THE SCIENCE OF READING:
A LITERATURE REVIEW

Prepared for the Connecticut State Department of Education

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HANOVER RESEARCH

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INTRODUCTION

State-driven initiatives focused on early literacy precede the COVID-19 pandemic, but new legislation passed in 2021 demonstrates the growing momentum around literacy instruction and how it is taught. In the last three years, 11 states have passed laws to increase evidence-based instruction in early elementary school. Since the start of the COVID-19 pandemic, 18 states and the District of Columbia have announced plans to use pandemic-related relief funds to expand the Science of Reading and evidence-based literacy practices in their jurisdictions. Furthermore, four states (i.e., Arkansas, Connecticut, North Carolina, and Pennsylvania) have passed legislation since the beginning of 2021 that mandates reading instruction aligned with the Science of Reading, or bans contradictory instructional practices (e.g., the three-cueing system).[1] These laws and initiatives come when reading assessment scores are declining, as indicated by National Assessment of Educational Progress scores, and evidence is emerging that popular curricula running counter to the Science of Reading do not support all students.[2]

Responses to the new legislation are mixed: proponents claim that mandates will provide consistent instruction to support fluency and comprehension, and opponents claim mandates are too prescriptive, phonics-heavy, and costly.[3] Although research-based and critically analyzed, the Science of Reading and its components continue to spark controversy and debate among research and education stakeholders. This reignition of the "reading wars"—a decades-long controversy on whether students should learn to read using phonics or whole-language instruction—has shifted to include "what constitutes scientific evidence, how much value we should place on scientific evidence as opposed to other forms of knowledge, and how preservice teachers should be instructed to teach reading."[4] Despite studies on grapheme-phoneme awareness and connections, and how these skills lead to successful reading skills, there remains a lack of consensus on how to effectively teach reading.[5]

Therefore, the Science of Reading requires a deeper understanding and increased awareness to ensure successful reading instruction and development. Petscher et al. (2020) define the Science of Reading as "**a phrase representing the accumulated knowledge about reading, reading development, and best practices for reading instruction obtained by the use of the scientific method**."[6] Although researchers and education stakeholders adhere to various definitions of this phrase, as described in this literature review, the Science of Reading comprises an understanding of research-based reading, reading development at different stages, and reading instructional practices (e.g., phonics instruction).[7] Such reading development and practices rely, in part, on a foundation of neurological research, which explains how brain mechanisms function to enable learners to connect sounds and oral language to letters and words, followed by whole passages of which

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1 Schwartz, S. "More States Are Making the 'Science of Reading' a Policy Priority." Education Week, October 13, 2021. https://www.edweek.org/teaching-learning/more-states-are-making-the-science-of-reading-a-policy-priority/2021/10

2 [1] "Assessments - Reading." National Assessment of Educational Progress. https://nces.ed.gov/nationsreportcard/reading/ [2] Adams, M.J. et al. "Comparing Reading Research to Program Design: An Examination of Teachers College Units of Study." Student Achievement Partners, January 2020. p. 11. https://achievethecore.org/page/3240/comparing-reading-research-to-program-design-an-examination-of-teachers-college-units-of-study

3 Doss Helms, A. "Some NC Leaders Say Mississippi's Model Charts The Way To Helping Kids Read." WFAE 90.7, April 26, 2021. https://www.wfae.org/education/2021-04-26/some-nc-leaders-say-mississippis-model-charts-the-way-to-helping-kids-read

4 [1] D'Orio, W. "Revisiting the Reading Wars." School Library Journal, 66:5, May 2020. p. 36. Retrieved from EBSCOhost. [2] Goldenberg, C. "Reading Wars, Reading Science, and English Learners." Reading Research Quarterly, 55, September 2, 2020. p. S131. Retrieved from EBSCOhost. [2] Petscher, Y. et al. "How the Science of Reading Informs 21st-Century Education." Reading Research Quarterly, 55:S1, 2020. p. S268. Obtained from EBSCOhost.

5 Petscher et al., Op. cit., p. S268.

6 Ibid.

7 Goodwin, A.P. and R.T. Jiménez. "The Science of Reading: Supports, Critiques, and Questions." Reading Research Quarterly, 55:S1, 2020. p. S8. https://onlinelibrary.wiley.com/doi/abs/10.1002/rrq.360

students comprehend the meaning. Figure ES 1 illustrates how neuroscience comprises a significant area of research that connects with education, linguistics, and psychology to inform the Science of Reading.

Figure ES 1: Research Areas within the Science of Reading

Source: University of Florida Literacy Institute[8]

This body of knowledge and four corresponding research areas, shown above, align with Connecticut's new legislation on reading instruction and initiatives. Along with Connecticut's new legislation on the Science of Reading, the Connecticut State Department of Education (CSDE) established the Center for Literacy Research and Reading Success, tasked with confirming district use of reading programs and curricula for early elementary school grades that align with the Science of Reading.[9] As such, CSDE has partnered with Hanover Research (Hanover) to conduct a series of research projects around the Science of Reading. The research projects will inform how the Department reviews and approves new reading programs and curricula that districts will subsequently adapt and use. The research will also be used by the Center for Literacy Research and Reading Success as the Center and CSDE together seek to support the state on their understanding of best practices for the Science of Reading.

To begin its support of CSDE and its efforts, Hanover presents this literature review on literacy and the Science of Reading, which combines academic literature and supplemental resources from educational experts and federal and state authorities. This report also provides optimal ways to "marry" the Science of Reading with instructional practices where possible. Structurally, this report contains the following two sections:

- **Section I: Understanding the Science of Reading** synthesizes academic studies that contextualize and define the Science of Reading and the efficacy of using the components of the Science of Reading to guide instruction;

- **Section II: Using the Science of Reading for Effective Instruction** reviews research on the five key components within the Science of Reading and evidence-based practices for incorporating the Science of Reading into classroom instruction.

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[8] Figure adapted from: Lane, H. "What Is the Science of Reading?" University of Florida Literacy Institute, January 10, 2021. https://www.youtube.com/watch?v=cnkJ6VvDr2M

[9] "Major Public Acts: 2021 Legislative Session." Connecticut General Assembly, June 30, 2021. p. 14. https://www.cga.ct.gov/2021/rpt/pdf/2021-R-0106.pdf

METHODOLOGY

Hanover's approach to this literature review began with a review of the secondary and peer-reviewed literature on the Science of Reading and supplements with insights from educational experts and published advice from federal and state authorities. Using similar sources, Hanover analyzed texts for examples of integrating evidence-based approaches from the Science of Reading into literacy instruction. Specifically, Hanover leveraged search engines such as EBSCOhost and SAGE Journals to collect relevant resources, along with specific journals (e.g., *Reading Research Quarterly*, *The Reading Teacher*, *Child Language Teaching and Therapy*, *Educational Psychology Review*, *Journal of Education Psychology*, *Journal of Learning Disabilities*, *Frontiers in Education Technology*, *Educational Psychology Review*), between 2015 and 2021.

When conducting this research, Hanover used the following primary search terms and the accompanying secondary search terms to ensure specific and relevant results. Secondary search terms supplemented primary search term using the AND search function. Figure ES 2 contains the search terms Hanover applied for this literature review. These terms appear alphabetically rather than in any order of importance to avoid implying bias in term presentation.

Figure ES 2: Search Terms

PRIMARY SEARCH TERMS	SECONDARY SEARCH TERMS
▪ "language comprehension" ▪ "letter sounds" ▪ "phonemic awareness" ▪ "phonemic manipulation" ▪ "phonic decoding" ▪ "phonics" ▪ "science of reading" ▪ "structured literacy" ▪ "reading development" ▪ "reading fluency" ▪ "vocabulary development"	▪ AND "development" ▪ AND "efficacy" ▪ AND "implementation" ▪ AND "instruction" ▪ AND "instruction" AND "efficacy" ▪ AND "practices"

Source: Hanover Research

Additionally, Hanover used these search terms to identify relevant secondary literature from organizations and associations. These sources supplement academic literature and enable this literature review to expand on the Science of Reading and its components. Specific organizations and institutions include:

- Education Commission of the States;
- Institute for Multi-Sensory Education;
- Institute of Educational Sciences
- International Literacy Association;
- IRIS Center, Peabody College, Vanderbilt University;
- National Reading Panel;
- North Carolina Department of Public Instruction;
- Stanford University; and
- The Center for Independent Studies.

KEY FINDINGS

The Science of Reading encapsulates research on reading, reading development, and reading instruction that shapes literacy instruction and policy. Notably, the Science of Reading has evolved since the mid-19th century and does not have one single definition. Rather, researchers tend to avoid a narrow approach to the Science of Reading to ensure that the concept remains a compilation of reading research and interpretation of the research. However, opponents continue to condemn the Science of Reading for its overly narrow scope and emphasis on decoding. However, researchers and practitioners emphasize how this concept connects to numerous contexts and factors (e.g., environmental, neurological, cultural) and requires a knowledge base built from empirical research and practical implementation on reading and associated practices. The four main research areas within the Science of Reading are education, psychology, linguistics, and neuroscience.

The Science of Reading comprises five key components: phonemic awareness, phonics, fluency, vocabulary, and comprehension. These components, explicitly identified by the National Reading Panel and frequently cited in the literature that followed, represent foundational skills that students must develop to improve as readers. Additionally, while these components comprise much of the research base on the Science of Reading, certain researchers (e.g., Graham 2020) emphasize that these components are not the only factors to consider in reading instruction. Still, phonemic awareness, phonics, fluency, vocabulary, and comprehension effectively improve student literacy in numerous studies throughout the pre-K through Grade 12 span. Although research tends to report on the interventions and outcomes of the key components at the elementary level, evidence supports instruction comprised of these strategies throughout elementary and secondary education. Further, multiple studies highlight the importance of developing skills aligned to these components synergistically, indicating that each is important throughout the development process, and students may learn reading strategies that draw from numerous components, so long as the strategies are appropriate for their ability levels.

Recent literature on the Science of Reading and its components indicates that educators must know *how* and *why* literacy develops instead of having a basic understanding that students must learn to connect sounds, letters, words, and meaning. As students learn to read, the key components build and expand in ways that enable students to take on more advanced words and texts. For example, as decoding becomes automatic, students can focus on meaning. Therefore, teachers must have a strong foundational knowledge of reading and instructional practices that support students in becoming skilled enough to engage with more challenging materials, fluent oral reading, comprehension of advanced passages, and other literacy skills. Further, a clear understanding of reading development and instruction enables educators to identify needs and select interventions that best fit students' skill levels. For example, Petscher et al. (2020)[10] note that students with learning disabilities struggling with reading may rely on vocabulary to comprehend a text when fluency skills need improvement. Knowing this may prompt teachers to develop the root of comprehension challenges successfully.

Instructional practices for components of the Science of Reading (i.e., phonemic awareness, phonics, fluency, vocabulary, comprehension) must incorporate such instruction synergistically, rather than in isolation. This multi-skill approach may build skill development sequentially, as demonstrated by Collins et al., or more cohesively, as described by Duke et al. The exact implementation approach aside, these skills require teachers to build students' reading habits cohesively so that students can read accurately and fluently while feeling confident that they

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[10] Full author list is as follows: Yaacov Petscher, Sonia Q. Cabell, Hugh W. Catts, Donald L. Compton, Barbara R. Foorman, Sara A. Hart, Christopher J. Lonigan, Beth M. Phillips, Christopher Schatschneider, Laura M. Steacy, Nicole Patton Terry, Richard K. Wagner. Hereafter referenced as Petscher et al. (2020).

understand a text. This cohesion also requires teachers to draw on multiple modalities of instruction, meaning students engage in reading *and* writing tasks or reading *and* speaking tasks. Such interventions and interventions that require active processing result in stronger reading outcomes. Put succinctly, Petscher et al. (2020) state, "To make meaningful gains, intervention for reading comprehension likely requires addressing multiple components of language and teaching content knowledge."[11]

Increasing teachers' knowledge of and competency in reading instruction results in improved student reading outcomes. A lack of in-depth training on reading, its components, and instruction can cause teachers to enter the workforce ill-prepared for supporting general education and special education literacy. Authors including, but not limited to, Englert et al. and Hindman et al., emphasize the importance of preservice training and in-seat professional development on tools and practices for reading components and overall literacy. Through preservice and in-seat teacher interventions, these authors demonstrate that providing teachers with the skills and tools for evidence-based literacy instructions enables students to improve, particularly students at-risk for reading challenges. Additionally, neuroscience research indicates that teachers' instructional approach to teaching reading (e.g., grapheme-phoneme decoding versus whole-word instruction) impacts the brain processes used to read, underscoring the importance of knowledgeable and competent educators. These teachers must also possess strong foundational skills to avoid imparting incorrect information and practices to students (e.g., incorrect pronunciation).

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[11] Petscher et al., Op. cit., p. S272.

