An Introduction to the Science of Reading

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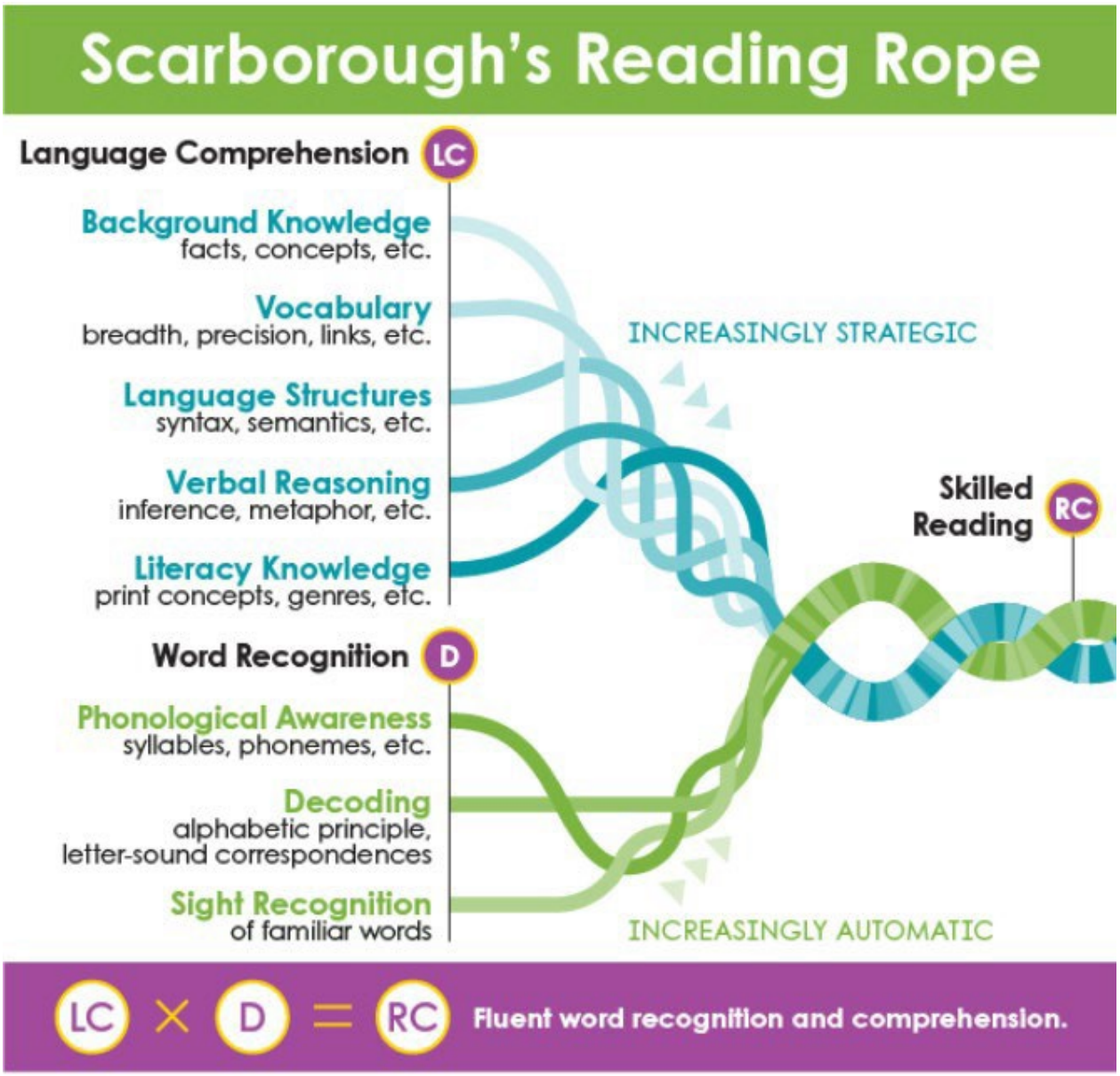
Video Reflection: How can understanding the Simple View of Reading impact instructional practice?
What is Scarborough's Reading Rope Reflection: How can the Reading Rope be used to identify and target instruction and intervention to meet student needs?



This interpretation of the Reading Rope incorporates Gough & Tunmer's (1986) Simple View of Reading.

What is Scarborough's Reading Rope?

In 2001, Dr. Hollis Scarborough created the Reading Rope using pipe cleaners to convey how the different "strands" of reading are all interconnected yet independent of one another. For many students, learning to read is a challenge. Scarborough's Rope captures the complexity of learning to read.

