cunningham, 2006; Reitsma, 1983; Share, 1999, 2004b; Share & Shalev, 2004). At first this may seem a bit surprising. However, a moment's reflection on the growth trajectories of early readers independently supports these findings (Adams, 1990; Ehri, 2005; Snow, Burns, & Griffin, 1998). Most children enter first grade knowing dozens of words, yet 2 years later they enter third grade knowing thousands of words. This steep growth trajectory within this limited time frame does not allow the opportunity for students to have dozens of exposures to each of those thousands of words, except for high-frequency words.

A common research paradigm involves having students silently read a narrative—for example, about a fictional city called *Yait.* Some students see the target word only once at the beginning of the passage, after which "this city" or "that city" is used. Other students receive two, four, six, or eight exposures to the target pseudoword in the passage. The frequency of exposure varies both within and across studies. Some studies test students on the newly encountered "word" the following day, or a week later, or even a month later. These tests may include a spelling test; an orthographic choice task using phonologically plausible foils (e.g., "Was the name of the city *Yate, Yait, Yat, Yaet,* or *Yaite?*"); or measuring reaction time (RT) to the words flashed on a computer screen (and comparing that to the RT to the homophonic foil). Performance accuracy is quite high for all types of queries, with spelling accuracy being the weakest. Many words are learned after a single exposure, yet there is an increase in accuracy if the words are encountered two to four times. Beyond four exposures, there is a very limited benefit in terms of performance on the various types of posttests. This learning paradigm mimics the self-teaching situation, in which the silent reading of passages involves encountering new words that need to be phonically decoded. The storage in long-term memory appears to be phonological and orthographic, not visual. One way this has been determined has been through efforts to allow only visual exposure to these new words and suppress phonological recoding (e.g., by having students continuously repeat a nonsense word while reading); such efforts result in very limited accuracy in the posttests (Share, 1999). It therefore appears that processing the letter sequence at a phonological level is the key to establishing an orthographic sequence in long-term memory.

Despite the success of the self-teaching model in accounting for a great deal of empirical findings, it leaves open an important question: Precisely what is it about phonological processing during phonic decoding that allows for the establishment of a very secure orthographic sequence in long-term memory? Ehri's theory of orthographic learning directly addresses that question.

Orthographic Mapping

Ehri has been refining her theory of word learning, recently dubbed *orthographic mapping* (Ehri, 2014), for four decades (Ehri, 1978, 1992, 1998, 2005, 2014; Ehri & Wilce, 1985; Miles & Ehri, in press). Her theory provides an empirically supported explanation of how we remember the words we read. Efficient orthographic learning requires two skills: letter–sound knowledge and phoneme segmentation (Ehri, 1998, 2005). Spoken words are already stored in long-term phonological memory, and the object of orthographic learning is to have a sequence of letters attach to, or bond to, the pronunciation of that spoken word. This is not to be confused with a letter-by-letter phonic decoding of the word. Rather, once it is familiar, the particular sequence of letters becomes *unitized* (Treiman, Sotak, & Bowman, 2001); that is, the whole string of letters as a unit is familiar and instantly activates the word's pronunciation, with no need for letter-by-letter phonic decoding.

Conventional phonic decoding involves a flow of information from letters to sounds, and those sounds are blended together to arrive at a pronunciation. Orthographic mapping benefits from this flow of information, but also proposes an additional flow of information that goes in the other direction—from (1) the oral word's pronunciation, to (2) a segmented representation of the oral word, to (3) the alphabetic characters that align with that segmented pronunciation. This process of associating a known and well-established phonological representation (the word's pronunciation) with a newly encountered stimulus (a letter sequence/printed word) allows for that newly encountered stimulus (the letter sequence) to become bonded in memory with that known phonological representation (the oral pronunciation). In a sense, it represents a flow of information that goes in the opposite direction from phonic decoding. It could be said that phonic decoding goes "from text to brain," while orthographic mapping goes "from brain to text." This is an oversimplification, however, because orthographic mapping involves "reciprocal bidirectional connections" (McKague, Davis, Pratt, & Johnston, 2008, p. 69). Nonetheless, this flow of information from pronunciation to letter sequence—a flow in the opposite direction from that found in phonic decoding—does not appear to be commonly understood outside the niche area of reading research that directly studies orthographic learning. Yet this flow of information is central to Ehri's theory (Ehri, 2005; Kilpatrick, 2015; Miles & Ehri, in press).

The result of this mapping process is a sequence of letters that is instantly familiar, stable, and highly unlikely to be confused with other words that look similar (e.g., *black, block, blank, blink, blind*). The fully specified representation is like a precise URL or "web address" within the memory system that activates the word's pronunciation and meaning the instant it is perceived (Ehri, 2005, 2014). Familiar written words are fully specified letter sequences that gain their familiarity by being bonded to the word's pronunciation at the phoneme/letter level, or in some cases the level of a group of letters (e.g., *-ight*; see more below on irregular words).

Phoneme segmentation and letter–sound knowledge work together to produce this orthographic mapping effect. For example, consider a first-grade girl who encounters the word *red* for the first time. If she is capable of segmenting the spoken word into its individual phonemes, /r/ /e/ /d/ (the letters between the slash marks represent the *sounds* associated with those letters and not the letters themselves), she then has three anchoring points in her long-term memory with which to attach that written letter sequence. She is attaching the new information (the letters in that word) to existing, well-specified information in her phonological long-term memory—namely, the segmented pronunciation of the word *red*. Again, notice that this represents the opposite direction of information flow from that required for phonic decoding. The net effect is that this particular letter sequence quickly becomes familiar because of the student's ability to associate the segmented phonemes in the spoken word's pronunciation to the written sequence designed to represent that spoken pronunciation.