SECTION I: UNDERSTANDING THE SCIENCE OF READING

In this section, Hanover synthesizes academic studies that contextualize and define the Science of Reading and the efficacy of using the Science of Reading to guide instruction. This section also defines key components of the Science of Reading (i.e., phonics, phonemic awareness, fluency, vocabulary, comprehension) and the efficacy of the approach and those components.

CONTEXTUALIZING AND DEFINING THE SCIENCE OF READING

The phrase "the Science of Reading" first appeared in a pedagogical context in the 19th Century and referred to teaching students how to correctly "sound out words."[12] However, despite roughly 200 years of use, the Science of Reading does not possess a strictly defined meaning, and its definition slightly varies across sources. Figure 1.1 presents definitions for the Science of Reading according to six sources.

Figure 1.1: A Sample of Definitions for the Science of Reading

SOURCE	DEFINITION
Patricia A. Alexander, as published in *Reading Research Quarterly*[13]	"I see the science of reading as contributing to a vast interdisciplinary store of critical information about reading-related skills, processes, antecedents, and outcomes, representing linguistic, cognitive, social, cultural, neurological, and psychological dimensions."
Steve Graham, as published in *Reading Research Quarterly*[14]	"The science of reading involves studying how reading operates, develops, is taught, shapes academic and cognitive growth, affects motivation and emotion, interacts with context, and impacts context in turn. It includes genetic, biological, environmental, contextual, social, political, historical, and cultural factors that influence the acquisition and use of reading."
International Literacy Association[15]	"A corpus of objective investigation and accumulation of reliable evidence about how humans learn to read and how reading should be taught."
Kirstina Ordetx, as published by the Institute of Multi-Sensory Education[16]	The Science of Reading (SoR) is a comprehensive body of research that encompasses years of scientific knowledge, spans across many languages, and shares the contributions of experts from relevant disciplines such as education, special education, literacy, psychology, neurology, and more.
Yaacov Petscher et al. (2020), as published in *Reading Research Quarterly*[17]	"'The science of reading' is a phrase representing the accumulated knowledge about reading, reading development, and best practices for reading instruction obtained by the use of the scientific method."
North Carolina Department of Public Instruction[18]	"'Science of Reading' (SoR) means evidence-based reading instruction practices that address the acquisition of language, phonological and phonemic awareness, phonics and spelling, fluency, vocabulary, oral language, and comprehension that can be differentiated to meet the needs of individual students."

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[12] Shanahan, T. "What Constitutes a Science of Reading Instruction?" *Reading Research Quarterly*, 55:1, 2020. p. S237. Retrieved from EBSCOhost.

[13] Alexander, P.A. "What Research Has Revealed About Readers' Struggles With Comprehension in the Digital Age: Moving Beyond the Phonics Versus Whole Language Debate." *Reading Research Quarterly*, 55, September 2, 2020. pp. S90–S91. Retrieved from EBSCOhost.

[14] Graham, S. "The Sciences of Reading and Writing Must Become More Fully Integrated." *Reading Research Quarterly*, 55, September 2, 2020. p. S35. Retrieved from EBSCOhost.

[15] Goodwin and Jiménez, Op. cit., p. S7.

[16] Ordetx, K. "What Is the Science of Reading?" Institute for Multi-Sensory Education, 2021. https://journal.imse.com/what-is-the-science-of-reading/

[17] Petscher et al., Op. cit., p. S268.

[18] "Science of Reading." North Carolina Department of Public Instruction. https://www.dpi.nc.gov/districts-schools/classroom-resources/office-early-learning/early-literacy/science-reading

Source: Multiple cited within the figure.

Figure 1.1 demonstrates that the Science of Reading lacks a standard definition; however, at the core of these definitions is a consistent meaning. Essentially, **the Science of Reading is a collection of research upon which education practices and policies build to inform literacy development and instruction.**[19] Notably, a 2020 article by Timothy Shanahan emphasizes that the Science of Reading comprises basic research, as historically understood, *and* practical, experimental research. Shanahan writes:[20]

> Although we have much to learn from basic studies of reading processes and neurological functions, it is important not to overrely [sic] on such evidence in determining how best to teach reading […] I argue not for ignoring the fruits of basic research but for adjudicating matters of pedagogy chiefly on the basis of experimental studies of instructional practice itself.

🔍 Neurological Research within the Science of Reading

As described in Figure ES 1, the Science of Reading draws from multiple research areas, including neuroscience.[21] This area of research indicates that two neurological pathways enable skilled reading: the dorsal pathway, which supports "phonologically mediated reading" that focuses on sounds, and the ventral pathway, which supports "access to meaning from print" that focuses on visuals.[22] The latter pathway appears to respond to words and nonwords more than groups of consonants; it also has greater sensitivity to word units such as letters, bigrams, and quadrigrams.[23] In analyzing the visual processes of reading, Stanislas Dehaene describes how reading involves the transformation of visual structures of the brain to produce a connection between vision and language, which requires the "recycling" of brain structures that evolved for uses that precede reading. Specifically, reading activates the left-hemispheric ventral visual cortex in all humans due to this region's ability to process high-resolution shapes, line configurations, and connect to the region that enables spoken language.[24] Through these functions, reading development uses neurons to form connections in the brain, forming an "efficient circuit for grapheme-phoneme conversion and lexical access allowing efficient word-reading skills to develop."[25]

As described by Castles et al., "The fundamental insight that graphemes represent phonemes in alphabetic writing systems does not typically come naturally to children. It is something that most children must be taught explicitly and doing so is important for making further progress in reading." This idea of instruction influencing how students learn to read appears in a quantitative analysis by Yoncheva et al., exploring left-lateralized N170 responses in an experimental study of 16 adults. In this study, researchers divided the sample into two groups, one of which learned to read a fabricated text using grapheme-phoneme decoding skills, while the other learned to apply a whole-word approach.[26] Results from brain imaging technology and analyses show that "selective attention to [grapheme-phoneme] mappings in particular is central in biasing which brain networks get trained, and consequently honed, as a student progresses with training."[27] Although this study focused on adults, a quantitative meta-analysis by Martin et al. uses 40 studies using fMRI (i.e., brain imaging) data—20 studies with adult samples, 20 studies with child samples—to explore how child and adult brain activation patterns compare when reading.[28] The authors find that although children and adults show certain differences in activated regions of the brain when reading, "Reading-related

[19] [1] Ordetx, Op. cit. [2] Shanahan, Op. cit., pp. S235–S236. [2] Goodwin and Jiménez, Op. cit., p. S7.
[20] Block quote reproduced nearly verbatim from: Shanahan, Op. cit., p. S236.
[21] Lane, Op. cit.
[22] Castles, A., K. Rastle, and K. Nation. "Ending the Reading Wars: Reading Acquisition From Novice to Expert." *Psychological Science in the Public Interest*, 19:1, June 1, 2018. p. 20. Retrieved from SAGE publications.
[23] Ibid.
[24] Dehaene, S. "The Massive Impact of Literacy on the Brain and Its Consequences for Education." *Pontificiae Academiae Scientiarvm ScriptaVaria*, 117. pp. 20–22. http://www.pas.va/content/dam/accademia/pdf/sv117/sv117-dehaene.pdf
[25] Petscher et al., Op. cit., p. S268.
[26] Yoncheva, Y.N., J. Wise, and B. McCandliss. "Hemispheric Specialization for Visual Words Is Shaped by Attention to Sublexical Units during Initial Learning | Elsevier Enhanced Reader." *Brain & Language*, 145–146, May 2015. pp. 1–4. https://reader.elsevier.com/reader/sd/pii/S0093934X15000772?token=012AD878C73F1A30D1D141AD70E698 DAED65C139F6D0E42ACB5CC2FA8FE07061F4B47BD22219879303158AE71B893714&originRegion=us-east-1&originCreation=20210930195017
[27] Ibid., p. 15.
[28] Martin, A. et al. "Reading in the Brain of Children and Adults: A Meta-analysis of 40 Functional Magnetic Resonance Imaging Studies." *Human Brain Mapping*, 36:5, January 27, 2015. p. 1963. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4950303/

activation common to children and adults was identified in left ventral [occipito-temporal] OT and left [inferior frontal gyri] IFG regions."[29] Although less research exists on how the brain evolves as students learn to read, these outcomes demonstrate differences in early versus experienced readers and the importance of instruction on not only the ability to read, but how the brain uses mechanical processes.

Understanding the unnatural process of rewiring brain functions to learn to read, how reading requires guided development, and how this "recycling" process can inform instructional approaches, Dehaene advocates a "strong 'phonics' approach to teaching," instead of whole-language instruction.[30]

Additionally, current conceptualizations of the Science of Reading intentionally avoid a narrow scope, moving beyond a strict understanding of the Science of Reading that supports phonics alone. Although phonics comprises the "core" of the Science of Reading, research within this concept points to numerous instructional components, approaches, and frameworks that support reading development.[31] For example, the National Reading Panel—ordered by Congress and organized by the National Institute for Child Health and Human Development and the U.S. Department of Education—finalized its report in 2000 on the most effective approaches to reading instruction.[32] This report, often cited in the literature on and aligned with the Science of Reading, identifies five key components of reading instruction: phonemic awareness, phonics, fluency, vocabulary, and comprehension.[33] Although, as emphasized by researcher Steve Graham, the Science of Reading comprises more than five key components, these components appear in numerous studies on reading development and effective reading instruction.[34] *Figure 1.2 introduces these concepts but by no means provides a comprehensive set of definitions or an exhaustive list of successful reading elements identified through the literature on the Science of Reading. Rather, it means to present a high-level overview, according to the National Reading Panel's 2000 report, of notable elements that appear in the following sections.*

Figure 1.2: Key Elements Identified through the Science of Reading

KEY COMPONENTS	DEFINITIONS
Phonemic Awareness	Instruction in phonemic awareness […] involves teaching children to focus on and manipulate phonemes in spoken syllables and words.
Phonics	Phonics instruction is a way of teaching reading that stresses the acquisition of letter-sound correspondences and their use in reading and spelling.
Fluency	Fluent readers are able to read orally with speed, accuracy, and proper expression […] Two instructional approaches, each of which has several variations, have typically been used to teach reading fluency [i.e., guided repeated oral reading, independent silent reading].
Vocabulary	There are two types of vocabulary—oral and print. A reader who encounters a strange word in print can decode the word to speech. If it is in the reader's oral vocabulary, the reader will be able to understand it. If the word is not in the reader's oral vocabulary, the reader will have to determine the meaning by other means, if possible. Consequently, the larger the reader's vocabulary (either oral or print), the easier it is to make sense of the text.

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[29] Ibid., p. 1977.

[30] Dehaene, Op. cit., pp. 19, 26.

[31] Goodwin and Jiménez, Op. cit., p. S8.

[32] "National Reading Panel (Historical/For Reference Only)." Https://Www.Nichd.Nih.Gov/.
https://www.nichd.nih.gov/research/supported/nrp

[33] [1]Klages, C. and M.-M. Scholtens. "Pedagogical Efficacy of Connections-OG in 3-D®: A Reading Program Based on the Science of Reading." *Frontiers in Education Technology*, 3:4, 2020. p. 11.
http://www.scholink.org/ojs/index.php/fet/article/view/3322/3331 [2] Rowland, J. "Trends in Teacher Certification." Education Commission of the States, January 2015. p. 11.
https://files.eric.ed.gov/fulltext/ED555548.pdf [2] Duke, N.K., A.E. Ward, and P.D. Pearson. "The Science of Reading Comprehension Instruction." *The Reading Teacher*, 74:6, 2021. p. 669.
https://onlinelibrary.wiley.com/doi/abs/10.1002/trtr.1993 [2] Petscher et al., Op. cit., p. S271. [2] Graham, Op. cit., p. S36.

[34] Graham, Op. cit., p. S36.

KEY COMPONENTS	DEFINITIONS
Comprehension	Comprehension is defined as "intentional thinking during which meaning is constructed through interactions between text and reader" (Harris & Hodges, 1995). Thus, readers derive meaning from text when they engage in intentional, problem-solving thinking processes.

Source: National Institute of Child Health and Human Development[35]

With these key components and definitions in mind, education leaders and stakeholders can better understand the research and implications of the Science of Reading, the efficacy of which is described in the following subsection.