Scarborough's Reading Rope is made up of lower and upper strands. When all these component parts intertwine it results in skilled and accurate, fluent reading with strong comprehension.

The lower strands include:

- Phonological awareness
- Decoding
    - Alphabetic principle
    - Letter-sound correspondences
- Sight recognition

The upper strands include:

- Background knowledge
- Vocabulary
- Language structures
- Verbal reasoning
- Literacy knowledge

The Lower Strands

Phonological Awareness

It's a skill set that includes identifying and manipulating units of oral language – parts such as words, syllables, onsets, and rimes. Did you know that you can improve your students' ability to read unfamiliar words without showing them a single printed letter?

Decoding

Decoding is the ability to apply knowledge of sound-letter relationships (phonics) to correctly pronounce written words. Did you know that in 2019, only 35% of 4th graders were at or above (NAEP) proficient level on the reading assessment?

Sight Recognition

Our sight word memory is also referred to as our orthographic lexicon, which includes all the words we can read accurately and effortlessly. Literate adults have a sight word memory of 30,000 to 70,000 words. Starting in 3rd grade, it is estimated that "skilled orthographic mappers" anchor 10-15 new words a day into their sight word memories. Sight word recognition is foundational to fluent reading.

The Upper Strands

Background Knowledge

Background knowledge is an essential component in learning because it helps us make sense of new ideas and experiences. Readers rely on background knowledge to attend to and make sense of what they are reading. This is especially important for readers who are still relying heavily on word decoding rather than rapid word recognition. Having knowledge about a variety of subjects, topics, and ideas makes it more likely that they will be able to make sense of what they are reading and more likely that they will add to their body of knowledge.

Vocabulary

An extensive and rich vocabulary enables readers to make sense of what they are reading. A reader with rich auditory and oral vocabulary will find it easier to read through texts that contain words they have not seen in print before. If the student can use their growing decoding skills and match their result with a word they already know the meaning of, they will be more confident in their abilities and will spend less overall effort on reading a text.

Language Structures

Syntax - The arrangement of words in a phrase or sentence. The English language has patterns and rules for the way we order our words. It also has some flexibility and variety in acceptable patterns, and even then, speakers and writers are allowed some leeway with these patterns.

Semantics - In linguistics, semantics is the study of the meanings of morphemes, words, phrases, and sentences. Knowledge of the meaning of a text is essential to reading.

Verbal Reasoning

Inference - a conclusion one can draw from known facts or evidence

Metaphor - a word or phrase used to say that something **is** another thing in order to suggest that they are similar

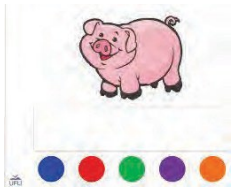
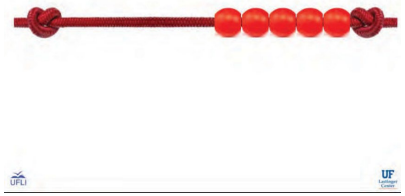
Literary Knowledge

Print Concepts - letters vs. words, 1:1 correspondence, reading left-to-right and top-to-bottom, spaces between written words, letter order matters, etc.

Genres of Literature – different types of books or stories defined by special characteristics

Source: Really Great Reading

Students have been reading about plants and pollination during their Living Things Unit of Study. A teacher is about to read aloud *Give Bees a Chance*. The teacher asked students to think about what they already know about bees based on the texts, photographs, and videos they have engaged with thus far. Students were then asked to share with a shoulder partner. The teacher then circulates the room listening to student responses.	During the writing block, the teacher is circulating and helping students with the editing stage of the writing process. With one student, the teacher is calling attention to subject-verb agreement.	Students are making nonlinguistic representations of phrases (e.g., busy as a bee, as sweet as honey, What's all the buzz about?).	Students are working on analyzing a piece of poetry. They are looking at each stanza and discussing the meaning of each stanza and how it applies to the poem as a whole.
A kindergarten teacher is preparing to read aloud, *Where the Wild Things Are*. Before beginning the reading, the teacher calls attention to the front of the book and the back of the book.	Students are reading a text and the teacher has them pause at the word tarnish. The teacher asks the students to think about the word's meaning. The students respond that they do not know what the word means. The teacher has two paper clips. One was shiny and the other was not. The teacher has the students analyze the difference and holds up the tarnished paper clip. The teacher says, "This paper clip is tarnished." The teacher then has the students reread the sentence with the word tarnish and discuss with their table team what it means in the context of the text.	Students are working independently to read and respond to a text. The teacher stops next to a student to listen in to the reading. The student's reading is effortless. Unfamiliar words are decoded with automaticity.	A teacher is preparing to utilize the poem, "Gathering Leaves" by Robert Frost. The teacher had created a PowerPoint presentation with various pictures displaying the fall season. During the reading of the poem, the teacher is emphasizing words and phrases that will help students activate their senses to make a mental model of the poem.