By contrast, consider a first-grade boy who lacks proficient phoneme segmentation skills. When he sees the word *red*, how is he to remember it? If that student cannot pull apart the spoken pronunciation, then he cannot attach the spoken word *red* to that particular letter sequence. Most dyslexic students are able to create a connection between the first sound in the pronunciation and the first letter of the word. But beyond that, there is little opportunity to create a familiar sequence out of the rest of those letters because there is nothing in the child's long-term memory to which that letter string can be reliably anchored. Thus the student must sound it out or guess over and over upon seeing the word. With time and many, many exposures (not the one to four exposures found in typical readers), struggling readers map high-frequency words and other words (Ehri & Saltmarsh, 1995; Share & Shalev, 2004). The net effect for these weak readers, however, is that this orthographic mapping process is so inefficient that their sight word vocabularies grow very slowly relative to those of their peers, and they almost never catch up.

The Problem of Irregular Words

A question that arises is how orthographic mapping works with irregular words. English is the most inconsistent of all the major alphabet-based written languages (Seymour, Aro, & Erskine, 2003). Interestingly, however, the inconsistencies of English spellings create much less of a problem for orthographic mapping than they do for phonic decoding.

Orthographic mapping requires creating connections between pronunciations and print. Students cannot map a word unless they know what the word is—either because they sounded it out, they guessed it correctly, or someone told them what the word is. Orthographic mapping thus works from a starting point in which something is already known and already stored in phonological long-term memory, which is the word's pronunciation. By contrast, phonic decoding presumes that the word is not known, and thus does not start with any known anchoring point in long-term memory. Phonic decoding requires sufficient accuracy with the letter–sound sequence and blending to identify the spoken word correctly. Orthographic mapping does not require the same level of consistency as phonic decoding. Consider the irregular word *put*. Once a student knows that the written word he or she is looking at is *put,* it is a simple matter of noticing the association between the sounds in the spoken word and the letters. Two of the sounds in the spoken word *put* attach to consistently regular letters (*p, t*), and only one has an irregular connecting point (*u*). It is as if the student were to say "Oh, *that's* how we spell *put*!"

This type of adjustment to the mapping process for an irregular word is equally true for words that are phonically regular. For example, the word *make* is phonically regular, but requires an adjustment when it is being mapped into orthographic memory because *make* has three sounds but four letters. Knowing the silent-*e* rule helps facilitate the adjusted mapping required for remembering such a word, but it requires an adjustment nonetheless. The same kind of adjustment needs to occur with phonically regular vowel and consonant digraphs (*ch, th, oa, ee*) because multiple letters represent a single sound. Also, such adjustments are routinely required in many multisyllabic words when an unstressed syllable has a vowel reduction, such as in *holiday* or *market.* The adjustments needed to map words to orthographic memory are routine for both regular and irregular words. These common adjustments are not problematic for students skilled in both letter–sound knowledge and phoneme segmentation. Yet they represent a major difficulty for those with the phonological-core deficit of dyslexia, due to their weaknesses in letter–sound skills and/or phonemic awareness.

Integrating Orthographic Mapping and the Self-Teaching Hypothesis

Elsewhere (Kilpatrick, 2015), I have made what may be the first formalized attempt to integrate the self-teaching and orthographic mapping models. On one level, this integration is straightforward. As proposed by the self-teaching model, students read and encounter new words. They perform phonological recoding, which activates the sounds of the letters in working memory. Ehri's theory then explains how the segmentation of that newly identified spoken word allows the reader to bond the segmented phonemes in the word's pronunciation to the printed letter sequence.

On another level, the integration of these two models requires a bit more thought. Throughout their elementary school years, readers add thousands of new words to their orthographic lexicons; however, this process appears to happen in the background, without conscious attention. It is doubtful that readers say with each new encounter of an unfamiliar word (let's say *clap*), "Hey, look how the /k/ sound maps onto the letter *c,* and how the /l/ sound I'm hearing next fits so well with that letter *l,*" and so forth. Neither Ehri's nor Share's theory tries to account for how orthographic memory occurs without conscious effort or awareness. The fact that this process occurs is well supported by numerous lines of research. But this research does not explain why we do not seem to remember mapping the thousands of words we know. The *phonemic proficiency hypothesis* (Kilpatrick, 2015; Kilpatrick & Song, 2018) appears to have resolved this question. The phonemic proficiency hypothesis allows for a virtually seamless integration of Ehri's orthographic mapping theory with Share's self-teaching hypothesis, while accounting for the fact that the mapping process is largely outside the conscious awareness of the reader.

The Phonemic Proficiency Hypothesis

A colleague and I have proposed (Kilpatrick, 2015; Kilpatrick & Song, 2018) that phonemic proficiency, which is related to but not identical with phonemic awareness, is a critical aspect of efficient orthographic learning when Ehri's (2004, 2014) orthographic mapping hypothesis is integrated with Share's (1995) self-teaching hypothesis. At the same time, the phonemic proficiency hypothesis incorporates the research on the phonological-core deficit of dyslexia (Fletcher et al., 2018; Hulme & Snowling, 2009; Vellutino et al., 2007) with the orthographic learning theories of Ehri and Share. As mentioned, Ehri (2005) proposes that a phoneme analysis mechanism (i.e., segmenting words into phonemes) is required for orthographic memory. However, for that to occur within the very time-limited context of Share's self-teaching opportunities (correctly sounding out a word takes very little time), phonemic segmentation/analysis must be highly proficient and largely unconscious. The phonemic proficiency hypothesis (Kilpatrick, 2015) suggests that proficient letter–sound skills and proficient phonemic skills both involve automatic processes that are precognitive and do not require conscious awareness.