DESCRIPTIVE SUMMARY OF THE LITERATURE

Recent literature on the Science of Reading highlights how multiple key components concurrently inform instruction to produce a positive impact on student reading development. Young children begin the process of learning to read by first developing alphabetic decoding skills. Castles et al. summarize an extensive body of research in this area, including over 200 studies across the past 50 years. The authors argue that "learning to read in an alphabetic writing system such as English requires the acquisition of the alphabetic principle— the insight that the visual symbols of the writing system (graphemes) represent the sounds of the language (phonemes)."[36] To begin alphabetic decoding, children must have the foundational skills of letter knowledge and phonological awareness, or the understanding that words are composed of "smaller elements of speech and that these sounds are represented by symbols in written text in a systematic way."[37]

Students must develop phoneme-grapheme connections to decode words and translate decoding skills to unfamiliar texts. Yet, without proper instruction, students cannot deconstruct words into codable segments, especially words that defy common patterns. Yoncheva et al. conduct a quantitative analysis of left-lateralized N170 responses in an experimental study of 16 right-handed adults to examine the differences in grapheme-phoneme or whole-word strategies for decoding words. The study shows that the ability to map grapheme-phoneme connections successfully has positive implications for recognizing familiar words and decoding and self-teaching unfamiliar words. [38] Therefore, students must receive targeted support in developing decoding and mapping skills that use brain mechanisms to fluently "[categorize] orthographic input as language."[39]

To effectively read and write, **students must form connections between a text and its meaning**.[40] Phonics instruction focuses on enabling children to understand grapheme-phoneme correspondences, allowing children to decode words and draw from their existing vocabulary to assign meaning to each word. Castles et al. summarize literature verifying how "phonics supports comprehension by allowing the child to link an unfamiliar printed word with a familiar word in oral vocabulary."[41] Ober et al. find similar results in their 2020 meta-analysis, which examined 65 experimental and non-experimental empirical studies to explore connections between decoding, executive functions, and reading comprehension. Results demonstrate that "Individual differences in decoding ability are strongly associated with various reading process and skills, including phonological awareness, knowledge of spelling-sound correspondences, and sight recognition of familiar words."[42] As decoding and language comprehension are essential for readers to become skilled at reading, certain readers may be more skilled in one of these aspects than another, wherein reading

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[35] Figure text reproduced verbatim from: "Report of the National Reading Panel: Teaching Children to Read: Findings and Determinations of the National Reading Panel by Topic Areas." National Institute of Child Health and Human Development, April 2000. https://www.nichd.nih.gov/publications/pubs/nrp/findings
[36] Castles, et. al. Op. cit., p. 11.
[37] Solari, Grimm, and Henry, Op. cit., p. 2.
[38] Yoncheva, Wise, and McCandliss, Op. cit., p. 32.
[39] Ibid.
[40] Castles, Rastle, and Nation, Op. cit., p. 10.
[41] Ibid., p. 14.
[42] Ober et al., Op. cit.

comprehension may become difficult for children who have specific word recognition difficulties (SWRD), specific reading comprehension difficulties (SRCD), or mixed reading difficulties (MRD).[43]

According to foundational research conducted by the National Reading Panel in the 1990s, instruction in phonics improved student skills in decoding, spelling, and text comprehension.[44] Drawing on 66 treatment-control group comparisons from 38 experimental studies, researchers find that phonics positively impacts spelling, decoding, and comprehension outcomes, particularly when students begin learning phonics in Kindergarten and Grade 1.[45] Similarly, Margie Gillis, Ed.D. spoke at the Florida Branch of the International Dyslexia Association (FLIDA) Conference of the importance of phonics being explicitly taught and "embedded in a rich and deep language context".[46] Researchers caution that effective systematic phonics instruction in Kindergarten must be developmentally appropriate for young learners and "begin with foundational knowledge involving letters and phonemic awareness."[47]

As children become more advanced readers, their reliance on alphabetic decoding decreases as they "[recognize] familiar written words rapidly and automatically, mapping their spellings directly to their meanings without recourse to decoding, a process [...] referred to as *orthographic learning*."[48] This phase of reading requires several skills, such as linguistic comprehension—the ability to comprehend spoken language. In a foundational study from 1990 on reading comprehension development, Hoover and Gough use results from a longitudinal study on elementary school students to assert that linguistic comprehension becomes an essential component of reading comprehension in the middle elementary grades.[49] Further, several decades of research identify Grades 3 and 4 as a transitional period for children when there is a notable increase in both decoding and comprehension abilities.[50]

As students learn and develop as readers, they rely less on alphabetic decoding, which becomes automatic. However, phonological processes remain important as students progress towards orthographic learning and fluency.[51] Castles et al. highlight the importance of orthographic learning to promote fluency through self-teaching, increased exposure to texts, and increased connections between spelling and meaning, including the spelling and meaning of irregular words.[52] For example, the National Reading Panel reviews 14 studies on the impacts of oral reading fluency on reading development, finding that repeated guided oral reading positively impacts reading achievement. Specifically, quantitative results demonstrate that guided oral reading produces the largest effect on reading accuracy with a mean effect size of 0.55, followed by fluency (mean effect size 0.44) and comprehension (mean effect size 0.35). These data result in an aggregate effect size of 0.50, corresponding to a moderate effect on reading based on the panel's methodology.[53]

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[43] Gillis, M.B. "How RTI Supports Early Identification of Students with Different Reading Profiles." *Dyslexia IDA*, 2017. Perspectives on Language and Literacy. p. 2.

[44] Castles, et. al. Op. cit., p. 12.

[45] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction." National Reading Panel, 2000. pp. 2–92, 2–93. https://www.nichd.nih.gov/sites/default/files/publications/pubs/nrp/Documents/report.pdf

[46] Gillis, M. "The Science of Reading: Comprehensive Literacy for ALL Students." , FLIDA Conference, September 23, 2017. http://fl.dyslexiaida.org/wp-content/uploads/sites/33/2017/09/The-Science-of-Reading-by-Margie-Gillis-on-09-23-2017-1.pdf

[47] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction," Op. cit., pp. 2–93.

[48] Castles, Rastle, and Nation, Op. cit., p. 19.

[49] Solari, Grimm, and Henry, Op. cit., p. 2.

[50] Ober et al., Op. cit.

[51] Castles, Rastle, and Nation, Op. cit., p. 19.

[52] Ibid., pp. 19–23.

[53] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction," Op. cit., pp. 3–2, 3–3.

As students move beyond alphabetic decoding and word recognition, text comprehension requires additional skills to draw meaning from the reading. Castles et al. synthesize previous research on reading comprehension from Perfetti and Stafura, outlining three necessary constructs: [54]

> The first is concerned with *knowledge*, be it linguistic knowledge, orthographic knowledge, or general knowledge. The second describes *processes* involved in reading, in which they include decoding, word identification, meaning retrieval, sentence parsing, inferring, and comprehension monitoring, along with the interaction of these processes with each other, and with knowledge. The third factor captures *general cognitive resources* such as memory.

A critical component within the knowledge construct is vocabulary. Although vocabulary instruction alone does not increase reading comprehension, Wright and Cervetti conclude from a qualitative analysis of 36 intervention-based studies that students receiving vocabulary interventions perform better on comprehension assessments that include taught words than students with no intervention. This result is particularly evident when interventions use active processes for learning words rather than definitions or dictionary-based approaches to instruction. [55] Notably, Wright and Cervetti find that "Even limited vocabulary instruction (i.e., less than one minute per word) is better than no vocabulary instruction at all if the goal is to support students' comprehension of a particular text."[56]

Additionally, several examined studies highlight that **students at varying levels of reading development may require different levels of instruction across the components of literacy**. Solari et al. conducted a randomized controlled trial of 300 first grade students to monitor progress in five components of reading at three points across the academic year (i.e., September, January, and May), with assessment measures in phonological awareness, word reading, fluence, linguistic comprehension, and reading comprehension. Students were placed into different profile groups based on reading ability (i.e., Low, Low-Average, Average, Above Average), which were found to have significant variation in skill and development across the subcomponents of literacy.[57] Differences in students' reading abilities "highlight[s] the wide range of reading instruction necessary to adequately address the reading needs of students in first grade."[58]

Specifically, the authors find that while students in the Low-Average and Average profile groups demonstrated improvements in reading skills across the three assessments in the examined academic year, students in the Low profile group did not achieve average-range outcomes in this same timeframe. In response, the authors summarize past literature confirming that "children who are struggling with reading early tend to struggle across elementary school and beyond," and highlight the necessity of targeted supports to enable these students to develop the necessary literacy skills for future success.[59] Knowing a student's trajectory may support targeted and effective instruction, particularly among elementary school students with reading challenges and those with low-average skill levels.[60]

Similarly, Ober et al. raise the discussion of the Matthew effect in their study of executive functioning and decoding, noting that "children with reading experiences and abilities that set them behind their typically developing peers tend to fall further and further behind peers as they develop."[61] Specifically, young children with limited executive functioning may struggle more than their peers in utilizing the necessary cognitive resources for processing text, causing decoding processes to take longer and require more effort. This challenge results in a "developmental cascade" that may begin in early childhood with small differences and

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[54] Block quote reproduced verbatim from: Castles, Rastle, and Nation, Op. cit., p. 28.
[55] [1] Wright, T.S. and G.N. Cervetti. "A Systematic Review of the Research on Vocabulary Instruction That Impacts Text Comprehension." *Reading Research Quarterly*, 52:2, April 2017. pp. 207, 219. Retrieved from EBSCOhost. [2] Castles, Rastle, and Nation, Op. cit., p. 36.
[56] Wright and Cervetti, Op. cit., p. 219.
[57] Solari, Grimm, and Henry, Op. cit., pp. 1, 4, 8–11.
[58] Ibid., p. 10.
[59] Ibid., p. 1.
[60] Ibid., p. 11.
[61] Ober et al., Op. cit., p. 753.

accumulate as children age to impact their development and cognitive processes.[62] Put succinctly, "Reading becomes a more challenging task when children have insufficient decoding skills or limited vocabulary, thus placing increased demands on cognitive resources."[63]

Lastly, considering the importance of the intensity of instruction, Coyne et al. compared the differences between two studies focused on what was considered Tier-2 interventions. Upon comparing these studies, students who required more interventions needed these to be "implemented with a high degree of intensity to impact or accelerate reading outcomes" which tended to be further than what most school were implementing at this level.[64] Coyne et al. defined instructional intensity to include the assurance that interventions "(a) use an evidence-based platform with content that is aligned to the needs of students, (b) increase dosage (i.e., supplement classroom reading instruction to increase total amount of time of reading instruction), (c) are delivered with consistency (i.e., similar minutes per day, days per week, total weeks), (d) are implemented with fidelity (i.e., instructional tools and programs are implemented as intended), and (e) are implemented with quality (i.e., maximize explicit instruction, opportunities to respond, high levels of engagement)."[65]

CONCLUSIONS

Despite ongoing education, linguistic, psychological, and neuroscience research, the reading wars and what constitutes the Science of Reading continue to cause division among education stakeholders. Contributing to the debate on teaching literacy is a lack of consensus of what the Science of Reading is.[66] Although the Science of Reading does not have a standard definition, researchers concur that it comprises an ongoing collection of research on reading development and instruction.[67] Opponents to the Science of Reading often highlight the concept's narrow focus and overemphasis on certain elements of instruction, namely decoding.[68] Other opponents may understand the concept of the Science of Reading but disagree with how these ideas manifest in districts (e.g., teachers forced to apply a prescribed approach to students, districts implementing costly programming).[69]

To clarify the Science of Reading, the examined studies in this report provide extensive information on the Science of Reading and how young children progress, beginning with alphabetic decoding and establishing grapheme-phoneme correspondences through phonics instruction. Children develop the vocabulary and fluency necessary to become skilled word readers and comprehend text without requiring intentional decoding processes. Neuroscience research suggests that this development that enables reading comprehension is possible through a ventral pathway in the brain that forms connections between visual and phonological meaning.

Further, these studies consistently highlight the importance of developing age-appropriate decoding and phonological awareness skills in young children to support literacy development and text comprehension abilities in later grades. Targeted instruction and interventions will be required to identify students struggling in the early stages of literacy development and ensure they are equipped with the decoding and phonics support necessary to succeed. Reflecting on these themes:[70]

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[62] Ibid.

[63] Ober et al., Op. cit., p. 754.

[64] Coyne, M.D. et al. "Evaluating the Effects of Supplemental Reading Intervention Within an MTSS or RTI Reading Reform Initiative Using a Regression Discontinuity Design." *Sage Journals*, 84:4, May 15, 2018.

[65] Ibid.

[66] [1] Lane, Op. cit. [2] Townsend, D. "What Is the 'Science of Reading,' and Why Does It Matter?" University of Nevada, Reno, October 5, 2021. https://www.unr.edu/nevada-today/news/2021/atp-science-of-reading

[67] Goodwin and Jiménez, Op. cit., p. S7.

[68] [1] Shanahan, Op. cit., p. S236. [2] Townsend, Op. cit.