Students are rereading text and identifying examples of figurative language. They will then use figurative language in their own writing.	Students are working on closed syllables. Their specific focus is CVC short vowel sounds. They are using Elkonin boxes and letter tiles for phoneme-grapheme correspondences.  Students then apply their knowledge to an accountable text (a decodable reader) that has CVC short vowel words as well as learned HFW.	The teacher is utilizing shared reading as an instructional method. For the initial read, students are invited to join in, but the teacher volume is the loudest and the teacher is reading with appropriate pacing and prosody. During the next read, the students will echo read. During the third read, they will all choral read the text. For the last read, the students will read the text independently as a class.	The teacher is having students blend initial, medial and final phonemes together to produce single-syllable words. The teacher is guiding students through correct articulation of the individual phonemes when necessary. Students are using Phoneme Counting Beads to support this work. 
The teacher is saying word pairs and asking students to listen carefully to the sounds within the words. The students are to give a thumbs up if the words rhyme and a thumbs down if the words do not rhyme.	Students are exploring different texts and analyzing themes. The teacher is supporting groups in collaborative discussions. The teacher is charting the student responses for the whole class to have a running list of themes.	Students are working on encoding words from a phonics lesson. For each word students are hearing the word, saying the word, writing the word, and reading the word. The teacher is modeling how to reference resources around the room such as the alphabet frieze and the sound wall.	Words are on the board such as **eruption**, **particles** and **volcanic**. There are also Spanish cognates listed such as **erupción** and **partícula**. The class is exploring the morphology of each word and then the teacher revisits a section of text from, *Volcano: The Eruption and Healing of St. Helens*.

The Superkids Reading Program

The SCIENCE of READING

Evidence for a New Era of Reading Instruction

BY LAURA STEWART
Author and National Director for The Reading League

ZB Zaner-Bloser

THE SCIENCE OF READING

Evidence for a New Era of Reading Instruction

"Upon the subject of education...I can only say that I view it as the most important subject which we as a people can be engaged in."

— Abraham Lincoln

THE PROMISE AND THE PERIL

Delivering on the promise of education starts with the mastery of the most fundamental foundational skill—the ability to read. Not only is reading critical to the success of further education but it is an expected accomplishment in order to thrive in contemporary society. Of equal importance, leading a literate life can bring immense joy and beauty to a human being's life.

Yet many children today are not learning to read. Currently in the United States, only about one-third of our fourth graders are reading at grade level with accuracy, fluency, and understanding (NCES, 2019). This number is unchanged in eighth and twelfth grades and has been relatively flat over time. In international comparisons, 15-year-olds in the United States rank 24th out of the 72 participating countries in overall literacy, lowest among English-speaking countries (OECD, 2015).

These figures are alarming, especially in an era when the literacy skills required to function in the world have never been more important. The promise of literacy for all seems out of reach for many of our youngest citizens.

> *"The attainment of reading skill has fascinated psychologists and invited more study than any other aspect of human cognition due to its social importance and complexity."*
>
> —Moats and Tolman, 2009, p. 31

It doesn't have to be this way. While many factors contribute to low reading achievement, nearly everyone can learn to read with evidence-based instruction.

Why? Because reading is a learned skill—like riding a bike or playing a musical instrument. There are accepted principles of instruction to guide teaching so that students become successful in this most important endeavor. We know a great deal about learning to read.

The past 40 years has yielded tremendous, interdisciplinary insights into the process of learning to read, gathered from developmental psychology, cognitive neuropsychology, developmental linguistics, and educational intervention research.

THE POWER OF EVIDENCE

The past 40 years has yielded tremendous, interdisciplinary insights into the process of learning to read, gathered from developmental psychology, cognitive neuropsychology, developmental linguistics, and educational intervention research. Indeed, this is the most studied aspect of human learning. Dozens of journals publish empirical research on reading. Major research syntheses from English-speaking countries have been consistent in the findings on learning to read and teaching reading (NICHD 2000; Rowe & National Inquiry into the Teaching of Literacy, 2005; Rose, 2006; National Early Literacy Panel, 2008). Because of its volume, nature, and consistency, current research around reading embodies what is considered the **science of reading.**

If the evidence is overwhelming and compelling, why are so many children failing to learn to read? Despite a preponderance of evidence about what constitutes good reading instruction, these **false theories** persist:

- Reading is as natural as speaking, therefore immersing children in print and literature will teach children to read.
- Teaching young children to look at pictures, skip over words, or guess at words based on context will develop the strategies necessary for reading comprehension.
- There are hundreds of ways to learn to read, therefore there is no single set of instructional principles that will work for all children.