Letter–Sound Proficiency

Studies have shown that by late first grade, typically developing readers can instantly respond to CVC nonsense words, such as *mot, tam,* or *gub* (e.g., Harn et al., 2008). Anyone who has administered the Phonological Decoding subtest from the Test of Word Reading Efficiency—Second Edition (TOWRE-2; Torgesen, Wagner, & Rashotte, 2012) to an average student at the end of first grade has directly experienced this. Consider what is involved for first graders to respond instantly to a CVC word, such as *mip.* In less than a second, they retrieve the sounds for the letters *m, i,* and *p,* and then blend those three sounds together. It is argued that those children do not use a conscious search process to retrieve those letter sounds, but that they are automatically available. This instant responding illustrates letter–sound proficiency: It involves automatic, unconscious access to the most common sounds of the letters, plus proficient phonological blending that allows those letter sounds to be accurately pronounced as a single, spoken unit (Harn et al., 2008). Due to its greater complexity, those first graders may not be able to respond instantly to the nonsense word *splenk.* But by the end of second grade, average students can do so, given their additional year of development of their letter–sound skills. Those second graders have instant access to letter sounds even when they encounter a complex string of letters. No conscious effort is involved in retrieving those letter sounds.

Phonemic Proficiency

Phonemic proficiency can be viewed as an advanced form of phonemic awareness. *Phonemic awareness* has been generally conceptualized as the ability to be aware of and/or manipulate phonemes within words. It is a latent construct that has been assessed in many ways with a variety of tasks, including segmentation, isolation, categorization, deletion, and substitution (Kilpatrick, 2012a, 2012b). Only recently has any effort been made to examine whether some phonemic awareness tasks are better suited than others for assessing the phonemic substrates of reading (Kilpatrick, 2012a, 2015). It turns out that phoneme manipulation tasks, the most common being phoneme deletion and substitution, correlate more strongly with reading than phoneme segmentation and blending tasks do (Catts, Fey, Zhang, & Tomblin, 2001; Kilpatrick 2012a, 2012b, 2015; Swank & Catts, 1994; Wagner, Torgesen, & Rashotte, 1999). Phoneme manipulation "ranks highly among phonological awareness tasks in predicting reading achievement" (Catts et al., 2001, p. 40).

Interestingly, very little attention has been paid to the speed of phonemic awareness task responses. We (Kilpatrick & Song, 2018) reviewed the very limited pool of studies on this. The findings from these studies indicate that using timed manipulation tasks, researchers discovered that phonemic awareness continues to develop well into third and fourth grade and appears to display continued influence on reading development well beyond first grade (e.g., Vaessen & Blomert, 2010). This contrasts with the common assumption that phonemic awareness plays no substantive role in reading development after early first grade (e.g., O'Connor, 2011). Evidence for a causal role in reading development for these more "advanced" phonemic skills comes from a recent review of the word reading intervention literature (Kilpatrick, 2015; Kilpatrick & Van den Broeck, 2016). Studies that rigorously trained students by using manipulation tasks (phoneme deletion and substitution) produced gains in real-word reading that ranged from 12 to 25 standard score points. By contrast, studies that trained phonemic awareness skills by using the more "basic" phonological awareness skills of phoneme segmentation and/or blending yielded increases in standard scores ranging from 6 to 9 points. Studies that incorporated no phoneme awareness training yielded increases of 0–6 standard score points in word-level reading (Kilpatrick, 2015; Kilpatrick & Van den Broeck, 2016). Noteworthy is the fact that socioeconomic status, age of the students, group size, severity of the problem, and total length of the intervention were evenly distributed across these three groups of studies with varying results. This indicates that these factors cannot explain the disparity in outcomes (cf. Flynn, Zheng, & Swanson, 2012; Torgesen, 2004b; Torgesen et al., 2003).

Phonemic proficiency goes beyond the conventional conceptualization of phonemic awareness and can account for the findings from the intervention research just mentioned. Phonemic proficiency, parallel to letter–sound proficiency, is conceptualized as the automatic, unconscious access to the phonemes in spoken words. This is more appropriately assessed via a manipulation task than a segmentation task. For example, in a segmentation subtest, all of a student's focus is on that task, so it is difficult to determine how automatic are the cognitive processes behind the task responses. However, manipulation tasks are more complex. A second grader with phoneme proficiency can respond in 1 second or less to a request to delete the /l/ from the spoken word *clap.* To do this, the student has to perform four classic phonemic awareness tasks in less than 1 second. First, he or she has to *segment* the word *clap.* Then the student has to perform *phoneme isolation,* which involves locating where the target sound appears on the word ("Is the /l/ in the beginning, middle, end . . ."). Next, he or she has to delete (*manipulate*) the sound. Finally, the student has to *blend* the remaining sounds to produce the correct response. Thus four traditional phonemic tasks—segmentation, isolation, manipulation, and blending—all occur in 1 second or less. I have contended (Kilpatrick, 2015) that for the student to perform those four operations that quickly, it is likely that access to the phonemes via segmentation does not require conscious effort, but is automatic. This is the essence of phonemic proficiency.

We (Kilpatrick & Song, 2018) have provided some evidence for phonemic proficiency and its role in word learning. In one study, 136 first graders were administered a phoneme manipulation task (a mix of deleting and substituting sounds). Correct responses were coded differently, depending on whether those responses occurred in less than or more than 2 seconds. These students were also administered the *Sight Word Efficiency* subtest from the TOWRE-2 (Torgesen et al., 2012). This subtest consists of a graded word list, and students have 45 seconds to read as many words as possible. The inference is that students with larger sight vocabularies will get higher scores than those with smaller sight vocabularies because it takes longer to sound out a word than to recognize a known word. We found that the correlation between this reading task and phonemic awareness items responded to instantly (i.e., in 2 seconds or less) was $r = +.58$. Yet the correlation between the reading task and the non-instant phonemic awareness responses was $r = +.004$. This suggests that instant access to the sounds in words tells us something about word-reading development that is not captured by correctly responding to a phoneme task without evidence of phonemic proficiency.