[69] Fofaria, R.R. "What Does This Science of Reading Bill Really Mean, and How Did We Get Here?" EducationNC, April 6, 2021. https://www.ednc.org/2021-04-06-science-reading-bill-nc-north-carolina-instruction-explain-educators-teacherss/

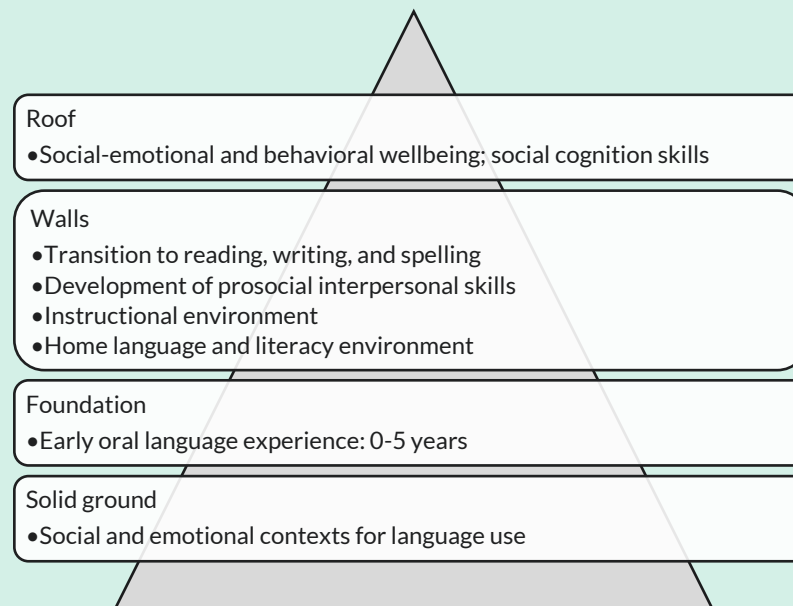[70] Block quote reproduced verbatim from: Castles, Rastle, and Nation, Op. cit., p. 39.

The guiding principle here would be that although there are many different aspects of reading that must be learned—alphabetic decoding, fluent word reading, text comprehension—this does not mean that instructional time should be devoted equally to all of them at all points in reading acquisition. Rather, instructional regimens to support these various abilities are likely to be most effective at particular points in development, and limited teaching time should be structured to reflect this.

Integrating Reading with Language and Social-Emotional Development

Given the COVID-19 pandemic and its significant impact on the social-emotional needs of students, and an education sector-wide shift towards social-emotional learning (SEL), the following research notes the work of Pamela Snow and her expansion of reading development to include SEL. Snow advocates for the integration of reading and language with an emphasis on social-emotional considerations through her framework, the Science of Language and Reading (SOLAR). Snow describes this framework through the Language House analogy in which social-emotional contexts provide the "solid ground" on which "strong foundations" of early language skills develop before students enter school.[71] Following the foundation, four walls are built from literacy, interpersonal, and different environmental factors, and a roof of inter- and intra-personal skills complete the house. Figure 1.3 provides a visual representation of this analogy.

Figure 1.3: The Language House Depiction of the SOLAR Framework

Roof
• Social-emotional and behavioral wellbeing; social cognition skills

Walls
• Transition to reading, writing, and spelling
• Development of prosocial interpersonal skills
• Instructional environment
• Home language and literacy environment

Foundation
• Early oral language experience: 0-5 years

Solid ground
• Social and emotional contexts for language use

Source: *Child Language Teaching and Therapy*[72]

Further, Snow notes that although the Language House image presents distinct components, the structure is interconnected. Reading, writing, language, and social-emotional skills reflect this interconnectedness (e.g., vocabulary supports spoken communication, reading comprehension, and writing ability).[73]

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[71] Snow, P.C. "SOLAR: The Science of Language and Reading." *Child Language Teaching and Therapy*, 2020. pp. 1–3. Retrieved from SAGE Journals.
[72] Figure reproduced with modifications from: Ibid., p. 3.
[73] Ibid., p. 9.

EXPLORING THE EFFICACY OF THE SCIENCE OF READING COMPONENTS

Empirical literature discussing the Science of Reading components' impact on reading development presents largely positive results regarding student outcomes and practical research implications. Multiple empirical studies that analyze discrete or all five key reading components (i.e., phonemic awareness, phonics, fluency, vocabulary, comprehension) determine that components support reading ability or identification of students' instructional needs. Figure 1.4 presents a review of the studies examined for this report as identified through the methodology described above and organized by year and the leading author's last name.

Figure 1.4: Summary of Literature on the Science of Reading

AUTHORS, YEAR, AND PURPOSE	METHODOLOGY	RESULTS AND IMPLICATIONS	LIMITATION(S)
Solari, E. J. et al. (2021)[74] • To determine the number of distinct reading profiles within the sample • To identify any significant differences in reading comprehension between profiles at designated points in time • To observe any differences in early reading subcomponent skills	• *Randomized control trial using a sample of 300 Grade 1 students* • Students participated in assessments three times during one academic year (i.e., September, January, May) • Trained assessors worked with the second author to prepare for and administer assessments • Assessment measures include phonological awareness, word reading, fluency, linguistic comprehension, and reading comprehension, each of which used specific timed or untimed subtests • Scored subtests included various tasks including sight reading words and texts, answering reading and listening comprehension questions posed by assessors	• Sample means and standard deviations present "average range performance" for all assessment measures • Researchers determine four distinct reading profiles (i.e., Low, Low-Average, Average, Above Average) • Students aligned with all profiles improved, except for the Above Average group, and the Average group nearly reached the Above Average outcomes by the May assessment • Only the Low group did not achieve average-range outcomes by the May assessment and demonstrates long-term risk if students do not receive targeted support, though these students should be easily identifiable for comprehensive (i.e., multi-skill) support • Profile groups demonstrate significant variations in subcomponent skills and development differs across skills on decoding and meaning-based, which shows that Grade 1 students have diverse instructional needs • Differences in measured outcomes demonstrate that students must develop subcomponent skills, not simply decoding and word reading skills, and teachers must attend to the needs of students nearing but still below average-range performance	• The Low profile contained about half of the study sample, which may be disproportionately large

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[74] Solari, Grimm, and Henry, Op. cit.

AUTHORS, YEAR, AND PURPOSE	METHODOLOGY	RESULTS AND IMPLICATIONS	LIMITATION(S)
Ober, T. M., et al. (2020)[75] ▪ To assess the correlation between executive function (EF) and decoding ▪ To explore variations in correlation based on EF elements (i.e., working memory, task-switching, inhibitory control) and decoding elements (i.e., word and nonword reading) ▪ To assess the effects of intervention or demographic characteristics ▪ To review any longitudinal change	▪ *Meta-analysis of 65 studies published between 1999 and 2019, which authors statistically coded as correlational and concurrently measured or other (i.e., cross-sectional, longitudinal, experimental)* ▪ Followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and checklist for selecting studies ▪ Conducted multiple univariate and multivariate meta-analyses for determining overall effect sizes and a robust variance estimation (RVE) approach for determining multiple effect sizes that control for non-independence of factors ▪ Reviewed data for longitudinal effects through meta-analytic structural equation modeling ▪ Assessed variations in effect sizes based on EF, coding, and sample (e.g., age) factors	▪ EF constructs, including inhibitory control, task-switching, and working memory, significantly effect word and nonword reading measures of decoding ▪ Age demonstrates a small decreasing effect on EF-decoding associations, which the literature contends is a result of reading experience leading to lighter cognitive demands and more efficient EF (i.e., experience leads to greater automaticity and less need for EF processes) ▪ Non-age moderators do not significantly impact EF-decoding associations, but researcher caution that moderators may produce significant effects under other research conditions ▪ Findings show that challenges with EF or decoding may negatively affect students' reading development trajectories (e.g., early learners with limited EF abilities may face challenges with cognitive processes, leading to slower decoding and slower subsequent literacy skill development) ▪ Results raise discussion of the Matthew effect in which "children with reading experiences and abilities that set them behind their typically developing peers tend to fall further and further behind peers as they develop" ▪ Findings demonstrate the potential for understanding EF-decoding associations beyond elementary school	▪ Cannot confirm causation given correlation within data ▪ Potential for additional moderators for which researchers do not account ▪ Potential problems with EF outcome measurements that may lead to overestimated effect sizes ▪ Limits number of EF processes under investigation ▪ Conducts analysis based on previous literature that contain gaps ▪ Select studies are non-experimental

[75] Ober et al., Op. cit.

AUTHORS, YEAR, AND PURPOSE	METHODOLOGY	RESULTS AND IMPLICATIONS	LIMITATION(S)
Castles et al. (2018)[76] ■ To provide an overview on the science of learning to read and why certain components, particularly phonics, are critical for understanding the English language ■ Situates literature and discussion around future research and instruction within the context of the reading wars	■ *Reviews 20th and 21st-century literature in three parts: (1) on the alphabetic code and how it forms the foundation for English reading development to demonstrate why certain instructional methods work, (2) on word-recognition fluency and how ongoing and diverse experience engaging with texts supports development, and (3) on the various processes that impact reading comprehension*	■ Two main factors impact why many remain opposed to phonics instruction: (1) educators lack an understanding of the efficacy of phonics to support alphabetic knowledge, and (2) stakeholders beyond educators lack an understanding of how science and research connect to reading comprehension, which causes the promotion of phonics to appear unwarranted ■ Literature highlights three "messages" regarding the evidence presented in the science of reading: (1) writing is important, (2) experience is important, and (3) reading development comprises multiple processes ■ Language and writing must inform instruction and research, and teachers must receive proper training on reading instruction ■ Although reading requires instruction on multiple skills and instruction, this does not mean that teachers should allocate instructional time equally across components ■ Thus, skilled readers of alphabetic writing systems continue to draw on the systematic relations between letters and sounds when they read and understand words. These skills alone, however, are not sufficient for fluent word reading	■ Focuses on general education students, not students with learning challenges

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[76] Castles, Rastle, and Nation, Op. cit.

AUTHORS, YEAR, AND PURPOSE	METHODOLOGY	RESULTS AND IMPLICATIONS	LIMITATION(S)
Wright and Cervetti (2016)[77] *As referenced in Castles et al. (2018)* ■ To explore the impact of vocabulary instruction on reading comprehension	■ *Conducts an analysis of 36 intervention-based studies that include students from pre-Kindergarten through Grade 12* ■ Explores studies using literature review and qualitative analysis approaches ■ Includes studies that instruct by teaching word meanings directly and teaching word-solving strategies ■ Analyzes differences in outcomes based on study characteristics (e.g., duration, intervention, word selection, active versus inactive processing)	■ Teaching word meaning through vocabulary instruction leads to increased reading comprehension for passages containing the taught words ■ Instructional methods that require active processing demonstrate greater effectiveness than passive processing (e.g., teaching definitions); however, the optimal intensity level of instruction is unclear ■ Results provide limited evidence that direct word instruction improves general reading comprehension ■ Results demonstrate no evidence that implementing one or two strategies for vocabulary development supports overall reading comprehension	■ Lacks sufficient studies to determine the relative impact of various vocabulary instructional methods on reading comprehension ■ Studies contain potential publication bias ■ Unable to assess longitudinal effects
Martin et al. (2015) ■ To compare brain activation patterns during reading in children and adults	■ *Conducts a quantitative meta-analysis of 40 fMRI studies, 20 of which study children and 20 of which study adults* ■ Includes studies based on three main criteria: (1) studies analyze healthy humans using fMRI technology, (2) studies implement reading or reading-related tasks with a visual element, and (3) study results provide single-contrast 3-D coordinates using a standard stereotactic space	■ Results provide quantifiable evidence of the differences and similarities between child and adult brain mechanics during reading ■ Commonalities between children and adults include brain activation in the left ventral occipito-temporal and inferior frontal gyri ■ Differences between child and adult brain activation demonstrate how beginning and experienced readers naturally apply distinct brain processes	■ Challenges inherent to original studies and with matching these child and adult studies

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[77] Wright and Cervetti, Op. cit.

AUTHORS, YEAR, AND PURPOSE	METHODOLOGY	RESULTS AND IMPLICATIONS	LIMITATION(S)
Yoncheva et al. (2015)[78] ▪ To test (1) whether grapheme-phoneme decoding new words using a newly created language engages left-lateralization mechanisms, which is associated with knowing a script rather than recognizing whole word forms, and (2) how grapheme-phoneme decoding impacts subsequent reading	▪ *Conducts a quantitative analysis of left-lateralized N170 responses in an experimental study of 16 young, right-handed adults* ▪ Participants received training of equal length on new words in a fabricated language using grapheme-phoneme *or* whole-word instructional practices ▪ Following training, participants then engaged in an electroencephalography reading verification assessment and a series of questions about their approach to reading the new words ▪ Researchers analyze cognitive processing and compare accuracy, speed, how initial reading impacts further reading, where participants focus their attention and participant outcomes based on the instructional method used	▪ Grapheme-phoneme decoding impacts reading speed and accuracy of subsequent decoding, particularly among unfamiliar words ▪ Only participants with grapheme-phoneme-driven instruction experience left-lateralized N170 responses (i.e., a neurological response associated with a specific timeframe that indicates word identification), demonstrating that brain function is influenced by how participants learned the new script ▪ Participants using whole-word skills read faster and more accurately than those using grapheme-phoneme, though grapheme-phoneme-trained participants demonstrate skilled use of reading new and unfamiliar words ▪ When learning something new, focusing learners' attention is important for ensuring strong decoding skills and targeting "left-lateralized phonological regions"	▪ N/A

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[78] Yoncheva, Wise, and McCandliss, Op. cit.

