The Science of Reading

WHAT is it?

Learning Targets

• What is the Science of Reading?
  • Definitions
  • Conceptual models
  • Reading in the Brain
Primary Sources for Today

A Reading Researcher’s Definition

- Accumulated body of basic clinical and brain research
- From the U.S. and around the world
- “Settled science” continually expanded and refined
- Primarily since 1980’s: from developmental psychology, linguistics, educational psychology, cognitive science, and cognitive neuroscience
- Not just “phonics”
- Important implications for helping children succeed

Adapted from Mark Seidenberg, Cognitive Neuroscientist at UW-Madison
An Educator’s Definition

The Science of Reading in Five Minutes
Stephanie Stollar

https://www.youtube.com/watch?v=j6ycr741up4&feature=youtu.be

Two Fundamental Truths

WE WERE NEVER BORN TO READ
Our brains are hardwired for speech, not reading

THE ALPHABETIC PRINCIPLE IS THE FOUNDATION OF AN ALPHABETIC WRITING SYSTEM
It is fundamentally different from pictograph and logograph systems
Conceptual Models Derived from The Science of Reading

- The Five Components or Pillars
- The Simple View of Reading
- Scarborough’s Reading Rope
- The Four-Part Processor

The Five Components of Reading

Report of the National Reading Panel, 2000
The Simple View of Reading

\[ D \times LC = RC \]

Decoding (word recognition) \( \times \) Language comprehension = Reading comprehension

Gough & Tunmer, 1986
The Simple View of Reading

Decoding $\times$ Language Comprehension $= \text{Reading Comprehension}$

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### The Simple View of Reading

Decoding \( \times \) Language Comprehension = Reading Comprehension

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### The Simple View of Reading

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5 Components Mapped onto the Simple View

2 Domains

Decoding (word recognition) × Language comprehension = Reading comprehension

Phonemic Awareness, Phonics, Fluency, Vocabulary, Comprehension

5 Components

A Path to Learning About the Science of Reading

Phoneme Awareness, Letter Sound Knowledge, Phonemic Proficiency, Decoding, Word Recognition, Reading Comprehension

Background Knowledge, Vocabulary, Knowledge of Text and Sentence Structures, Language Comprehension
The Simple View is Not So Simple

Over time, the weight of the two components shifts
The Many Strands Woven Into Skilled Reading

Language Comprehension
- Background Knowledge
- Vocabulary Knowledge
- Language Structures
- Verbal Reasoning
- Literacy Knowledge

Word Recognition
- Phonological Awareness
- Decoding (and Spelling)
- Sight Recognition

Skilled Reading:
Fluent execution and coordination of word recognition and text comprehension

Reading comprehension

(Scarborough, 2001)

4-Part Processing Model for Word Recognition (Seidenberg & McClelland, 1989)

Mary batted her eyelashes at Tom.

Context Processor

Meaning Processor

Orthographic Processor

Phonological Processor

/b/ /a/ /t/

bat
What Happens Under the Hood?
Reading in the Brain

- PET Scans
- fMRI
- MEG

? Reading Brain Circuitry

? Differences between the brains of good and poor readers

? Effective Interventions

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Stanislas Dehaene

“It is simply not true that there are hundreds of ways to learn to read...when it comes to reading, we all have roughly the same brain that imposes the same constraints and the same learning sequence.” (2009, p.218)
Stanislas Dehaene: Reading in the Brain

https://www.youtube.com/watch?v=25GI3-kiLdo 4:22 - 6:23

The Reading Network

The typical reading network with its key components

Ozerov-Poizhik et al. 2016

Slide courtesy of Nadine Gaab, The Gaab Lab, Harvard University
What research confirms with 10 million students over 2 decades

- Reading is not a natural process and does not result from simple exposure to language or words.
- The process of learning to read re-writes the organization of the brain.