We (Kilpatrick & Song, 2018) also examined this phenomenon with 58 typical fifth-grade readers. To evaluate the impact of phonemic awareness on sight vocabulary, we used a reading test that only contained irregular words (from Adams & Huggins, 1985), like *iron, tongue, suede,* and *yacht.* The assumption is that sounding out these words is likely to yield an incorrect response, so the test assesses prior familiarity with those words. The inference is that those with higher scores are likely to know more words in general (i.e., to have a larger sight word vocabulary). The same phonemic task was used as with the first graders. Coincidentally, the correlation between the instant responding on the phonemic awareness task and the reading measure was, again, $r = +.58$. But the correlation with the non-instant responding was $r = -.25$, suggesting that even among a population of typical fifth-grade readers, those with presumably larger sight vocabularies had greater phonemic proficiency than those with presumably smaller (though average) sight vocabularies. Thus, even in a population of typical fifth-grade readers, the degree of phoneme proficiency correlated with the likelihood of identifying phonically irregular words, which is a fairly direct assessment of the orthographic lexicon.

Phonemic Proficiency and Orthographic Learning

Students routinely encounter new and unfamiliar words while reading silently. They use their letter–sound skills and phonological blending to determine the word. This is Share's self-teaching scenario. Once the word is correctly determined, the pronunciation of the word is activated. Students with automatic, unconscious access to the sounds within that word's pronunciation can implicitly map those sounds within the pronunciation to the letter sequence representing that pronunciation, as orthographic mapping theory suggests. Phonemic proficiency allows the mapping process to be unconscious, given that the two subprocesses involved in mapping are unconscious and automatic (i.e., letter–sound proficiency and phonemic proficiency). This explains why most of us would have no recall of consciously making connections between pronunciations and letter patterns while we were learning the tens of thousands of words we know.

The Development of Word-Learning Skills

I have proposed a description of the interaction between the developmental of reading-related phonological skills and word-level reading (Kilpatrick, 2015). This developmental paradigm is presented in Table 35.2. The left side of the table portrays three levels of phonological development, while the right side depicts three levels of word-reading development. It is proposed that the phonological skills directly to the left of the given reading skills represent causal factors for that level of reading. Additionally, each level of reading development has a causal relationship with the next level of phonological development. This reciprocal, causal relationship was first established empirically by Perfetti, Beck, Bell, and Hughes (1987).

Early phonological skill development appears to have a causal relationship with the speed and efficiency with which children develop knowledge of letter names and sounds. The "softer" evidence for a causal relationship is found in studies that examined phonological skills before children learned letter names and sounds. Those with stronger early phonological skills learned letter names and sounds more quickly than those with weaker phonological skills (Cardoso-Martins, Mesquita, & Ehri, 2011; Share, 2004a). Harder causal evidence comes from experimental studies in which children provided with early phonological awareness training outperformed untrained children in the acquisition of letter names and letter sounds (Cardoso-Martins et al., 2011; Williams, 1980).

TABLE 35.2. Developmental Levels of Phonological Awareness and Word Reading

Level of phonological awareness	Level of word-reading skill
1. *Early phonological awareness* Rhyming, alliteration, first sounds, and syllable segmentation	1. *Letters and sounds* Requires simple phonology to learn letter names and letter sounds
2. *Basic phonemic awareness* Blending and segmentation	2. *Phonic decoding* Requires letter sounds and blending
3. *Advanced phonemic awareness* Phonemic proficiency	3. *Orthographic mapping* Requires letter–sound skills and advanced phonological awareness/proficiency

Learning letter sounds is causally related to the development of basic phoneme-level awareness. We know this from studies of adults who, due to lack of opportunity, never learned to read. These individuals do not naturally develop phoneme-level awareness (Morais, 1991). There then appears to be a causal relationship between the development of phoneme-level awareness and blending, and that of phonic decoding and basic spelling. These basic phoneme-level skills are typically developed by the end of first grade. It is often at that point that phonemic awareness assessments (e.g., Dynamic Indicators of Basic Early Literacy Skills, Aimsweb, easyCBM) and training programs (e.g., Blachman, Ball, Black, & Tangel, 2000) discontinue phonological/phonemic awareness training. This appears to assume that any further phonemic awareness development that occurs after first grade is of no consequence for reading. Yet this is not the case (Ashby, Dix, Bontrager, Dey, & Archer, 2013; Kilpatrick, 2015; Torgesen et al., 2001; Truch, 1994; Vaessen & Blomert, 2010). Indeed, practicing phonic decoding/letter–sound skills and spelling throughout first and second grades appears to make these segmenting and blending skills more automatic and efficient. This appears to represents a causal factor in the development of more "advanced" phonemic awareness skills. It is these advanced skills, as demonstrated by instant responses to phoneme manipulation tasks, that provide the phonemic proficiency to drive orthographic mapping skills and thus rapidly expand the sight word vocabulary.

Impaired Development in Dyslexia

Students with the phonological-core deficit, which is the basis of dyslexia (Ahmed, Wagner, & Kantor, 2012; Vellutino et al., 2004), do not move smoothly through the levels of phonological development or reading development depicted in Table 35.2. They typically have poor early phonological skills, which is why they lag behind their peers in developing letter–name and letter–sound knowledge. When their letter–sound skills do develop, their phonological systems are not efficient enough for the learning of those letter sounds to prompt the next level of phonological skills, that is, phoneme segmentation and blending. However, even many children with dyslexia will develop these "basic" phonological skills by late second or third grade (recall that typically developing readers have these skills in place by late first grade). With proper instruction, children with dyslexia who have basic segmentation and blending skills can benefit from phonics instruction. However, when these children learn phonics and spelling skills, these skills do not naturally prompt the more "advanced" phonemic skills needed for orthographic mapping. Thus children with the phonological-core deficit only develop the phonological skills to the level they are directly taught. They do not develop those skills via reading instruction, like their typically developing peers.

IS THERE A NEED TO DIAGNOSE SUBTYPES OF DYSLEXIA?