AUTHORS, YEAR, AND PURPOSE	METHODOLOGY	RESULTS AND IMPLICATIONS	LIMITATION(S)
Perfetti and Stafura (2014)[79] *As referenced in Castles et al. (2018)* ▪ To present the Reading Systems Framework, which uses a wider scope than many other frameworks and focuses on the lexicon	▪ *Synthesizes research on reading theories generally and the proposed Reading Systems Framework* ▪ Analyzes the interaction between word identification processes and comprehension processes and how lexical knowledge and word meaning bridge these processes	▪ Proposes the Reading Systems Framework based on three claims about reading: (1) reading requires three types of knowledge (i.e., linguistic, orthographic, general); (2) reading processes use the types of knowledge distinctly and interactively; and (3) reading processes occur in a cognitive system that connects to other systems and relies on limited processing resources	▪ N/A
Hoover and Gough (1990)[80] *As referenced in Castles et al. (2018)* ▪ To analyze the longitudinal effects of decoding and linguistic comprehension on reading	▪ *Conducts a longitudinal study on the impact of decoding and linguistic comprehension on reading among bilingual Grade 1 through Grade 4 students*	▪ Decoding and listening skill-levels help explain differences in student reading comprehension, particularly when observing the product of these factors ▪ Decoding and listening comprehension correlations are often negative among readers at lower reading levels ▪ For students with strong decoding skills, as listening comprehension increases, reading comprehension expands at increasing rates	▪ N/A

Source: Multiple cited within the figure.

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[79] Perfetti, C. and J. Stafura. "Word Knowledge in a Theory of Reading Comprehension." *Scientific Studies of Reading*, 18:1, January 2, 2014. http://www.tandfonline.com/doi/abs/10.1080/10888438.2013.827687
[80] Hoover, W.A. and P.B. Gough. "The Simple View of Reading." *Reading and Writing*, 2:2, June 1, 1990. https://link.springer.com/article/10.1007%2FBF00401799

SECTION II: USING THE SCIENCE OF READING FOR EFFECTIVE INSTRUCTION

In this section, Hanover reviews evidence demonstrating the effectiveness of the Science of Reading components that positively impact reading instruction and outcomes. Given the expansive collection of literature on these components, this section presents seminal publications according to the methodology described above.

DESCRIPTIVE SUMMARIES OF PRACTICES BASED ON THE SCIENCE OF READING

PHONEMIC AWARENESS

Phonemic awareness instruction significantly and positively impacts students' reading outcomes, including comprehension, word reading, and spelling.[81] In the seminal National Reading Panel report, researchers present findings from a meta-analysis of 52 experimental and quasi-experimental studies with 96 treatment and control group comparisons.[82] Following statistical analysis, researchers conclude that explicit phonemic awareness instruction supports all students in gaining this foundational skill, both in the short- and long-term, and that phonemic awareness is a transferable skill that expands as students apply it to reading and writing activities.[83] Moreover, the National Reading Panel finds that phonemic awareness skills improve students' reading (e.g., word reading, pseudoword reading, comprehension) and spelling capabilities in the short- and long-term. Further analyses demonstrate that certain conditions produce greater impacts on phonemic awareness (i.e., optimal instruction is five to 18 hours long, applies small-group instruction occurs before Grade 1, focuses on one or two skills at a time, and includes letters).[84] In addition to these conditions, Coyne et al. noted statistically significant impacts on phonemic awareness and decoding when students had additional intervention, such as those which are found in Tier-2 frameworks.[85]

In a 2016 assessment-based study, Wade-Woolley expands on the positive impact of phonemic awareness on reading through an analysis of 110 students in Grades 4 and 5. Here, Wade-Woolley measures phonemic awareness and prosodic awareness (i.e., knowing how to impose stress and intonation in multisyllabic words) and how these skills are differentially related to reading long and short words through distinct assessments for phonemic awareness, prosodic awareness, word reading, and nonword decoding.[86] Specific assessments analyzed word reading using a list of words from the Educator's Word Frequency Guide (i.e., the word reading assessment), the Word Attack subtest of the Woodcock Reading Mastery Test—Revised (i.e., the nonword reading test), the Phoneme Elision subtests of the Comprehensive Test of Phonological Processing (i.e., the phonemic awareness test), and the Aural Stress Assignment task (i.e., the prosody test).[87] Results confirm that both phonemic and prosodic awareness are positively correlated with reading and individually impact students' reading ability. Specifically, phonemic and prosodic processes predict successful reading when reading long words (i.e., three or four syllables). For short words, again, both processes distinctly affect reading outcomes, though phonemic awareness had a greater influence.[88]

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[81] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction," Op. cit., pp. 2–3.

[82] Ibid., pp. 2–15.

[83] Ibid., pp. 2–28, 2–40.

[84] Ibid., pp. 2–3, 2–4.

[85] Coyne et al., Op. cit.

[86] Wade-Woolley, L. "Prosodic and Phonemic Awareness in Children's Reading of Long and Short Words." *Reading & Writing*, 29:3, March 2016. pp. 371, 374–375. Retrieved from EBSCOhost.

[87] Ibid., pp. 374–375.

[88] Ibid., pp. 378–379.

Relatedly, phonological awareness (i.e., the early development of basic speech and sound identification, such as rhyme and syllable awareness, which includes phonemic awareness) comprises a critical skill in understanding how sounds connect. Specifically, the article on compelling Science of Reading evidence by Petscher et al. (2020) draws from multiple authors to summarize how "phonological awareness and alphabet knowledge are substantial correlates and predictors of decoding skills."[89] Such early letter-sound perception that connects to later decoding begins before formal reading instruction and impacts future comprehension. Therefore, identifying young students with deficiencies in phonological skills enables educators to identify those at risk of reading challenges.[90]

PHONICS

Systematic phonics instruction helps students learn to read, significantly more so than alternative or no phonics instruction. The National Reading Panel's phonics-centered meta-analysis of 38 experimental and quasi-experimental studies with 66 treatment-control group comparisons shows that phonics instruction positively and significantly impacts students' growth in reading compared to students who received unsystematic or no phonics instruction.[91] Three phonics programs discussed by the National Reading Panel that all support student literacy with no statistically significant difference in outcomes include those on *synthetic phonics* (i.e., a program teaching students to convert letters into sounds before combining these elements into words), *larger-unit phonics* (i.e., a program teaching students to analyze and blend phonemes and larger parts of words), and *miscellaneous phonics* (i.e., programs teaching phonics systematically but differently than the two preceding programs).[92]

> *"In addition to promoting the refinement of known word representations […] proficiency in manipulating attained grapheme-phoneme associations serves as a crucial self-teaching device, which enables beginning readers to decode novel words that they have not encountered previously."[88]*
>
> *- Yoncheva et al.*

As students become more familiar with phoneme-grapheme connections and how to decode them, they gain the ability to read increasingly complex words, therefore shifting attention from word reading to comprehension. As Duke et al. describe in reference to Suggate, "instruction aimed at improving students' word reading, including through phonemic awareness and phonics instruction, often has a positive impact on reading comprehension."[94] Demonstrating the impact of phonics on reading, Suggate conducts a meta-analysis of 71 intervention-based treatment-control group studies with follow-up data to determine the long-term effects of instruction and associated moderators.[95] With a total sample of 8,161 students in pre-Kindergarten through Grade 6, Suggate finds that reading interventions, including phonics, significantly impact reading outcomes, though effects diminish over time.[96] Specifically, "on average, 11 months after participating in interventions with a phonemic awareness, phonics, fluency, or comprehension approach, a small effect of the intervention remained."[97] Notably, moderators include the grade level and intervention type. Grade-level analyses indicate that interventions were 3.5 times more effective for students in Grade 3 and 4 than in pre-Kindergarten and Kindergarten. Additional follow-up analyses demonstrate that students maintained and transferred phonemic awareness and comprehensions skills more than phonics and fluency skills. Suggate attributes this outcome to either the increasing returns of phonemic awareness or how "all children— also including control group children—either receive instruction in phonics

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[89] Petscher et al., Op. cit., pp. S270–S271.

[90] Ibid., p. S271.

[91] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction," Op. cit., pp. 2–92.

[92] Ibid., pp. 2–93.

[93] Block quote reproduced nearly verbatim from: Yoncheva, Wise, and McCandliss, Op. cit., p. 2.

[94] [1] Duke, Ward, and Pearson, Op. cit., p. 664. [2] Suggate, S.P. "A Meta-Analysis of the Long-Term Effects of Phonemic Awareness, Phonics, Fluency, and Reading Comprehension Interventions." *Journal of Learning Disabilities*, 49:1, February 1, 2016. Retrieved from EBSCOhost.

[95] Suggate, Op. cit., pp. 77, 81.

[96] Ibid., pp. 77, 86.

[97] Ibid., p. 86.

skills or develop these skills implicitly […] during regular schooling between posttest and follow-up, such that any advantage for the constrained phonics skills […] washes out."[98]

Additionally, building student understanding of letter-sound correspondence demonstrates particular importance in developing literacy in students with or at risk for reading challenges and those for whom English is a second language. Phonics instruction can help students both by preventing and remediating reading difficulties. For example, the National Reading Panel's meta-analysis of 38 experimental and quasi-experimental studies found substantially improved reading growth and performance among younger students (i.e., 0.58 effect size for Kindergarten students and 0.74 effect size for Grade 1 students), identified by research as at-risk for future reading issues, and students with reading difficulties (i.e., 0.32 effect size for students with an IQ-reading ability discrepancy).[99] Ultimately, researchers conclude that "systematic phonics instruction is significantly more effective than non-phonics instruction in helping to prevent reading difficulties among at-risk students and in helping to remediate reading difficulties in disabled readers."[100] Further, systematic and explicit phonics instruction comprises one of the components described by Petscher et al. (2020) as having "Compelling Evidence in the Science of Reading."[101] This practice supports reading outcomes for monolinguistic and dual-language students learning to decode words and foundational skills associated with decoding.[102]

Earle and Sayeski further indicate how systematic, explicit phonics instruction supports literacy development among students with reading disabilities who require more significant interventions and repetition in their literature review of studies from 1984 to 2016 on letter-sound correspondence. Through explicit, systematic instruction, teachers outline clear language and apply phoneme-grapheme mapping practice. Direct and explicit phoneme-grapheme mapping calls on teachers to select specific skills and tools for teaching the concept (e.g., a new and challenging sound) and the language and format used to teach the concept. Early and Sayeski emphasize the model-lead-test format followed by independent practice for phoneme-grapheme mapping instruction.[103]

> ### 🔍 Training Preservice and In-Seat Teachers
>
> **Additionally, including phonics within preservice teacher (PST) training comprises an effective approach for supporting phonics instruction with implementation fidelity.** Although incorporating other key components of reading in PST and in-seat training may also improve teachers' instruction and student outcomes as demonstrated by Hindman et al. and Pyle et al., Englert et al. analyze phonics interventions, specifically, and confirm their effectiveness in increasing PST knowledge, confidence, and value in supporting reading skills among students with disabilities.[104] Specifically, Englert et al. conducted an intervention-based study comprised of 48 PSTs and found that increasing PSTs' knowledge of and confidence in teaching phonics through coursework, scaffolded teaching tools, and supported practical experience leaders to increases in teacher quality and student literacy.[105] The authors conclude that

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[98] Ibid., pp. 87–88.

[99] "Report of the National Reading Panel: Teaching Children to Read: Findings and Determinations of the National Reading Panel by Topic Areas," Op. cit., pp. 2–94.

[100] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction," Op. cit., pp. 2–94.

[101] Petscher et al., Op. cit., pp. S270–S271.

[102] Ibid., p. S271.

[103] Earle, G.A. and K.L. Sayeski. "Systematic Instruction in Phoneme-Grapheme Correspondence for Students With Reading Disabilities." *Intervention in School and Clinic*, 52:5, 2017. p. 263. Retrieved from SAGE Journals.

[104] [1] Englert, C.S. et al. "Preparing Special Education Preservice Teachers to Teach Phonics to Struggling Readers: Reducing the Gap Between Expert and Novice Performance." *Teacher Education and Special Education*, 43:3, 2020. Retrieved from SAGE Journals. [2] Hindman, A.H. et al. "Bringing the Science of Reading to Preservice Elementary Teachers: Tools That Bridge Research and Practice." *Reading Research Quarterly*, 55, 2020. Retrieved from EBSCOhost. [2] Pyle, N. et al. "Effects of Expository Text Structure Interventions on Comprehension: A Meta-Analysis." *Reading Research Quarterly*, 52:4, 2017. pp. 494–495. Retrieved from EBSCOhost.

[105] Englert et al., Op. cit., pp. 238–252.