~Patricia Mathes, PhD

Brain Activation While Reading a Word (MEG)

Amplify, Science of Reading, A Primer, pp. 30-31: Primer 1
Image used with permission from Amplify
Brain Activation While Reading a Word (MEG)

MEG Images Confirm the Temporal Directionality of the 4-Part Processor

- MEG brain imaging shows us the temporal directionality of brain activation while reading
Exploring More Deeply

The Science of Reading

- Mark Seidenberg video interview with Reading Rockets
  https://www.readingrockets.org/teaching/experts/mark-seidenberg

- Maryanne Wolf TVOParents video interview
  https://www.youtube.com/watch?v=S-HYayerEeI

- Marilyn Adams, Learning to Read presentation at University of Toronto
  https://www.youtube.com/watch?v=sLTuUoVByUo

- Learning To Read, Amplify Primer Part Two
  https://go.info.amplify.com/hubfs/Primer%20II/Primer2_2018_Final.pdf

- Stephanie Stollar Consulting: https://wakelet.com/@stephaniestollar;
  https://twitter.com/ss tollar6?lang=en;
  https://www.facebook.com/StephanieStollarConsulting/

Exploring More Deeply

Scarborough's Reading Rope:

- Nancy Hennessey - Multi-Faceted Nature of Reading Acquisition
  https://institute.aimpa.org/professional-training/access-to-experts-series/unraveling-the-reading-rope

- 95 Percent Group Webinar Series
  https://info.95percentgroup.com/s carborough-webinar-replay?submissionGuid=a7c3a36f-f984-48f9-96d8-1abd9a4d46ac

The 4-Part Processor

- Seidenberg & McClelland, A Distributed, Developmental Model of Word Recognition and Naming

- D. Tracey, The Magic School Bus in Your Students' Brains
Exploring More Deeply

Reading in the Brain

- Stanislas Deheane, *Reading in the Brain*
- Stanislas Deheane videos:
  - How the Brain Learns to Read [https://www.youtube.com/watch?v=25GI3-kiLdo](https://www.youtube.com/watch?v=25GI3-kiLdo)
  - Reading the Brain [https://www.youtube.com/watch?v=MSy685vNqYk](https://www.youtube.com/watch?v=MSy685vNqYk)
  - The Brain Prize Presents Stanislas Deheane [https://www.youtube.com/watch?v=wlYZBi_07vk](https://www.youtube.com/watch?v=wlYZBi_07vk)
- Sally Shaywitz, *Overcoming Dyslexia*
- Amplify Learning To Read Primer, Part One [https://go.info.amplify.com/hubfs/CFER/Primer/PrimerPt1_LearningToRead.pdf](https://go.info.amplify.com/hubfs/CFER/Primer/PrimerPt1_LearningToRead.pdf)
- Nadine Gaab, The Typical and Atypical Reading Brain [https://vimeo.com/208357450](https://vimeo.com/208357450)
- Guinevere Eden, Brain Imaging Studies of Reading and Reading Disability, lecture at UC-Davis [https://www.youtube.com/watch?v=dD9asOTrTKk](https://www.youtube.com/watch?v=dD9asOTrTKk)

Scarborough’s Reading Rope

The Many Strands Woven Into Skilled Reading

Language Comprehension
- Background Knowledge
- Vocabulary Knowledge
- Language Structures
- Verbal Reasoning
- Literacy Knowledge

Word Recognition
- Phonological Awareness
- Decoding and Spelling
- Sight Recognition

Skilled Reading: Fluent execution and coordination of word recognition and text comprehension (Scarborough, 2001)
Learning Targets

Develop a deeper understanding of each strand of the reading rope, which helps to inform curriculum and instructional decision making.

The Many Strands Woven Into Skilled Reading

**Language Comprehension**
- Background Knowledge
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**Word Recognition**
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**Skilled Reading:**
Fluent execution and coordination of word recognition and text comprehension

(Scarborough, 2001)
Language Comprehension

Background Knowledge
Vocabulary Knowledge
Language Structures
Verbal Reasoning
Literacy Knowledge

Increasingly Strategic

Background Knowledge Strand

Language Comprehension

Background Knowledge
Vocabulary Knowledge
Language Structures
Verbal Reasoning
Literacy Knowledge
Background Knowledge

- Knowledge of the world is applied to make sense of new information
- The Baseball Study (Recht and Leslie) demonstrates the importance of background knowledge to reading comprehension
- One of the best ways to ensure our students build background knowledge is to make sure they can read proficiently
Vocabulary Strand

Tier 1: Everyday, common words

Tier 2: Academic vocabulary that cross subject areas

Tier 3: Domain-specific
Vocabulary

- Broader, deeper vocabulary facilitates decoding, reading fluency, and understanding

- **Built informally** through listening, reading and intentional discussion. Read Alouds!