There are three very well-established subtypes of reading disabilities (Fletcher et al., 2007; Gough & Tunmer, 1986; Hulme & Snowling, 2009)—namely, *dyslexia, hyperlexia,* and a combined type (traditionally called *garden-variety poor readers*; Gough & Tunmer, 1986). Dyslexia refers to poor word reading despite adequate language skills. Hyperlexia refers to skilled word reading but weak reading comprehension, typically due to oral language comprehension difficulties. The combined type refers to problems in word reading and oral language comprehension. Distinguishing among these three types of reading problems is essential for designing a given student's remedial instruction. Students with dyslexia and hyperlexia do not make good small-group partners. Their strengths and weaknesses in reading have no functional overlap.

Subtypes Based on Rapid Automatized Naming

Although there are three empirically derived subtypes of reading disabilities, with dyslexia being one of them, efforts to subdivide dyslexia into valid subtypes have been problematic on many levels. The most popular subtyping approach in the empirical reading research distinguishes among dyslexic students based on the presence or absence of poor phonemic awareness and poor rapid automatized naming, or RAN (Wolf et al., 2002). The subtypes involve the presence of one or the other or both, the latter being referred to as the *double deficit*. The presumption has been that students with problems in both have more severe word-reading difficulties. However, that may not be the case, as students with a severe single deficit in phonemic awareness can have greater difficulties than students with more moderate problems in both phonemic awareness and RAN (Vukovic & Siegel, 2006). The status of subtypes based on these characteristics is still under investigation. Moreover, there is no clear, empirically based protocol for distinguishing among these subtypes when it comes to planning instruction.

Despite these uncertainties, it is still recommended that practitioners invest the 2–4 minutes of total administration time involved in tests of RAN when evaluating struggling readers. Table 35.3 lists six reasons for including assessments of RAN and working memory (WM) in any evaluation of struggling readers. One of these relates to the fact that the double deficit tends to suggest poorer outcomes from milder interventions (i.e., Tier 2). Research has shown that for some students, skipping Tier 2 of RTI and going directly to Tier 3 provides better outcomes for such students than requiring students to demonstrate poor progress at Tier 2 before trying a more intensive Tier 3 remediation (Al Otaiba et al., 2014).

TABLE 35.3. Rationale for Including Rapid Automatized Naming (RAN) and Working Memory (WM) in Reading Evaluations or Universal Screenings

1. They are good predictors of later reading skills.
2. They are good predictors of how well students will respond to reading interventions.
3. They help evaluators and teachers understand *why* students struggle in reading. This is particularly true when students appear to have adequate phonemic awareness and phonic decoding skills, but still struggle with word identification and fluency.
4. They affect how one interprets a student's larger profile; if either RAN or WM is weak, one can anticipate the need to build stronger phonemic awareness skills in struggling readers. For example, a phonemic awareness scaled score of 9 (37th percentile) on the Elision subtest from the CTOPP-2 may be adequate for students with RAN and WM scores of 10 or higher, but inadequate for students with either a RAN or WM score of 7 or lower. The latter students should receive phonemic awareness instruction to compensate for the negative impact that weak RAN or WM is likely having on reading. Several studies that showed large improvements in phonemic awareness and word reading also showed substantial improvements in RAN and WM performance (Kilpatrick, 2015). This was the case even though RAN and WM were not directly addressed in the intervention.
5. Knowing that a student has a WM weakness in particular can affect the choice of remedial strategies. The classic special educational strategies of multiple repetitions and multisensory tasks are based upon decades of clinical experience with struggling students, a large proportion of whom have WM difficulties. Such strategies are not quite so necessary for students who struggle academically but have average or better WM. Knowing a student's WM skill level can thus influence the selection of intervention techniques.
6. The presence of poor RAN and WM increases the validity of an SLD diagnosis in students with reading problems, given the capacity of weaknesses in these skills to predict future struggles in reading and weaker RTI response.

These six possible advantages can justify the brief assessment time involved in administering RAN and WM subtests in reading evaluations and including them in universal screenings.

Subtypes Based on the Dual-Route Model of Reading

In recent years there has been increased discussion of subtypes of dyslexia based on the dual-route model of reading (Feifer, 2011, 2014; Mather & Wendling, 2012), and even a new reading test battery that, in fair measure, is designed to distinguish among these subtypes (Feifer & Nader, 2015). Before the validity of this popular subtyping model is considered, two broader categories of dyslexia must be distinguished: *acquired dyslexia* and *developmental dyslexia*.

Acquired Dyslexia

Acquired dyslexia refers to a situation in which a skilled reader (typically an adult) loses all or some of his or her reading ability as a result of a stroke, head injury, or other neurological condition. Acquired dyslexia was first described in clinical cases in the early 1970s (Marshall & Newcombe, 1973). Although persons with acquired dyslexia showed a variety of reading related difficulties, some displayed one of three subtypes: *surface dyslexia* (Patterson, Marshall, & Coltheart, 1985), *phonological dyslexia* (Coltheart, 1996), or *deep dyslexia* (Coltheart, Patterson, & Marshall, 1980).

Individuals with surface dyslexia struggle to instantly recognize words that were previously familiar to them, but they can sound out phonically regular words and nonsense words. By contrast, those with phonological dyslexia remember the words they previously learned before the neurological incident, but can no longer read nonsense words or sound out new words. Individuals with deep dyslexia are similar in some respects to those with phonological dyslexia but have more varied symptomatology, including a tendency to make semantic errors, such as reading "truck" for *bus*. These acquired dyslexia subtypes are well-established clinical syndromes, even though most individuals with acquired dyslexia do not fall into these distinct subtypes.

This distinction among these types of dyslexia was instrumental in developing the *dual-route model of reading*. The dual-route model acknowledges that some words are not familiar to the reader and must be read by phonological recoding. This is called reading by the *phonological route*. Other words are familiar to the reader, and these words are read instantly, without conscious effort. This is called reading by the *direct route*. These two routes parallel the deficits found among some of those with acquired dyslexia. Individuals with phonological dyslexia still have access to the direct route but struggle immensely with the phonological route, while those with surface dyslexia display the opposite pattern.