WHAT IS KNOWN ABOUT THE PROCESS OF LEARNING TO READ

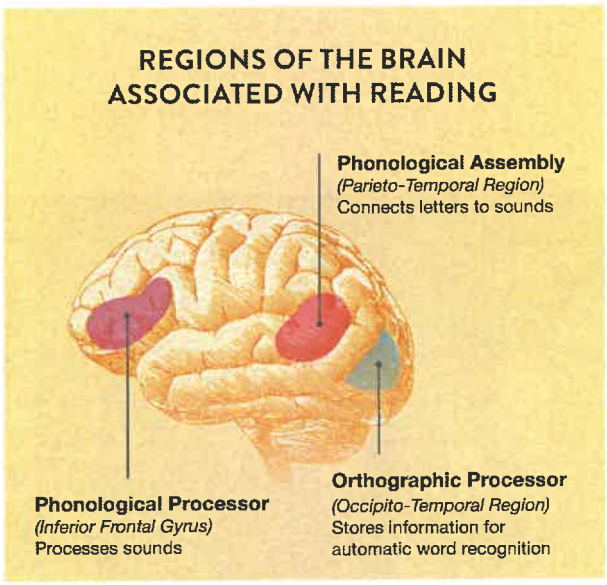
The Development of the Reading Brain

First words, first steps, and learning to read are milestone moments. Of these milestones, children naturally learn to speak and walk as part of the human experience. But when it comes to reading, "human beings were never born to read" (Wolf, 2018). While some children seem to effortlessly begin reading, the majority of people need to be taught. Reading and writing are recent inventions in the grand scope of humanity. Although spoken language is "hard wired" inside the human brain and the brain is fully adapted for language processing, the written code has not been around long enough for humans to have developed a "reading brain" (Wolf, 2007; Dehaene, 2009). Rather, the neural circuitry that is necessary to read is created primarily through instruction.

The past three decades have produced exciting evidence about what happens in the brain during reading and what needs to take place instructionally in order to wire the brain to be able to read. Through the advancement of fMRI technology, researchers have compared the neural systems of fluent readers to the neural systems of struggling readers. These studies reveal what needs to happen to build efficient neural connections for reading.

> *"Within his brain, the child is literally building the neural circuitry that links the sounds of spoken words, the phonemes, to the print code, the letters that represent those sounds."*
>
> —Shaywitz, 2003, p. 177

> *...the potential of neuroscience to help expand our understanding of reading processes, their development, and their occasional dysfunction is profound.*
>
> —Hruby & Goswami, 2011, p. 170



Three primary regions of the brain are associated with reading (Sandak, Mencl, Frost, & Pugh, 2004; Houde, Rossi, Lubin, & Joliot, 2010). The **phonological processor**, toward the front of the brain on the left side, is the part of the brain that handles spoken language. Virtually everyone is born with this language area intact; children learn to speak and to understand speech just by being immersed in language. The **orthographic processor**, toward the back of the brain on the left side, is the part of the brain that deals with visual images. Most everyone also has the visual part of the brain intact; children easily recognize images, such as objects and faces. But no one is born with the neural system connecting vision and speech, the **phonological assembly region** of the brain, and this is the system that enables reading. This system must be built through successful instructional experiences (American Psychological Association, 2014; Hruby & Goswami, 2011; Shaywitz & Shaywitz, 2004; Shaywitz & Shaywitz, 2008). Clearly, then, one of the first "calls to action" with a beginning reader is to develop the connection between phonology and orthography (print and sound)—the essential alphabetic principle.

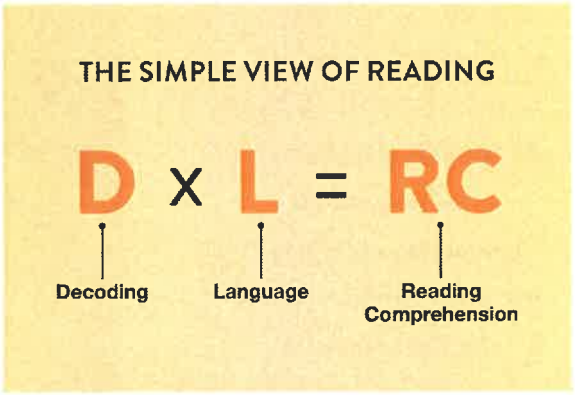
Brain imaging studies have taken place throughout the United States, and the images are consistent again and again; therefore, what has to take place instructionally is consistent as well. As cognitive neuroscientist Stanislas Dehaene states, "It simply is not true that there are hundreds of ways to learn to read....When it comes to reading, all [children] have roughly the same brain that imposes the same constraints and the same learning sequence" (2009).