- **Built formally** through explicit instruction and word study that includes morphology and etymology

Language Structures Strand

**Language Comprehension**

- Background Knowledge
- Vocabulary Knowledge
- **Language Structures**
- Verbal Reasoning
- Literacy Knowledge
Language Structures (Syntax/Grammar)

- Often best accomplished in the context of writing instruction
- Start with bare bones sentence: Subject/Predicate
- Focus on the function of words through sentence expansion and combining
Verbal Reasoning Strand

Language Comprehension

- Background Knowledge
- Vocabulary Knowledge
- Language Structures
- **Verbal Reasoning**
- Literacy Knowledge

Verbal Reasoning (Semantics)

Making Inferences
Recognizing figures of speech

- **Metaphor**: Brad was a shining light in his class.
- **Hyperbole**: I’m so hungry I could eat a horse.
- **Understatement**: You might be a wee bit sore after your car accident.
- **Pun**: I know the drill at the dentist’s office.
- **Irony**: A fire station burns down.
- **Personification**: My computer threw a fit yesterday.
- **Idiom**: You hit the nail on the head.
Literacy Knowledge Strand

Language Comprehension

- Background Knowledge
- Vocabulary Knowledge
- Language Structures
- Verbal Reasoning
- Literacy Knowledge

Literacy Knowledge

- Concepts of print
- Characteristics of different genres of text
  
  **Narrative:** story elements, story maps

  **Informational & Expository:** Organizational structures

  **Poetry:** rhythm and rhyme schemes

  **Formal vs Informal Writing:** books, opinion, academic, letters, etc
The Many Strands Woven Into Skilled Reading

Phases of Word Reading Development

(Scarborough, 2001)

(Ehri, 1996; Ehri & Snowling, 2004)

I walked to the mailbox.

I walked to the mailbox.
Word Recognition

Teaching word recognition successfully to all students requires in-depth teacher knowledge of the structure of English.

Phonological Awareness

- Able to discriminate and manipulate speech sounds
  - Words in a sentence
  - Syllables in a word
  - Onset-rimes in a syllable
  - Phonemes in a syllable

Phonological Awareness

Phonemic Awareness

Phonics
Phonological Awareness

Word Awareness  Syllable Awareness  Onset-Rime Awareness  Phoneme Awareness

Substitution  Addition  Deletion  Segmenting  Blending  Categorization  Identity  Isolation

Manipulating phonemes facilitates decoding needed for instant sight recognition

Segmenting phonemes facilitates encoding
Blending phonemes facilitates decoding

Entry point into phonemic awareness

Adapted by Amy McGovern from Susan Smartt’s image: Next Steps in Literacy
Decoding (and spelling)

Connecting speech sounds to letters or letter combinations
Decoding and spelling are inverse processes

Print to Speech  \[ \text{fun} = /f\text{u}\text{n}/ \]  Speech to Print

Supplementing Decoding/Encoding

- Syllable Structure
- Morphology
- Etymology: language of origin
Sight Recognition (of familiar words)

**Sight Word:**

- any word whose pronunciation, spelling, and meaning are linked in long-term memory such that it is recognized automatically, effortlessly, and unconsciously when seen in print

- Not just high frequency or phonetically irregular words

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How to Achieve Sight Recognition

**Orthographic mapping:** the process by which ALL words become sight words (Ehri, 2014, and Kilpatrick, 2015)

**Orthographic mapping is “the most important scientific discovery you have never heard of.”**

David Kilpatrick
Orthographic Mapping

- Skilled readers develop this skill naturally
- Students with word-level reading difficulties do NOT
- Usually takes about 1-4 appropriate exposures (phoneme/grapheme mapping)
- Does not occur simply through repeated visual exposures

David Kilpatrick:

“Understanding word recognition development, particularly orthographic mapping, represents the key to unlocking the mystery behind most reading difficulties.”