It must be pointed out that the dual-route model describes two different ways of *reading* words, not two different ways of *learning* words. These two routes do not translate into two reading strategies. Familiar words are instantly and effortlessly recognized, so no strategy is involved. By contrast, the phonological route uses the strategy of phonic decoding. But the result is that the word is read/identified, but not necessarily learned. The dual-route model makes no presumptions about how unfamiliar words become familiar. Nor does this model tell us how one becomes skilled with the phonological route. It must be emphasized that the dual-route model long predates the more recent advances in our understanding of orthographic learning, described earlier in this chapter.

The dual-route model is not a useful instructional framework. To be useful instructionally, we need a framework that allows us to understand the development of the skills needed for children to become good orthographic mappers. These skills will allow students to efficiently remember more and more words, and thus read more words via the direct route. We also need to know the best way for struggling readers to develop the skill of accurately sounding out unfamiliar words and thus read via the phonological route when encountering new words. The dual route model provides no answers here. As a result, a healthy skepticism must be applied when one seeks to superimpose the subtypes of acquired dyslexia onto developmental dyslexia.

Developmental Dyslexia

Developmental dyslexia, by contrast, refers to a situation in which an individual has never developed typical reading skills, despite adequate opportunity and effort. Unlike those with acquired dyslexia, individuals with developmental dyslexia have not mastered phonological recoding or orthographic mapping. Is there evidence to suggest that some children can develop orthographic mapping without developing phonological recoding (phonological dyslexia) while other children develop the opposite pattern (surface dyslexia)? Can the subtype distinction found in clinical populations of adults with acquired dyslexia be validly superimposed onto cases of developmental dyslexia in children?

This question has been investigated in the research literature for decades. The consensus among reading researchers is that distinguishing between phonological and surface dyslexia as subtypes of developmental dyslexia is not well supported empirically. Multiple teams of reading researchers have reviewed the studies that attempt to make such a distinction and do not find convincing evidence that such a distinction can or should be made (Ahmed et al., 2012; Fletcher et al., 2018; Hulme & Snowling, 2009; Van den Broeck & Guedens, 2012; Vellutino et al., 2004).

There is no attempt here to provide a review of the vast subtyping literature. However, listed below are some of the major problems with the understanding that the surface and phonological patterns represent valid subtypes of developmental dyslexia.

First, as mentioned, this subtyping scenario superimposes an adult, neuropathology-based model onto children who do not display similar neurological conditions. The dual-route model describes the two "routes" of word identification among *skilled* readers. It does not inform us about how those routes develop, which is precisely what needs to be addressed if we are to properly understand developmental dyslexia. The phonological versus surface subtyping model treats the dual-route theory as a word-learning theory when it is actually a "finished-product" theory; that is, it describes the finished product of skilled reading. As a result, using the dual-route model for understanding developmental dyslexia appears to be inherently problematic.

Second, the evidence in favor of the phonological versus surface dyslexia subtypes has been mixed at best, and those results have often depended on the specific type of research methodology used (for more detail, see below). At worst, after adjustments for the methodology, the distinction between those subtypes virtually disappears (Van den Broeck & Guedens, 2012; Van den Broeck et al., 2010). However, despite the fact that the empirical research field remains rather skeptical of a distinction between phonological and surface subtypes of dyslexia, some authors in the areas of school psychology and neuropsychology seem to present this subtyping scenario as if it were a well-established phenomenon, and little or no mention is made of the controversy surrounding its existence (e.g., Feifer, 2011, 2014; Mather & Wendling, 2012).

Third, initial and subsequent attempts to find developmental surface and phonological dyslexia have used chronological-age (CA) controls (Castles & Coltheart, 1993; Heim et al., 2008). Such research designs yield results suggesting that a portion of students fit the phonological and surface subtypes, while most exhibit the mixed type. But critics have pointed out major confounds in using CA control groups (e.g., Stanovich, Siegel, Gottardo, Chiappe, & Sidhu, 1997; Van den Broeck & Guedens, 2012). As a result, there has been a shift to including reading-age (RA) controls—for example, matching fifth graders who are reading at a second-grade level with average second grade readers. For two decades, the reading research field considered this a more valid comparison because it removed some of the confounds associated with the CA matched design. When RA controls are used, fewer students fit the phonological dyslexia subtype, more fit the mixed profile, and the surface dyslexia subtype virtually disappears (Stanovich et al., 1997; Van den Broeck & Guedens, 2012).

More recently, Van den Broeck and colleagues (Van den Broeck & Guedens, 2012; Van den Broeck et al., 2010) have demonstrated that, like the CA control design, the RA control design has significant confounds, and the design itself may *produce* the phonological dyslexia subtype rather than *reflect* an actual subtype. They have pointed out that in subtyping studies, it is most common for dyslexic children in fourth through sixth grades to be compared with RA control second graders on word identification tests. In such matches, it is common to find a substantial portion of dyslexic children to have lower rates of nonsense-word reading than the second-grade typical readers used in the comparison. This is taken as evidence for the phonological dyslexia subtype.

The problem with this design is that it fails to account for the fact that the older dyslexic children have had 2–4 more years of instructional experience and exposure to reading. Such experience allows them to eventually learn many common second-grade-level words and thus receive a score comparable to typical second graders on a word identification test. But their actual phonological skills that underlie reading remain weak, as reflected in their poor nonsense-word reading. In addition, based on the fact that these older students have a larger vocabulary than their younger controls, they have better use of set for variability, discussed above, to respond correctly to words on word identification subtests. As a result, matching a fifth-grade dyslexic reader and a second-grade typical reader with the same word identification raw score confounds age, experience, and set for variability. Such confounds create the pattern of phonological dyslexia because the older children sound out words more poorly than their normative word-reading scores would suggest. The apparent cases of phonological dyslexia in these studies thus seem to be an artifact of the confounded research design.