"tutoring can be an effective means to address the phonics difficulties of struggling readers and that PSTs also may benefit from implementing a systematic and intensive phonics protocol."[106]

Further, in Earle and Sayeski's review of misconceptions and best practices for letter-sound development, the authors warn that gaps in teacher knowledge of language structure can prevent effective instruction (e.g., teachers mispronouncing sounds or providing inaccurate examples of letter-sound connections in words). Therefore, Earle and Sayeski suggest that teachers use consistent pronunciations and improve their own skills using online or peer supports to ensure effective instruction.[107]

FLUENCY

Fluency supports reading comprehension, as students who struggle to decode and recognize words are also likely to struggle to understand what they are reading. According to the IRIS Center, "fluency develops when students practice reading and rereading words, passages, or other texts with a high degree of success."[108] Reading fluency can be seen as the "culmination of early reading skill development," because achieving reading fluency requires phonological awareness, alphabet knowledge, and word decoding skills.[109] As described by Duke et al., fluency functions as the connection between decoding and comprehension as students build reading accuracy and automaticity.[110]

"Reading for themselves allows children to build their experience with printed words, which […] is crucial for building word-reading fluency. Once children can read even simple texts on their own—either for pleasure or for learning—their exposure to words grows rapidly"[106]

-Castles et al.

Fluency instruction and development incorporate repeated reading practices and typically occur during early elementary school through Grade 3 or 4, with additional gains made in later years for some students.[112] Rupley et al., present a historical, qualitative review of fluency and synthesize findings from Rasinski et al. and Paige et al. to convey that fluency skills support academic achievement in secondary education and college entrance exam success.[113] Specifically, Rasinski et al. conducted a non-randomized study of 81 first-year college students to test oral reading fluency based on a single passage. Researchers timed participants' oral reading, asked a follow-up question to ensure participants read for meaning, and collected ACT data as an additional measurement.[114] Using these data, researchers found that automaticity and accuracy (i.e., fluency) comprise key factors in college readiness, demonstrated by ACT scores. As such, researchers conclude that "both word recognition accuracy and automaticity continue to be important factors for reading and academic success into the middle, secondary, and postsecondary grades," and that monitoring fluency can support teachers in targeting instruction (e.g., wide reading, repeated reading, assisted reading) in ways that prepare students for post-secondary opportunities.[115]

[106] Ibid., p. 253.

[107] Earle and Sayeski, Op. cit., p. 267.

[108] "What Components Comprise High-Quality Reading Instruction? Page 6: Fluency." IRIS Center, Peabody College Vanderbilt University. p. 6. https://iris.peabody.vanderbilt.edu/module/rti03/cresource/q3/p06/#content

[109] Petscher, Y., E.J. Solari, and H.W. Catts. "Conditional Longitudinal Relations of Elementary Literacy Skills to High School Reading Comprehension." *Journal of Learning Disabilities*, 52:4, July 1, 2019. p. 326. Retrieved from SAGE Journals.

[110] Duke, Ward, and Pearson, Op. cit., p. 665.

[111] Block quote reproduced nearly verbatim from: Castles, Rastle, and Nation, Op. cit., p. 24.

[112] [1] "What Components Comprise High-Quality Reading Instruction? Page 6: Fluency," Op. cit., p. 6. [2] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction," Op. cit., pp. 3–28. [3] Rupley, W.H. et al. "Fluency: Deep Roots in Reading Instruction." *Education Sciences*, 10:6, June 2020. https://www.mdpi.com/2227-7102/10/6/155

[113] Rupley et al., Op. cit., p. 7.

[114] Rasinski, T.V. et al. "Reading Fluency and College Readiness." *Journal of Adolescent & Adult Literacy*, 60:4, 2016. p. 3. https://onlinelibrary.wiley.com/doi/abs/10.1002/jaal.559

[115] Ibid., pp. 5–7.

Additionally, Paige et al. analyze the impact of fluency on secondary students' success in a non-random, assessment-based study of 108 ninth grade students. Researchers use results from accuracy, automaticity, prosody, and vocabulary assessments as indicators of fluency to determine the association between fluency and reading comprehension and the extent to which indicators predict outcomes. Following assessments, supervised by researchers and school administrators, and statistical analysis, empirical evidence shows that "automaticity, word identification accuracy, and prosody form a highly reliable scale reflecting the construct of oral reading fluency."[116] Within these indicators, increasing automaticity will not necessarily lead to increased reading comprehension, though "secondary students exhibiting appropriate prosody experience advantages in comprehension processing."[117] Paige et al. further conclude that instructing and assessing accuracy, prosody, and vocabulary in secondary students with reading difficulties would support reading comprehension development.[118]

Similar to Paige et al., Petscher et al. (2019) analyze oral reading fluency in elementary school to understand implications for secondary school. Specifically, researchers conducted a longitudinal, quantitative analysis of 3,157 students (classified as English learners, students with a specific learning disability, and general education students) using Grade 3 and Grade 10 data. With these data, researchers explore the relationship between Grade 3 fluency and vocabulary and Grade 10 reading comprehension overall and between student classifications. [119] The authors find that the predictive strength of elementary oral reading fluency on secondary reading comprehension varies depending on student group, but that fluency strongly correlates with later reading comprehension among general education students.[120] Because fluency typically stabilizes by Grade 3 for general education students, fluency skills serve as early warning indicators of students being at-risk for reading comprehension difficulties in the future.[121]

Furthermore, Hudson et al. analyze 16 experimental and quasi-experimental studies with treatment-control comparison groups to understand the effect and characteristics of fluency interventions on Grade 1 through Grade 5 students with reading difficulties. Fluency interventions in these studies, published between 2000 and 2019, include repeated reading with multiple features, listening while reading, continuous reading, listening only, and neurological impress method (NIM) only.[122] Following systematic review, the authors conclude fluency interventions, particularly repeated oral reading, support reading development among students with reading difficulties. Further, results show that intentionally implementing fluency interventions led to larger effects on reading comprehension than general fluency, and one-on-one interventions with a trained instructor demonstrate a greater impact on reading than group interventions.[123]

Given the positive impact and predictiveness of oral reading fluency, teachers should provide opportunities for repeated oral reading practice to develop fluency skills. The National Reading Panel finds that instructional approaches that encourage repeated oral reading increase reading proficiency instead of silent reading. [124] To reach this conclusion, the National Reading Panel conducted a meta-analysis of 14 experimental studies comprised of students in kindergarten through Grade 12 supplemented by a qualitative review of 37 studies that did not meet meta-analysis standards for unspecified reasons.[125] The meta-analysis produced an effect size of 0.41 for guided oral reading on reading outcomes, demonstrating a moderate

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[116] Paige, D.D. et al. "Interpreting the Relationships Among Prosody, Automaticity, Accuracy, and Silent Reading Comprehension in Secondary Students." *Journal of Literacy Research*, 46:2, June 1, 2014. p. 141. Retrieved from SAGE Journals.

[117] Ibid., pp. 123, 144–146.

[118] Ibid., p. 147.

[119] Petscher, Solari, and Catts, Op. cit., pp. 324, 327.

[120] Ibid., p. 333.

[121] Ibid.

[122] Hudson, A. et al. "Fluency Interventions for Elementary Students with Reading Difficulties: A Synthesis of Research from 2000–2019." *Education Sciences*, 10:3, March 2020. pp. 5–14. https://www.mdpi.com/2227-7102/10/3/52

[123] Ibid., pp. 23–24.

[124] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction," Op. cit., pp. 3–3, 3–4.

[125] Ibid., pp. 3–2.

effect, though results are inconclusive regarding independent reading. Ultimately, the National Reading Panel states that "classroom practices that encourage repeated oral reading with feedback and guidance leads to meaningful improvements in reading expertise for students—for good readers as well as those who are experiencing difficulties."[126]

Foorman et al. add recommendations on oral reading fluency practice to support reading development. Here, researchers recommend that "each student reads connected text every day to support reading accuracy, fluency, and comprehension."[127] In making this recommendation as part of an Institute of Education Science practice guide, researchers analyzed 22 of the 56 randomized controlled trials and quasi-experimental studies on early elementary reading instruction with samples comprised of students in Kindergarten through Grade 3.[128] Regarding fluency, specifically, 18 studies "found positive effects in at least one key outcome domain for this recommendation: oral reading fluency, oral reading accuracy, reading comprehension, and word reading."[129] These studies led researchers to conclude that proactive reading and responsive reading produce comparable positive effects on early reading development, though students must have first mastered the alphabetic principle.[130]

VOCABULARY

Teaching vocabulary using instructional methods based on active processing effectively develops students' vocabularies, which supports comprehension. According to Wright and Cervetti's 2016 qualitative analysis of 36 intervention studies and the impact of interventions on passage-level comprehension, teaching word meanings supports reading comprehension when a given text contains the taught words. Specifically, instruction demonstrates greater effectiveness when students engage in active learning processes, such as comparing and contrasting word meanings and using new words in a sentence, compared to a definition or dictionary-based approach.[131] Although evidence remains unclear on how much active processing is necessary to support reading outcomes, "more attention to active processing has a stronger impact on comprehension of passages containing the taught words compared with more receptive approaches, such as exposure during reading, brief definitions, or a dictionary method."[132]

In addition to using active processing, Silverman et al. demonstrate the effectiveness of applying custom (i.e., researcher-developed) instructional methods with multiple aspects of comprehension, as opposed to standardized instructional methods, when teaching vocabulary listening comprehension and reading comprehension to support language comprehension. These researchers conducted a meta-analysis of 43 experimental and quasi-experimental studies comprising Kindergarten through Grade 5 students. Their goal was to understand the impact of language comprehension interventions (i.e., vocabulary or semantics, syntax, morphology) on students' language and reading comprehension and whether effects differ based on student group or intervention characteristics.[133] As stated, custom instruction methods, including those that teach vocabulary, demonstrate effectiveness in developing language comprehension, and researchers add that instruction that combines aspects of language comprehension (i.e., vocabulary and semantics, syntax, morphology) is more beneficial than isolated instruction.[134] According to Silverman et al., "interventions

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[126] Ibid., pp. 3–3.

[127] Foorman, B. et al. "Foundational Skills to Support Reading for Understanding in Kindergarten Through 3rd Grade." National Center for Education Evaluation and Regional Assistance (NCEE), Institute of Education Sciences, U.S. Department of Education, July 2016. p. 32. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/wwc_foundationalreading_040717.pdf

[128] Ibid., pp. 82–89.

[129] Ibid., p. 83.

[130] Ibid., pp. 82–83.

[131] Wright and Cervetti, Op. cit., pp. 206–209, 219–220.

[132] Ibid., pp. 215, 219.

[133] Silverman, R.D. et al. "Beyond Decoding: A Meta-Analysis of the Effects of Language Comprehension Interventions on K–5 Students' Language and Literacy Outcomes." *Reading Research Quarterly*, 55, September 2, 2020. pp. S207, S209–S210. Retrieved from EBSCOhost.

[134] Ibid., pp. S221–S230.

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including attention to both vocabulary and morphology showed positive effects on vocabulary, and interventions combining syntax and vocabulary showed positive effects on reading comprehension."[135]

Vocabulary instruction should comprise a variety of methods, including direct and indirect methods, that engage readers and provide exposure to different texts. Given the lack of experimental studies analyzing targeted vocabulary instruction and outcomes, the National Reading Panel concludes that a meta-analysis on this key component was not possible given the panel's criteria. However, the National Reading Panel conducted a less robust analysis of 47 studies, comprising mostly Grades 3 through 8 students and using a range of methodological approaches and variables. Through this detailed review, the panel concludes that a combination of teaching methods best supports students in learning vocabulary and that age- and ability-appropriate instructional methods are important for effective vocabulary acquisition.[136] Figure 2.1 contains nine implications for instructional practices based on the National Reading Panel's review.

Figure 2.1: National Reading Panel Conclusions on Vocabulary Instruction

- Vocabulary should be taught both directly and indirectly.
- Repetition and multiple exposures to vocabulary items are important.
- Learning in rich contexts is valuable for vocabulary learning.
- Vocabulary tasks should be restructured when necessary.
- Vocabulary learning should entail active engagement in learning tasks.
- Computer technology can be used to help teach vocabulary.
- Vocabulary can be acquired through incidental learning.
- How vocabulary is assessed and evaluated can have differential effects on instruction.
- Dependence on a single vocabulary instruction method will not result in optimal learning.