Kilpatrick, 2015, p. 129
Exploring More Deeply

Ehri’s Phases of Reading Development
- University of Florida Literacy Institute
  https://education.ufl.edu/ufli/files/2020/03/EhriPhases.pdf

Background Knowledge
- The Knowledge Gap, Natalie Wexler
- Teaching Content is Teaching Reading, Daniel Willingham:
  https://www.youtube.com/watch?v=RiP-ijdqEc http://www.danielwillingham.com/
- Building Background Knowledge, Reading Rockets:
  https://www.readingrockets.org/article/building-background-knowledge

Vocabulary
- Selecting Vocabulary, Academic Word List:
  http://www.uefap.com/vocab/select/awl.htm
- Hart and Risley study: https://www.youtube.com/watch?v=fOLzEUmXV5s
- Thirty Million Word Center: https://tmwcenter.uchicago.edu/tmwcenter/research/
- The Words Children Hear: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4567506/
- Bringing Words to Life, Beck, McKeown, & Kulcan
- Words Worth Teaching, Andrew Biemiller

Language Structures/Syntax
- The Writing Revolution, Hochman & Wexler
- William VanCleave: https://www.youtube.com/watch?v=h5SOuiF6_GQ
- The Writing Rope, Joan Sedita:
  https://keystoliteracy.com/blog/we-need-a-writing-rope/
Exploring More Deeply

Phonological and Phonemic Awareness

- Maria Murray, The Reading League
  [https://www.youtube.com/watch?v=-craxHFB37U&t=7s](https://www.youtube.com/watch?v=-craxHFB37U&t=7s)
- Reading 101, Module 2, Reading Rockets
- What Is Phonological Awareness? Margie Gillis
  [https://www.youtube.com/watch?v=K0G6teawxls](https://www.youtube.com/watch?v=K0G6teawxls)

Decoding and Encoding

- Reading 101, Module 3, Reading Rockets
- How Spelling Supports Reading
  [https://www.readingrockets.org/article/how-spelling-supports-reading](https://www.readingrockets.org/article/how-spelling-supports-reading)
- How Words Cast Their Spell
  [https://www.aft.org/sites/default/files/periodicals/joshi.pdf](https://www.aft.org/sites/default/files/periodicals/joshi.pdf)

Sight Word Recognition/Orthographic Mapping

- David Kilpatrick Essentials of Assessing, Preventing, and Overcoming Reading Difficulties
- David Kilpatrick presentation for Reading in the Rockies 2017
  [https://www.cde.state.co.us/cdesped/sd-sld_archived_readingrockies2017](https://www.cde.state.co.us/cdesped/sd-sld_archived_readingrockies2017)
- Maria Murray, The Reading League, [https://www.youtube.com/watch?v=XfRHcUeGohc](https://www.youtube.com/watch?v=XfRHcUeGohc)
- 95 Percent Group
  [https://www.95percentgroup.com/kilpatrick-webinars](https://www.95percentgroup.com/kilpatrick-webinars)
Exploring More Deeply

**Syllable Types**

- Maria Murray, The Reading League
  [https://www.youtube.com/watch?v=CWFxhWKxW9o](https://www.youtube.com/watch?v=CWFxhWKxW9o)
- Six Syllable Types, Reading Rockets
  [https://www.readingrockets.org/article/six-syllable-types](https://www.readingrockets.org/article/six-syllable-types)

**Morphology and Etymology**

- Marcia Henry, *Unlocking Literacy*
Primary Sources of Information

Why is the Science of Reading Important?

• For Students
• For Teachers
• For Society

What Does Our Data Show?

How Can We Align Instruction to the Science of Reading?
Reading success is important for students

- Gateway to academic learning
- Assists acquisition of advanced vocabulary and complex sentence structure
- Contributes to crystallized, fluid, and emotional intelligence
- Essential for life success in 21st century
- Builds positive self-concept and emotional health
- Mitigates the negative impacts of trauma

Reading knowledge is important for teachers

- The more teachers know about language, the better able they are to successfully teach all students
- Improves the relationship between teacher effort and student outcomes
- Additional professional learning is often needed to make up for insufficient teacher preparation in reading
Proficient readers are important for society

- It’s an equity issue
- Impact on national economy
- Impact on the health care system
- Impact on participatory democracy
- Link to the full range of social problems
- Link to criminal justice system
- Link to poverty

Why should we be concerned with the Science of Reading? Consider our **national ranking** on NAEP

[Graph of National Ranking Over Time]

[Link: http://www.wisconsinreadingcoalition.org/]
Consider student NAEP Results:
% Below Proficient, % Below Basic

[Graph showing NAEP results for different groups.]