Theoretical Models and Frameworks

Knowing the regions of the reading brain is helpful in understanding neural activity during the act of reading. It's also helpful to explore the theoretical underpinnings of the science of reading. Researchers have developed the following frameworks to describe how children learn to read.

The Simple View of Reading (Gough & Tunmer, 1986)

When thinking about the essential skills and capabilities necessary to "build the reading brain," Gough and Tunmer's model known as the Simple View of Reading is helpful in framing the essential equation. The premise is that strong reading comprehension results only when both decoding (defined here as *word recognition*) and language comprehension (sometimes referred to as *listening comprehension* or *linguistic comprehension*) are strong. In other words, children need to learn essential skills to get the text off the page while also developing their understanding of the world and of literacy. It is important to note that the formula for the Simple View is deliberately multiplicative, not additive. Although reading is inherently complex, this model is helpful in that the essential subskills of reading can be assigned to the domains on the left side of the equation.

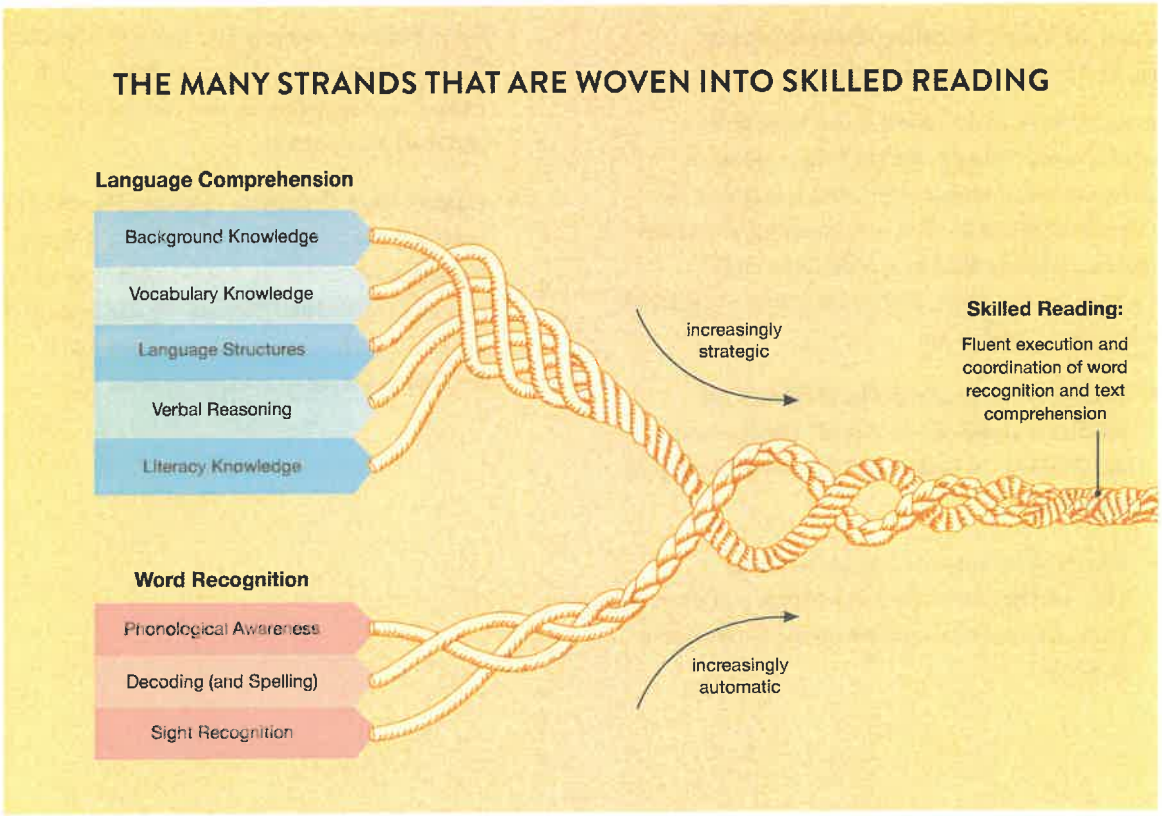


The Many Strands Woven into Skilled Reading (Scarborough, 2001)

Hollis Scarborough's "rope model" provides a vivid and elegant visual metaphor of the word recognition and language comprehension subskills that combine as skilled reading is accomplished. The subskills are like strands in a rope that become more intertwined and integrated as reading skills develop.