Source: National Reading Panel[137]

These nine implications for vocabulary instruction demonstrate how vocabulary research within the Science of Reding may be used to inform everyday instructional practices. Baker et al. concur with the National Reading Panel conclusion that instruction should comprise multiple instructional methods, specifically for English learners, in their recommendation to "Teach a set of academic vocabulary words intensively across several days using a variety of instructional activities." [138] In making this recommendation, Baker et al. reference six of the guide's 15 randomized controlled trials and quasi-experimental studies on vocabulary, reading, and English language instruction comprised of English learners in pre-Kindergarten through Grade 7.[139] All studies in this analysis use multiple interventions with multiple instructional components, including targeted academic words, explicit and in-depth instruction, and instruction and activities on word learning.[140] Baker et al. add that "as there is no contradictory negative evidence, the panel has assigned a *strong evidence* rating for this recommendation."[141] Specific teaching practices include selecting brief and engaging passages for instruction, focusing on a narrow set of academic vocabulary for multiple lessons, teaching new words in multiple ways (e.g., listening, speaking, writing), and providing strategies for learning new words independently.[142]

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[135] Ibid., p. S229.
[136] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction," Op. cit., pp. 4-1-4–4.
[137] Figure text reproduced verbatim from: Ibid., pp. 4–27.
[138] Baker, S. et al. "Teaching Academic Content and Literacy to English Learners in Elementary and Middle School." National Center for Education Evaluation and Regional Assistance (NCEE), Institute of Education Sciences, U.S. Department of Education, April 2014. p. 3.
https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/english_learners_pg_040114.pdf
[139] Ibid., pp. 85–87.
[140] Ibid., pp. 83–84.
[141] Ibid., p. 13.
[142] Ibid., pp. 14, 16, 18, 21.

Further, in their 2016 practice guide on supporting Kindergarten through Grade 3 reading, Foorman et al. recommend that despite minimal evidence, teachers should teach academic language skills such as vocabulary in addition to inferential and narrative language. [143] Researchers contend that "By guiding students to develop their academic language skills, teachers can mitigate some of the challenges that students encounter when learning to comprehend text." [144] Evidence for this recommendation is based on seven randomized controlled trial studies analyzing reading outcomes in Kindergarten through Grade 2 students at risk of reading difficulties. Using these studies, researchers indicate that vocabulary instruction leads to positive but inconsistent impacts on reading, noting that studies lack substantial evidence of positive effects. [145] Teaching practices for implementing this recommendation include conversing with students to support inferential language use and understanding, teaching narrative language skills directly, and incorporating vocabulary instruction during other reading activities. [146]

While many studies on vocabulary instruction to promote literacy analyze elementary readers, Collins et al. explore vocabulary expansion among students entering middle school. The authors present evidence for vocabulary development to support reading through an intervention-based study at Camp CHRONICLE, which engages upcoming Grade 6 students with reading disabilities in literacy instruction. Through written and oral pre- and post-test assessments, Collins et al. find that the multilinguistic structured literacy intervention that integrates multiple processes (i.e., phonology, morphology, orthography, semantics, syntax) improved outcomes. [147] As part of the camp's vocabulary instruction, instructors at Camp CHRONICLE support students in creating word webs and word walls composed of more advanced terms. [148] By using these instructional strategies and those aligned with other key components of reading, "Camp CHRONICLE provides an adaptable framework for intervention that systematically addresses discourse-, sentence-, word-, morpheme-, and syllable-level language skills presented in a way that adolescents find engaging and motivating." [149]

> ### 🔍 A Note on Morphological Skill Development
>
> **Morphology, which "can enable students to comprehend the meanings of new words based upon their structural similarity to known words," supports students' vocabulary** along with decoding, orthographic rules, spelling, and comprehension. [150] In Fallon and Katz's literature review on morphology within a multilinguistic structural literacy program, citing publications from 1968 to 2019, the authors describe how students who are aware of word (i.e., morphemic) structures have stronger reading and writing abilities. Additionally, the multilinguistic structural literacy approach strongly aligns with speech-language pathologists' roles and responsibilities in supporting students with dyslexia, demonstrating future implications of the extensive morphology literature. [151]

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[143] Foorman et al., Op. cit., p. 6.

[144] Ibid.

[145] Baker et al., Op. cit., pp. 63–66.

[146] Ibid., pp. 8–9, 11.

[147] Collins, G. et al. "Integrating Morphological Awareness in a Multilinguistic Structured Literacy Approach to Improve Literacy in Adolescents With Reading and/or Language Disorders." *Language, Speech & Hearing Services in Schools*, 51:3, July 2020. Retrieved from EBSCOhost.

[148] Ibid., p. 537.

[149] Ibid., p. 541.

[150] [1] Fallon, K.A. and L.A. Katz. "Structured Literacy Intervention for Students With Dyslexia: Focus on Growing Morphological Skills." *Language, Speech & Hearing Services in Schools*, 51:2, April 2020. pp. 338–339. Retrieved from EBSCOhost. [2] Hempenstall, K. *Read about It: Scientific Evidence for Effective Teaching of Reading*. edited by J. Buckingham. Center for Independent Studies, 2016. p. 22. https://dataworks-ed.com/wp-content/uploads/2016/05/Kerry.pdf

[151] Fallon and Katz, Op. cit., p. 342.

COMPREHENSION

Multiple reading components and skills (e.g., phonological awareness, phonics) support comprehension, but comprehension-focused instruction must occur in tandem with other components and with active reading strategies to support literacy.[152] According to the National Reading Panel, formal instruction in multiple comprehension strategies improves students' text understanding, information use, and overall reading-comprehension skills.[153] To explore reading comprehension instructional strategies that improve literacy, the National Reading Panel conducted an analysis (though not a meta-analysis due to high variance in the methodology and implementation of the studies) of 203 experimental and quasi-experimental studies. Through this analysis, researchers identified 16 types of reading comprehension instruction, seven of which demonstrate effectiveness (i.e., "comprehension monitoring, cooperative learning, graphic and semantic organizers including story maps, question answering, question generation, and summarization"). [154] Researchers further stress the importance of cognitive strategies to support comprehension, particularly when teachers instruct using a process of demonstrating, explaining, modeling, and interacting with students.[155]

Additionally, expository text structure interventions demonstrate positive impacts on reading comprehension across elementary and secondary grade levels. [156] These interventions aim to support students in understanding the organization of a text, the relationships between ideas, and the vocabulary words that provide meaning. For example, Pyle et al. conduct a meta-analysis to explore the effect of expository text structure interventions on reading comprehension and which components of these interventions support improvements in reading comprehension. The analysis used 21 experimental, quasi-experimental, and single-case studies to review the efficacy of text structure interventions and components among students in Grades K-12.[157] Researchers find that expository text structure interventions produce large and statistically significant effects on reading comprehension. However, specific outcomes vary when analyzing intervention factors (i.e., number of text structures taught, implementer, grade level, dosage), intervention characteristics (e.g., gradual release approach), texts (e.g., compare-and-contrast passages, cause-and-effect passages), and student responsiveness (e.g., elementary versus secondary comprehension). [158] Researchers attribute positive outcomes to text structure interventions providing students "with an organizational framework for approaching expository text that is often complex and dense with academic vocabulary."[159] Further, Pyle et al. suggest the practices contained in Figure 2.2.

Figure 2.2: Suggestions for Text Structure Instruction and Intervention

- Explicitly describe expository text structures
- Teach students the clue words associated with various text structures
- Model the use of text structures in reading (and writing)

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[152] [1] Duke, Ward, and Pearson, Op. cit., p. 666. [2] Collins et al., Op. cit., p. 533. [2] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction," Op. cit., pp. 4–39, 4–40.

[153] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction," Op. cit., pp. 4–39, 4–40.

[154] Ibid., pp. 4–41, 4–42.

[155] Baker et al., Op. cit., pp. 4–47.

[156] [1] Pyle et al., Op. cit. [2] Wijekumar, K., B.J.F. Meyer, and P. Lei. "Web-Based Text Structure Strategy Instruction Improves Seventh Graders' Content Area Reading Comprehension." *Journal of Educational Psychology*, 109:6, 2017. https://www.apa.org/pubs/journals/features/edu-edu0000168.pdf [2] Hebert, M. et al. "The Effects of Text Structure Instruction on Expository Reading Comprehension: A Meta-Analysis." *Journal of Educational Psychology*, 108:5, 2016. Retrieved from EBSCOhost. [2] Hall-Mills, S.S. and L.M. Marante. "Explicit Text Structure Instruction Supports Expository Text Comprehension for Adolescents With Learning Disabilities: A Systematic Review." *Learning Disability Quarterly*, February 18, 2020. Retrieved from SAGE Journals.

[157] Pyle et al., Op. cit., pp. 469, 472, 474, 478.

[158] Ibid., pp. 493–495.

[159] Ibid., p. 497.

- Consider introducing graphic organizers as a support
- [Obtain] exemplary, single-structured texts for use as model texts to then prepare students to comprehend multiple-structured texts
- Teach students text features as another signal for where information is located in text and how it is organized
- [Ensure] students take increasing responsibility for attending to the complexity of text structures in authentic texts
- [Ensure] have independent opportunities to engage with the structure of texts in the context of developing deeper knowledge in a particular content area

Source: *Reading Research Quarterly*[160]

These eight instructional practices provide examples of how teachers may incorporate an evidence-based intervention (i.e., text structure instruction) into their lessons. Although Pyle et al. note that they "cannot suggest the key intervention components needed to teach text structures effectively," these practices may facilitate text structure-based activities and lessons that use complex reading passages.[161]

Wijekumar et al. and Hebert et al. further indicate the **positive impact of text structure instruction on reading comprehension**. Specifically, Wijekumar et al. conducted a randomized controlled trial of 2,489 Grade 7 students using the web-based text structure strategy program Intelligent Tutoring System for the Text Structure Strategy (ITSS). The program aims to develop reading comprehension through summarizing, highlighting, and questioning activities as students learn to "select, encode, and strategically organize" texts.[162] Researchers conclude that ITSS has a small but significant effect on comprehension and mid-to-large effects on text structure competence, knowledge, and summaries. Research implications support the use of text structure instruction to develop strategic memories and frame reading comprehension activities (e.g., elaborating, inferencing, summarizing, monitoring comprehension).[163]

Furthermore, Hebert et al. conducted a meta-analysis of 45 studies on students in Grade 2 through 12 to understand the impact of teaching text structures on reading comprehension and transferring skill on three levels (i.e., temporal context/maintenance, near-contexts/untaught text structures, far-contexts/general reading comprehension). Researchers find that expository text structure instruction supports comprehension across all transfer levels, though the effects were moderated when comparing results to higher-performing comparison groups. Alternatively, two moderators (i.e., incorporating writing and teaching more text structures) increased effect sizes.[164]

CONCLUSION

Through the studies described, researchers find that the five key components of the Science of Reading and associated instructional strategies positively impact reading development, most evidently in the early elementary grades. Although evidence suggests additional research be conducted to support reading interventions among specific student populations and for certain interventions, phonemic awareness, phonics, fluency, vocabulary, and comprehension steadily demonstrate positive effects.

Notably, research consistently demonstrates the effectiveness and importance of integrating instructional approaches so that teachers develop multiple reading components via multiple modalities. These instructional approaches often indicate effectiveness when actively engaging students, whether through oral reading for fluency, comparing and contrasting word meanings for vocabulary, or analyzing text structures for comprehension. This integration, along with the need for selecting age- and ability-appropriate instructional strategies, underscores the importance of pre-service training and professional development.

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[160] Figure text reproduced nearly verbatim from: Ibid.
[161] Ibid.
[162] Wijekumar, Meyer, and Lei, Op. cit., pp. 741, 747.
[163] Ibid., pp. 757–758.
[164] Hebert et al., Op. cit., sec. Abstract.

Ineffective and Currently Unsupported Instructional Strategies

As described in this section, the Science of Reading supports numerous evidence-based instructional strategies, frameworks, and supports. However, schools and individual teachers often implement strategies that lack sufficient evidence of effectiveness or rigorous evaluation. As such, Petscher et al. (2020) highlight the practices that are lacking strong evidence of effectiveness, including those that (1) researchers have not evaluated and (2) researchers evaluated and lack rigor or evidence of effectiveness. The "common instructional approaches that lack generalizable empirical support include": [165]

- Close reading;
- Use of decodable text;
- Sustained silent reading;
- Multisensory approaches;
- The three-cueing system to support word recognition development;
- Teaching vocabulary in isolation to support reading comprehension;
- Word study and morphological analysis to support reading comprehension;
- Instructional programs used to support auditory or visual systems;
- Interventions that aim to "decrease visual confusion" or "modify transient channel processing;"
- Video games to support reading through increased visual attention; and
- Interventions to increase working memory.

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[165] Bulleted text adapted from: Petscher et al., Op. cit., pp. S271–S273.

SUMMARY OF THE LITERATURE ON EFFECTIVE READING COMPONENTS

Figure 2.3 provides an overview of the literature discussing instructional strategies based on the Science of Reading organized by year and the leading author's last name.