Where are the unmet needs?

The Ladder of Reading

[Diagram of the ladder of reading with different levels of reading proficiency.]

Used with Nancy Young’s permission
We can **PREVENT** reading failure

After research-based instruction, the number of first graders reading below the 30th percentile can be as few as 5%.

Foorman et al., 1998; Torgesen, 2002; Vellutino et al., 2007; Torgesen et al., 2009; Mathes et al., 2011

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Teach ALL the Strands of the Reading Rope

![Diagram of the Reading Rope](image)

Language Comprehension
- Background Knowledge
- Vocabulary Knowledge
- Language Structures
- Verbal Reasoning
- Literacy Knowledge

Word Recognition
- Phonological Awareness
- Decoding (and Spelling)
- Sight Recognition

**Skilled Reading:** Fluent execution and coordination of word recognition and text comprehension

Increasingly automatic

(Scarborough, 2001)
Most of the Instructional Debate Concerns the Bottom Half of the Rope

Whole word rote memorization?

Speech to print instruction in phonological awareness and the alphabetic code?

Using a variety of strategies, including pictures, context, first sound, etc.?

Images from https://soyouthinkyoucanteachesl.com/2015/03/04/using-the-whole-language-approach-to-teach-reading/

For word recognition, choose...
Our goal: building a sight word lexicon

- Phonics and phonemic awareness manipulation must be proficient
- Sufficient practice and review
  - Decoding and encoding
  - Isolated skills
  - Decodable text

“Understanding word recognition development, particularly orthographic mapping, represents the key to unlocking the mystery behind most reading difficulties.”

Kilpatrick, 2015, p. 129
Therefore....

Anything that pulls the reader away from the phoneme/grapheme structure of the word works against orthographic mapping.

Stanislas Dehaene Talks About Reading

https://www.youtube.com/watch?v=wIYZBi_07vk
But What About Whole Word Memorization?

- Produces only SHORT term gains
- 5,000 word limit vs 50,000-75,000 needed for competent reading
- Builds inefficient habits

The Power of Phonics

If a child memorizes ten words, the child can read ten words.

But if the child learns the *sounds* of ten letters, the child can read...

- 350 three-sound words
- 4,320 four-sound words
- 21,650 five-sound words

Dr. Martin Kozloff (2002)
But What About Using Multiple Strategies?

Look at the picture
Try a word that makes sense
Get your lips ready for the 1st sound
Skip over the word
Flip the vowel sound
Say any chunks you know
Stretch out the sounds
Ask for help

Try one of these decoding strategies instead:

If I Get Stuck is free from Tiny Steps Make Big Strides

PSST! is free from the Kastner Collection padlet
Aligning Instruction with the Science of Reading
Using Structured Literacy

How we teach:
● Explicit
● Systematic
● Cumulative
● Diagnostic

What we teach:
● Phonology
● Sound-Symbol
● Syllables
● Morphology
● Syntax
● Semantics

Typical vs. Structured Literacy

Typical Literacy
i.e., “Balanced Literacy”
● Phonemic awareness covered haphazardly or not at all.
● Full range of sound-letter correspondences assumed to be learned naturally; phonetic patterns covered unsystematically and in context.
● Memorization of Dolch/Fry (i.e., “sight”) words, with little or no attention to their phonetic components.
● Focus on using first/last letters; heavy reliance on context clues, including pictures.
● Misread words ignored if they do not seriously interfere with comprehension.
● Use of repetitive and leveled readers that contain unlearned phonetic patterns and encourage guessing.
● Lots of class time devoted to independent reading.

Structured Literacy
i.e., Science of Reading
● Phonemic awareness emphasized as a pre-reading skill.
● Explicit, systematic instruction on the full range of sound-letter correspondences, beginning with simple patterns and proceeding to more complex ones.
● High-frequency words taught according to phonetic patterns; irregular words analyzed for their phonetic/non-phonetic elements.
● Focus on all the letters/sounds in a word; context clues used only to help identify highly irregular words or clarify meaning.
● Misread words promptly corrected, with explicit instruction on how to sound them out.
● Use of decodable readers that contain only vocabulary with already-learned phonetic patterns.
● Very little class time devoted to independent reading.