Both the Simple View and the Rope Model are helpful in understanding what essential elements need to be taught and developed as children learn to read. A key question emerges: what should be emphasized instructionally?

To determine the answer, one must consider brain-energy allocation. For readers to be able to navigate through text and utilize language comprehension strategies, a level of automaticity in word recognition needs to be secured. Therefore the goal is to develop that strong and stable neural system early on, through instruction, to allow for instant retrieval of words; or in other words, to access words from memory by sight. "Sight word reading" is not limited to high-frequency or non-decodable words; this simply refers to the automatic retrieval of words without conscious attention. When words are recognized instantaneously, readers can focus their attention on constructing the meaning of text.



Word recognition is the foundation of reading; all other processes are dependent on it (Snowling & Hulme, 2011).

Phases of Word-Reading Development
(Ehri, 1996; Ehri & Snowling, 2004)

The central focus of this model is that to be able to recognize words "by sight" during fluent reading, a reader must master phoneme-grapheme mapping, or the alphabetic principle. This understanding progresses in phases, each supported by specific instruction. The phases are not stages, as they are part of a predictable developmental continuum.

- Prealphabetic reading: The child may use incidental visual clues to "read" familiar words but does not yet understand that letters represent speech sounds.
- Partial alphabetic reading and writing: The child has some letter-knowledge and phoneme awareness and may represent some letter-sounds in words.
- Full alphabetic reading and writing: The child has phoneme awareness, knows basic sound/symbol correspondences, and can sound out words and spell phonetically.
- Consolidated alphabetic reading: The child has some sight vocabulary, uses strategies to figure out unknown words, and may segment words into morphological units. Because the recognition of words is mostly automatic, attention can be devoted primarily to comprehension.

Orthographic Mapping

(Ehri & Wilce, 1985; Kilpatrick, 2015)

Orthographic mapping is the name given to the process of effortless retrieval of words inherent in skilled reading and described by the Simple View of Reading, Scarborough's Rope, and the Phases of Word-Reading Development.

The orthographic mapping process essentially explains how a reader develops a sight vocabulary; readers move from letter-sound knowledge to phonic decoding to orthographic mapping. This is not a visual process; we don't store and retrieve words visually. Every step in word-reading development requires deep, secure phonologic integration. Orthographic mapping is a natural outcome of effective reading instruction, and, once in place, readers rapidly accelerate their acquisition of sight words.

> *"Orthographic mapping is the process readers use to store written words for immediate, effortless retrieval. It is a means by which readers turn unfamiliar written words into familiar, instantaneously accessible sight words."*
>
> —Kilpatrick, 2015, p. 81

WHAT NEEDS TO BE TAUGHT

Considering the significant evidence on how humans develop as readers, many researchers have sought to answer the question "What needs to be taught?" The National Reading Panel (NRP) was convened to review scientific studies of effective reading instruction and answer this question. In the Report of the National Reading Panel (NICHD, 2000), the panel identified the five components of reading that are essential and effective when taught thoroughly and skillfully:

- **Phonemic awareness:** Phonemic awareness is awareness of the smallest units of sound in spoken words (phonemes) and the ability to manipulate those sounds. Phonemic awareness falls under the category of phonological awareness, which includes the understanding of broader categories of sounds, including words, syllables, and onsets and rimes. Although the NRP identified "awareness" as the goal, subsequent research specifically on orthographic mapping has yielded an understanding that phonemic proficiency is both critical to and a result of orthographic mapping, and it continues to develop throughout the elementary grades (Kilpatrick, 2015).
- **Phonics:** Phonics is a way of teaching that stresses the acquisition of letter-sound correspondences (phoneme-grapheme representations) and their use in reading and spelling.
- **Fluent text reading:** Fluency is reading with accuracy, appropriate rate, and prosody (expression).
- **Vocabulary:** Vocabulary is the understanding of words and word meanings.
- **Comprehension:** Comprehension—the understanding of connected text—is considered an "essential element" of reading, but it is more accurately the goal of reading and the result of mastery and integration of all the components of effective instruction.

Although they were not reported by the NRP, written expression (or composition) and oral language (speaking and listening) are also considered essential components for literacy. Since the report of the NRP, none of its findings have been refuted and the evidence has been corroborated and expanded upon.