To address the issue of the CA control and RA control designs, Van den Broeck and colleagues have developed two ingenious and sophisticated designs that avoid these confounds without creating new confounds. With these non confounded designs, the phenomena of phonological dyslexia and surface dyslexia virtually disappear. Rather, these authors argue for a developmental explanation in which different continuous skill levels in phonemic awareness, reading experience, and compensating factors all interact differently at different ages to produce the variability we see among children with dyslexia. It is this variability that has been traditionally interpreted as phonological versus surface subtypes of dyslexia (Van den Broeck & Guedens, 2012; Van den Broeck et al., 2010). It is worth pointing out that the findings of Van den Broeck and colleagues are consistent with the orthographic learning theories of Ehri and Share, described above (Van den Broeck & Guedens, 2012; Van den Broeck et al., 2010). By contrast, the conventional phonological versus surface dyslexia subtyping is not consistent with the orthographic learning literature.

A fourth problem is related to the previous point. The variations in nonsense-word and irregular-word reading performance found among individuals with dyslexia that have formed the basis of the proposed dyslexia subtypes can be better explained via an updated model of word-reading development, such as the one described earlier in this chapter. Students who might be considered to have phonological dyslexia are typically older students who can instantly identify an array of common words that have been mapped via orthographic mapping, albeit after many, many more exposures than would be needed by typically developing readers (Ehri & Saltmarsh, 1995; Share & Shalev, 2004). In studies of dyslexia, these students' pools of mapped words are not at grade level. Yet these students struggle with nonsense-word reading because they have not adequately developed the phonological skills listed on the left side of Table 35.2. Students who are considered to have surface dyslexia can be better understood by recognizing that they have typically received phonic-based instruction and they have only developed to the second level of phonemic awareness development and reading development in Table 35.2. Such students can sound out words, but are not efficient at orthographic mapping, since they have not developed the more advanced phonemic awareness skills needed for efficient orthographic mapping. Consistent with this interpretation is the finding that subtyping studies have found that children with both phonological and surface dyslexia display below-average phonemic awareness skills, indicating that poor phonemic awareness skills are found in those alleged to have surface dyslexia as well as those alleged to have the phonological subtype, but typically to a milder degree (Hulme & Snowling, 2009). This is consistent with Table 35.2 and with the developmental explanation provided by Van den Broeck and colleagues.

Fifth, the dual-route subtyping issue does not seem to reflect more recent work on the nature of the orthographic tasks that gave rise to the notion that orthographic skills should be considered separate reading-related subskills. As described above, more recent research has suggested that orthographic task performance is a by-product of phonological skills, letter–sound skills, and reading experience. It does not appear to be an independent reading-related subskill or to have a causal relationship with early reading development. Yet presentations regarding the phonological and surface dyslexia subtypes appear to assume this older understanding of the nature of orthographic skills.

Sixth, related to the previous point, is that the distinction of dyslexia into phonological and surface subtypes appears to assume that some form of visual memory plays a significant role in word-level reading. For example, one author describes a child with surface dyslexia as a student who has "an under-reliance upon the orthographical or spatial properties of the visual word form" (Feifer, 2014, p. 157). It is unclear precisely how the term "orthographical" is being used in this statement, but we have no evidence that any spatial or visual word "form" properties are involved in the way skilled readers learn words as unitized wholes. This issue has been addressed extensively above.

More problematic in this regard is the instructional advice that would result from such a notion. After making a major contribution to our knowledge of the neuropsychological substrates of learning new words, Glezer and colleagues (2015) lapse into speculation when they say, "These findings have interesting implications for reading remediation in individuals with phonologic processing impairments because they suggest the possibility that these individuals might benefit from visual word learning strategies to circumvent the phonologic difficulties and directly train holistic visual word representations in the VWFA [visual word form area]" (p. 4971).[3] It is no coincidence that they did not cite a study to support this instructional suggestion because it appears likely that no such study exists. Their suggestion is entirely intuitive and without an empirical basis. By contrast, Truch (1994) reports that out of 281 individuals with phonological-core dyslexia ages 5–55, only one did not make progress in phonological awareness training, and 70% reached an average or above-average level of phonological awareness skills. Truch noted that for those students whose phonics skills were not moving forward, training in advanced phonemic awareness resulted in dramatic gains in both phonic decoding and sight word learning. So Truch provides rather extensive and direct evidence (as do others—e.g., Torgesen et al, 2001; Vellutino et al., 1996) that "phonologic processing impairments," as Glezer and colleagues call them, can be successfully overcome in more than 99.5% of those with such "impairments" (i.e., 1 out of Truch's 281 equals less than an 0.5% failure rate among those with phonological-core dyslexia). Thus there is no need to suggest speculative ideas about "visual word learning strategies" that have no demonstrated efficacy and run counter to our current empirical understanding of both normal word-learning skills and effective word-reading intervention.

Conclusions Regarding Dyslexia Subtypes

From the previous considerations, it would seem that the proposed phonological and surface subtypes of dyslexia do not have a well-established empirical foundation. This conventional subtyping model does not reflect research advances in the last 20 years regarding word-reading development, orthographic skills, and the role (or lack thereof) of visual skills in reading; nor does it take account of the research literature on word-reading intervention effectiveness. Despite its recent popularity in the field of school psychology, practitioners should not feel the need to attempt to establish dyslexia subtypes when evaluating students who struggle in word-level reading.

IMPLICATIONS OF RECENT ADVANCES FOR DIAGNOSING READING DISABILITIES

This chapter has presented numerous concepts and research related to understanding the nature of word-level reading difficulties. Several implications that can be drawn from these concepts and research may inform decisions about the presence or absence of a reading difficulty, and whether such a difficulty (if present) rises to the level of being considered an SLD.