Courtesy of Erica Melzer
Printable copy available at www.breakingthecode.com
Implementing the Science of Reading

Is not a clean, linear, one size fits all process

★ Begins with small changes you can make right now to help MORE children learn to read in your classroom.

★ Requires a growth mindset, a reflective energy, and a lot of ongoing professional learning.
What does it take to implement the SoR?

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<th>Dedicated, caring, and compassionate leadership</th>
<th>An in depth reflection of how reading is taught to see where you are in alignment with the science and where you may need improvement</th>
<th>Review of assessments used for screening, progress monitoring, and instructional diagnosis. Purchase, train and support via professional learning what is missing.</th>
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<tr>
<td>Review of all the materials in the district used to teach reading for regular classroom instruction AND intervention, think through where it is and is not aligned to the SoR.</td>
<td>LONG TERM and ongoing Investment in professional learning in the Science of Reading. Develop a 5 year plan. Think about how you will support NEW teachers that join your ranks every year</td>
<td>On-going coaching support for teachers as they implement new ways of teaching reading</td>
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<td>Teachers with a growth mindset</td>
<td>Foundational Reading Materials that include EXPLICIT instruction in PA, Phonics, encoding and using Decodable Text aligned with the phonics instructional sequence.</td>
<td>Schedules conducive for whole group and small group instruction with adequate minutes</td>
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**EQUITY**

Teaching reading through an equity lens demands that we understand the science behind how children learn to read so that we may effectively serve ALL children in our classrooms.

![Heart](image)
Exploring More Deeply

Importance for Students
- What Reading Does for the Mind, Stanovich and Cunningham, 1998

Importance for Teachers
- The Research-Practice Divide in Beginning Reading, Spear-Swerling, 2007
  https://www.tandfonline.com/doi/abs/10.1080/00405840701593881
- Measuring Teachers’ Content Knowledge of Language and Reading, Moats and Foorman
  https://www.jstor.org/stable/23764733?seq=1
- Teachers’ Knowledge about language constructs related to literacy skills and student achievement in low socio-economic status schools, Pittman et al., 2019

Importance for Society
- Interviews in Children of the Code
  https://childrenofthecode.org/cotcintro.htm

Exploring More Deeply

Mining the NAEP Explorer for Data
- Using the NAEP Data Explorer to Ask Better Questions, Find Better Answers

Aligning Instruction with Science/Structured Literacy
- What is Structured Literacy?
  https://dyslexiaida.org/what-is-structured-literacy/
- Structured Literacy Instruction: The Basics
  https://www.readingrockets.org/article/structured-literacy-instruction-basics
- An Explanation of Structured Literacy and a Comparison to Balanced Literacy
  https://iowareadingresearch.org/blog/structured-and-balanced-literacy

Whole Word Memorization
- McCandliss et. al, Hemispheric specialization for visual words is shaped by attention to sublexical units during initial learning
  https://news.stanford.edu/2015/05/28/reading-brain-phonics-052815/
Orthographic Mapping vs. Multiple Cues

- Reading Matters Connecting Science and Reading: [https://seidenbergreading.net/2019/12/06/lucy-calkins-on-the-attack/](https://seidenbergreading.net/2019/12/06/lucy-calkins-on-the-attack/)
- Shanahan on Literacy: [https://shanahanonliteracy.com/blog/is-it-a-good-idea-to-teach-the-three-cueing-systems-in-reading](https://shanahanonliteracy.com/blog/is-it-a-good-idea-to-teach-the-three-cueing-systems-in-reading)

Resources: Books
Emily Hanford Audio Documentaries

Play direct audio from APM Educate Podcast website or TRL’s Knowledge Base page

**Hard to Read**: How American schools fail kids with dyslexia, September, 2017

**Hard Words**: Why aren’t kids being taught to read? September, 2018

**At a Loss for Words**: How a flawed idea is teaching millions of kids to be poor readers, August, 2019

**What the Words Say**: Why so many kids don’t understand what they read, Coming August 6, 2020

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Our contact information:
The Reading League Wisconsin

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Thank you for your commitment to building educator knowledge and increasing student achievement.