It is important to recognize that instructional emphasis differs depending on the child's development. Although all these elements are essential, in the prealphabetic phase, alphabet knowledge, phonological awareness, and oral language are emphasized. In the partial alphabetic and full alphabetic phases, phonological awareness, phonics, word recognition, and spelling should be emphasized in order to secure the neural connections and free up brain energy for deeper comprehension. Vocabulary and comprehension are taught in all phases, beginning with reading aloud to children until they can accurately read substantive text by themselves. Reading with fluency, expanding vocabulary, and deciphering ever-more-complex words through advanced phonemic awareness and phonics are emphasized in the consolidated alphabetic phase and beyond, throughout the elementary years.

> *How do children learn to read?...The answer is the same for all children. Cultural, economic, and educational circumstances obviously affect children's progress, but what they need to learn does not change.*
>
> —Seidenberg, 2017, p. 101

PUTTING IT ALL TOGETHER: INSTRUCTION COUNTS

Because reading is not a natural process, as educators consider the importance of developing the essential neural system for reading through instruction focused on the skills and subskills involved in effective reading, these key evidence-based principles of instruction are essential:

- Explicit and systematic **phonics** instruction is critical for learning to read. Phonics instruction goes beyond letter-sounds and includes phonological awareness and proficiency (particularly phonemic proficiency), phoneme-grapheme mapping, syllable patterns, and morphology. Phonics instruction continues throughout the elementary grades to build deep and secure neural systems for sight word recognition. (Adams, 1990; Stanovich & Stanovich, 2003; Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998; Pennington, 2009; NICHD 2000; Kilpatrick, 2015; Yoncheva, Wise, & McCandless, 2015).

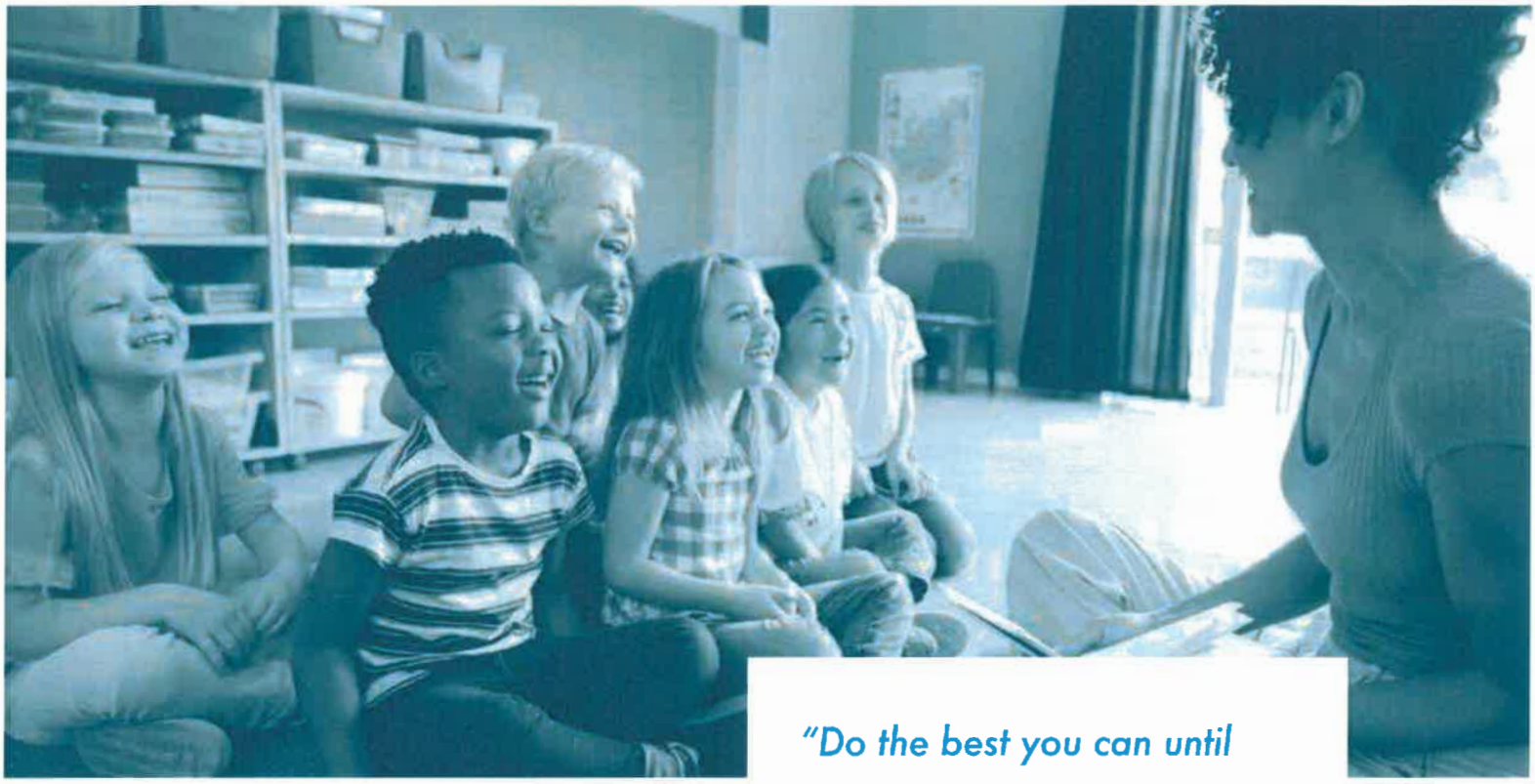
- Instruction must be **explicit**; explicit instruction begins with direct instruction and includes guided practice with decreasing levels of support. In explicit instruction, the objective of the lesson is clear and teaching is intentional (Pearson & Gallagher, 1983; Archer & Hughes, 2011).