One of the key themes of the chapter is that we must not just look at isolated word reading and phonic decoding, but must work from a broader understanding of word-reading development—from letter–sound knowledge, to phonic decoding and spelling, to the size of a student's orthographic lexicon. A student can arrive at a given profile of test scores via multiple routes, and the hope is that the material in this chapter will allow practitioners (1) to examine multiple possibilities to determine the nature of a student's reading struggles and (2) to take a proper perspective on interpreting a profile of test scores.

It will be important to consider the relationship between a student's language skills and his or her word identification subtest performance. It is important to acknowledge that students with stronger vocabulary skills can create the impression that their word reading is stronger than it really is, due to their ability to use set for variability in responding to conventional word-reading subtests. It will be important to put more weight on a nonsense-word reading subtest for such students.

Timed tests of real words and nonsense words arguably provide a better indication of a student's sight vocabulary and his or her letter–sound proficiency, two hallmarks of skilled reading. It is much harder to compensate under timed conditions than on untimed reading subtests. Tests like the TOWRE-2, the Test of Silent Word Reading Efficiency—Second Edition, or the timed real- and nonsense-word subtests from the Kaufman Test of Educational Achievement—Third Edition (KTEA-3) can be very valuable in this regard. Personal experience with these tests suggests that the real-word versions of these tests are very useful at the elementary level, but less so at the secondary level. This is because the word difficulty is not challenging enough on the TOWRE-2 Sight Word Efficiency subtest, and the timing is not long enough to get to the more difficult words on the KTEA-3 timed word-reading subtest. At the elementary level, however, this type of subtest may provide the most valid assessment of the size of a student's sight vocabulary (i.e., below-average performance means a limited orthographic lexicon whereas an average or better score suggests an average or larger orthographic lexicon).

The 3-second timing on the word identification subtest from the Wechsler Individual Achievement Test—Third Edition is too long to assess automaticity. Also, the timed sentence-reading tasks found in the Woodcock–Johnson IV Tests of Achievement, the Woodcock Reading Mastery Test—Third Edition, and the KTEA-3 use common words that older students eventually map to memory, so it does not adequately address their fluency or automatic word recognition with grade-level reading material. *Such subtests should not be used to "rule out" a reading difficulty with students beyond about third grade.* However, if an older student has a low score on such a subtest, that indicates a very limited sight vocabulary.

RAN and WM should also be considered as part of any evaluation of students who struggle with word-level reading. As described in Table 35.3, such tests are quickly administered and have multiple advantages in understanding a student's reading profile.

Two skills needed for orthographic mapping are letter–sound proficiency and phonemic proficiency. The former can be assessed with the TOWRE-2 Phonetic Decoding subtest (valuable at all age levels) and the timed nonsense-word subtest from the KTEA-3. However, at this writing, there are no commercially available tests for phonemic proficiency. The CTOPP-2 is highly recommended for assessing phonological awareness, RAN, and phonological WM. It is highly recommended and should be a central component in any assessment of a student with word-level reading difficulties. However, the phonological awareness subtest (Elision) is untimed. Universal screeners have timed phonological awareness tasks, but they do not go beyond the first-grade level of skill and thus do not address phonemic proficiency. The Phonological Awareness Screening Test (PAST)[4] is free and is designed to assess phonemic proficiency. It is available from *www.thepasttest.com* or from *kilpatrickd@cortland.edu*.

The practitioner's greatest assessment tool is a strong knowledge base regarding the nature of typical word-reading development and the sources of reading difficulties. With such a knowledge base, evaluators can more appropriately select and interpret tests of word-level reading and related skills (i.e., phonemic awareness, RAN, WM, spelling, and vocabulary). Such evaluations should yield more accurate representations of a student's skills, which should lead to better decisions regarding the next step in addressing the student's reading difficulties. The next step may involve general educational intervention within an RTI/multi-tiered system of support framework, or it may involve a designation of SLD. Regardless of which route is taken, it will be important to incorporate the highly effective reading intervention approaches that prompted the development of RTI in the first place (Kilpatrick, 2015). These approaches allowed a large portion of struggling readers to "catch up" with their typically developing peers. And for most of those who did not catch up, they developed better reading skills than they would have if traditional remedial approaches had been used.

NOTES

1. This must not be misinterpreted to mean that general visual sequencing skills underlie our memory for written words. Only letter sequences based on phonology appear to be involved. Skill at recalling sequences of shapes or even nonpronounceable letter sequences (e.g., *ZNWRT*) do not appear to relate to reading like phonologically based, pronounceable letter sequences.

2. Actually, these examples do not truly represent visual memory failures, which is why the term *visual memory failure* is given in quotation marks. Rather, they represent failures in phonological retrieval. A true visual memory failure would involve failure to recognize something as visually familiar. In other words, rather than just failing to come up with the name of an acquaintance, it would involve not even recognizing the person visually as someone we had ever seen before.

3. It is an unfortunate quirk of reading research history that with the discovery that the left fusiform gyrus area is activated when familiar words are seen, this area was improperly named the *visual word form area.* We have no evidence to suggest that the visual form of the word plays any role in the initial storage or subsequent activation of known words. There is ample evidence to show it is *the precise letter order* that is instantly recognized in known words, as a holistic letter sequence. Thus *bear, BEAR, bear, BEAR, bear, BEAR,* and even *bEaR* all provide the same activation—as a holistic, familiar letter sequence—because they all represent the same letter order, despite their dramatically different visual word forms. Interestingly, Glezer and colleagues (2015) showed in their study that the now familiar sequences were all processed first phonologically before they became unitized, orthographically familiar wholes. There was nothing in their study to suggest that phonology can be bypassed in this learning process, nor is there anything in the broader reading research literature to suggest this.

4. This is not to be confused with another phonological awareness test using the same acronym, PAST, that turns up on Internet searches. This other test, called the Phonological Awareness Skills Test. It takes a different approach to phonological awareness assessment and does not assess phonemic proficiency.

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