- Instruction must be **systematic**; systematic instruction provides a definite scope and sequence of skills from less complex to more complex and includes cumulative review. When instruction is systematic, nothing is left to chance; for example, all 44 phonemes are taught in a deliberate progression (NICHD 2000; Shaywitz, 2003; McCardle & Chhabra, 2004).

- Instruction should be **engaging**. When students understand the purpose for the learning tasks, are provided opportunities for incremental steps of success, and see their own realities reflected in the curriculum, they see learning as relevant to their lives and are therefore more deeply engaged (Pressley, et al., 2001; Chopra, 1994; Jackson & Zmuda, 2014).

- **Early instruction** matters; a prevention-oriented approach is more effective than intervention. There are devastating... consequences of reading failure that can be prevented with effective early instruction (Fletcher, Lyon, Fuchs, & Barnes, 2007; Foorman, 2003; Torgesen, 2002). Higher levels of literacy are possible when students achieve basic reading skills early in their school careers (Cunningham & Stanovich, 1998; Foorman, Francis, Shaywitz, Shaywitz, & Fletcher, 1997). Although older students with reading difficulties can improve, the later the intervention, the longer it takes (Torgesen, 2002); also, many times the effects of remedial instruction may dissipate over time (Quirk & Schwanenflugel, 2004).

- Instruction needs to be **intensive**. Instruction is data-driven and focused on essential skills. All students receive high-quality, evidence-aligned tier one instruction. Students at risk are identified early on and are provided with specific, targeted instruction; progress is monitored and adjusted continually (Fuchs, Fuchs, & Vaughn, 2014; Kilpatrick, 2015).



"Do the best you can until you know better. Then when you know better, do better."

— Maya Angelou

NEXT STEPS

We have a long way to go to improve literacy outcomes for all children, but the time is rife with potential. We can stop doing what doesn't work, and we can dismiss outdated practices based on misconceptions about the process of reading. Instead we can be guided by the evidence.

But we can't teach what we don't know. According to the National Council on Teacher Quality, only 37 percent of elementary and special education programs appear to be teaching scientifically based reading methods to preservice teachers. And yet research has proven that it is a knowledgeable teacher that makes the difference in student achievement; "Teacher knowledge and instructional expertise have been found in correlational and pre- and post-test students to be related to student reading achievement" (Lyon & Weiser, 2009, p. 475). Supporting teachers in preservice and in-service professional development around the science of reading is critical.

IN CONCLUSION

We know a great deal about how the brain develops as we learn to read. We know what instructional practices are effective for all children. And we are secure in the knowledge that "A large body of research evidence shows that with appropriate, intensive instruction, all but the most severe reading disabilities can be ameliorated in the early grades and students can get on track toward academic success." (Moats, 2011).

Right now many of our nation's children are not proficient readers. We can change that and deliver on the promise of literacy for all.

ABOUT THE AUTHOR

Laura Stewart is the national director for The Reading League. Laura has been in education for more than 25 years, working as a classroom teacher, building and district administrator, adjunct professor, director of numerous professional development initiatives, and as chief academic officer for professional development for the Highlights Education Group. She presents throughout the United States and internationally and is the author of 12 children's books, numerous teacher's guides, journal articles, and dozens of training workshops. Laura is co-author of the book *The Everything Guide to Informational Literature, K–2: Best Texts, Best Practices* (Corwin Press, 2014).

The Reading League is a nonprofit organization with the mission of advancing the awareness, understanding, and use of evidence-based reading instruction. By leveraging the existing research in ways that inspire educators to refine their literacy instruction, The Reading League bridges the gap between research and classroom practice. This results in improved literacy outcomes for students. Learn more, follow, and join The Reading League at thereadingleague.org.

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