Figure 2.3: Summary of the Literature Discussing Effective Instructional Practices

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Duke et el. (2021)[166] ■ Present current literature on reading comprehension and the effective practices that support it	■ *Literature review of how students develop reading comprehension supplemented by a model for effective literacy instruction and reviews studies on Pre-K-Grade 12 reading* ■ Emphasizes how teaching a narrow set of skills (e.g., only decoding and listening comprehension) is not sufficient to develop reading comprehension, and "a differentiated and layered approach to reading comprehension instruction is the most scientifically advisable way forward"	■ Word reading skills (i.e., phonological awareness, print awareness, phonics, and word recognition instruction) lay foundations for reading comprehension ■ Fluency connects decoding and reading comprehension by enabling students to accurately read and devote bandwidth to comprehension ■ Reading comprehension instruction should occur alongside other foundational skills as monitoring comprehension while reading provides feedback on reading accuracy ■ Text structure instruction supports comprehension by presenting common text organization and elements ■ Building one's vocabulary through content knowledge instruction aids overall reading comprehension ■ Increasing engagement with texts (e.g., volume reading, discussions, writing) in addition to lessons on other reading skills increases comprehension

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[166] Duke, Ward, and Pearson, Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Collins et al. (2020)[167] ■ Identifies main components of a "multilinguistic structured literacy approach," (i.e., a language-based intervention) for students facing challenges with literacy or language development ■ Reviews the efficacy of the approach in practice	■ *Three case studies based on qualitative and quantitative assessments based on a sample of adolescents participating in Camp CHRONICLE, a two-week summer camp for supporting dyslexic students with literacy during the summer before Grade 6* ■ Preservice speech-language pathologists support students on a group and individual level ■ Students write comics as a tool for gradually developing narrative, syntax, semantics, vocabulary, and orthographic knowledge skills ■ Each day, students complete oral assessments and written pre-tests and post-tests analyzed for narrative elements, length, complexity, and errors ■ All components of the multilinguistic structured literacy intervention are taught explicitly, systematically, and sequentially with substantial student-teacher interaction	■ Phonological awareness develops with vocabulary, morphological awareness, and orthographic knowledge to guide students in learning the pronunciation, root words, prefixes, and suffixes ■ Following narrative elements and syntax, vocabulary development and morphological awareness enable students to avoid use more diverse and advanced words and sentences ■ Practicing oral fluency through self-monitoring and self-regulation provides students with decoding strategies that support literacy ■ A multilinguistic approach that combines multiple components enables students to understand how sounds, letters and letter combinations, and meaning change and impact one another

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[167] Collins et al., Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Englert, C. S., et al. (2020)[168] • Analyzes the impact of a literacy course for preservice teachers (PSTs) on PSTs' knowledge, readiness for, and success in literacy instruction • Assesses PSTs' ability to implement instructional tools with fidelity	• *Intervention-based study of 48 PSTs tutoring Grade 1-3 school students with learning disabilities using pretest-posttest assessments to measure effects* • Researchers use "three optimizing conditions" as interventions hypothesized to improve PST knowledge, readiness, and success: an instructional protocol and toolkit, quality practical experience, and simplified course elements (i.e., tutoring one student, highly structured course progression) • PSTs worked with a mentor, supervisor, and breakout groups, and had access to classroom materials (e.g., books, paper, whiteboards) • Study measurements included PST knowledge assessments and PST survey and student progress monitoring assessments on student understanding • PSTs' knowledge and instructional abilities improve with clear ability to implement tools with fidelity and tutees' reading skills improve	• Interventions increase PST confidence in and knowledge on teaching reading components, despite beginning the semester with little prior knowledge, which prevents novice teachers from beginning careers without the ability to instruct students or diagnose miscues • Phonics lessons for tutees included explicit decoding, sound blending, and rehearsal to increase reading component skills • Student subtest performance following phonics tutoring shows improvements and success on CORE subtest items that go beyond instructional material taught by PSTs • Students' reading fluency, and especially accuracy, increase following interventions • The largest improvements following interventions are PSTs' abilities to diagnose phonic aspects of student miscues, which is important because "Without explicit attention to this component in the course, the phonics knowledge of PSTs seemed to lie superficial and inert"

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[168] Englert et al., Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Hindman, A. H., et al. (2020)[169] ■ Reviews the lattice model of reading development and evidence regarding the need for increased PST literacy training ■ Suggests a solution to literacy instruction training gaps	■ *Review of literature on pre-K-Grade 4 teachers' engagement with two training programs, including randomized controlled trials* ■ Contends that PST training and the Science of Learning, which includes the Science of Reading, need greater alignment to prepare teachers for literacy instruction (e.g., through scaffolded instructional training) ■ Poses two interventions to support teachers in literacy instruction based on known implementation among in-seat teachers and alignment with the lattice model ■ Story Talk intervention includes workshops, coaching, and teacher collaboration ■ ISI intervention combines training, regular district community discussions, and use of the ISI computer program, which includes teaching tools, algorithms that identify individualized lessons for students, and other guidance on teaching skills to support instruction (e.g., classroom management)	■ Story Talk intervention: focuses on vocabulary, comprehension, social-emotional, and cognitive processes; demonstrates effectiveness in improving teachers' instructional quality and skills and increasing student vocabulary ■ ISI intervention: focuses on phonemic awareness, phonics, fluency, vocabulary, comprehension, socio-emotional, and cognitive processes; demonstrates effectiveness in supporting student decoding and comprehension skills and leads to greater longitudinal improvement

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[169] Hindman et al., Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Hudson et al. (2020)[170] • To identify the characteristics of effective oral reading fluency interventions and their impact on fluency and comprehension outcomes	• *Meta-analysis of 16 experimental and quasi-experimental studies on elementary oral reading fluency interventions* • Conducts meta-analysis with two goals: (1) understanding whether fluency interventions increase fluency (i.e., accuracy, rate, and prosody) and comprehension among Grade 1 to 5 students with reading difficulties, and (2) to analyze characteristics of effective fluency interventions • Interventions include repeated reading with multiple features, listening while reading, continuous reading, listening only, and neurological impress method (NIM) • Reviewed studies for interventions' impact on transfer and local effects and how group sizes effect outcomes • Only included group studies with a control group in the analysis to avoid limitations with case studies	• Fluency interventions positively impact reading fluency and comprehension for elementary students with reading difficulties • Fluency interventions demonstrate positive impacts on reading comprehension more than general fluency, indicating that fluency connects to decoding and comprehension rather than simply word recognition • One-on-one fluency interventions with a trained instructor who can model fluent reading would support fluency and comprehension in elementary students with reading difficulties • No single intervention is effective for all students and teachers may need to adjust approaches if students are not responding • Repeated reading and continuous reading with a teacher demonstrate effectiveness, and listening while reading and small-group interventions demonstrate less effectiveness

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[170] Hudson et al., Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Petscher et al. (2020)[171] ■ Reviews what is and is not considered evidence according to the Science of Reading ■ Classifies instructional practices as having compelling evidence, lacking evidence, or needing more evidence of effectiveness ■ Identifies areas for future research	■ *Review of literature on the Science of Reading to categorize evidence in the Science of Reading using studies that analyze student outcomes across grade levels* ■ Categorizes based on studies' rigor and "[contends] that the highest priority in the science of reading should be the replicable and generalizable knowledge from observational and experimental methods, rooted in a deductive research approach to knowledge generation that is framed in a correspondence theory of truth"	■ Phonological awareness (and alphabet knowledge) supports the alphabetic principle, which is a critical aspect of "accurate and efficient decoding" ■ Systematic and explicit phonics instruction with phonological awareness and letter knowledge develops decoding skills and, subsequently, literacy ■ Multiple opportunities to read supports reading development by strengthening fluency, accuracy, and comprehension ■ Observing differences in foundational components supports the identification of students at risk for reading challenges
Rupley et al. (2020)[172] ■ Present historical landscape of fluency and its impact on student literacy	■ *Reviews literature on reading fluency in the United States chronologically from 19th-century through present-day reading research and instruction* ■ Focuses on oral reading as a significant aspect of fluency and how it compares to silent reading	■ Automatic processing of basic text features and attention to "prosodic and syntactic features") demonstrate significance in fluency development and, ultimately, comprehension ■ Fluency skills, particularly oral reading, demonstrate clear connections to comprehension and performance on assessment outcomes, and "findings appear to suggest that oral reading can have a positive impact on student reading achievement, a conclusion carried forward within the ensuing standards movement."

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[171] Petscher et al., Op. cit.
[172] Rupley et al., Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Silverman et al. (2020)[173] ▪ Analyze the impact of language comprehension interventions on elementary students' language and reading outcomes	▪ *Conducts a meta-analysis of 43 experimental and quasi-experimental studies (majority randomized control trials) on elementary school students' (majority Kindergarten through Grade 2 students) language and literacy outcomes* ▪ Analyzes studies with vocabulary and semantics, syntax, and morphology interventions to support language and literacy outcomes ▪ Compares outcomes across student groups (i.e., English learners, low socio-economic status, at-risk) ▪ Compares custom (i.e., researcher-developed) and standardized measures	▪ Custom vocabulary, listening comprehension, and reading comprehension interventions positively effect students' language comprehension ▪ Instructional methods that include multiple aspects of language (i.e., vocabulary and semantics, syntax, morphology) demonstrate more success than those focusing on one aspect ▪ Additional research on how to best support diverse populations and incorporate technology is needed
Fallon and Katz (2019)[174] ▪ Describes structured literacy and associated strategies with a focus on morphological skills to support dyslexic students	▪ *Review of literature on structured literacy, morphological awareness skill, and specific, research-based, clinical practices to support students with spoken and written language impairments; includes research on students in pre-K-Grade 8*	▪ Morphological skills, which influence other areas (e.g., decoding, spelling, vocabulary, comprehension, writing, metalinguistics), aid speech and written language; therefore, students with the skills are better prepared to read and write than students without knowledge on word structures ▪ Structured literacy—and its emphasis on morphology, phonology, semantics and syntax—aligns with speech-language pathologist roles and responsibilities and expands student supports ▪ A morphology-centered structured literacy approach benefits students; specifically, "Because morphemes convey both meaning and grammatical form, as well as depict the phonology and orthography of written words, involvement of multilinguistic components is naturally facilitated and empirically supported

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[173] Silverman et al., Op. cit.
[174] Fallon and Katz, Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Petscher et al. (2019)[175] ▪ Analyzes the connection between Grade 3 fluency and vocabulary and Grade 10 reading comprehension overall and based on student group	▪ *Longitudinal quantitative study on reading comprehension development using a sample of 3,157 general education, English Learner (EL,) and special education students in Grade 3 and Grade 10* ▪ Applies a multiple group structural equation model with quantile regression to explore the connection between Grade 3 literacy skills (e.g., vocabulary) and Grade 10 comprehension ▪ Measures skills through the Peabody Picture Vocabulary Test, DIBELS Oral Reading Fluency, and Florida Assessments for Instruction in Reading Comprehension ▪ Key limitations include disability status being used to determine at-risk status of reading comprehension regardless of disability, EL status did not specify students' primary language	▪ Oral reading fluency serves as an "early indicator of problems in reading comprehension" ▪ General education students' fluency skills stabilize around Grade 3, which causes it to be an accurate indicator of future performance ▪ A lack of oral fluency in students with disabilities appears to cause students to rely on vocabulary skills for comprehension ▪ Early vocabulary knowledge correlates to high school reading comprehension for general education, EL students, and students with learning disabilities ▪ Outcomes support teachers using vocabulary—particularly through explicit instruction and indirect instruction that uses topic-based texts with repetition—to improve reading comprehension, particularly among EL students ▪ Word-level and early fluency skills among students with disabilities connects to reading comprehension and academic success in secondary school
Earle and Sayeski (2017)[176] ▪ Describes key elements and current misconceptions of effective letter-sound instruction	▪ *Reviews literature on letter-sound practices to clarify misconceptions and describe practices described in academic literature published between 1984 and 2016, including studies with elementary, secondary, and post-secondary students*	▪ Letter-sound skills develop decoding and spelling skills, which subsequently support literacy ▪ Direct, explicit, and systematic phoneme-grapheme instruction guides students through "building blocks" of letter-sound awareness and allows teachers to gauge understanding and administer appropriate assessments ▪ Developing students' consonant and vowel understanding supports phonetic skills and differentiation between "voiced and unvoiced sounds" as they learn to connect letters and sounds ▪ Scope, sequence, and distribution of practicing letter-sound knowledge can support students in building and maintaining literacy skills

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[175] Petscher, Solari, and Catts, Op. cit.
[176] Earle and Sayeski, Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Pyle et al. (2017)[177] ■ Analyzes the efficacy of expository text structure on Grade K-12 reading comprehension outcomes ■ Analyzes intervention factors correlated with improved comprehension outcomes	■ *Conducts a meta-analysis of 20 peer-reviewed studies across 43 years that discuss student reading development in Grades K-12, most of which use random assignment within the methodology* ■ Uses a five-step search process of identifying studies for the analysis that filtered for those applying an experimental, quasi-experimental, or single-case design ■ During the meta-analysis process, researchers categorized comprehension outcome measures by "outcome measure, researcher-developed comprehension measure, measure of the NAEP cognitive target, and measure type" and conducted individual analyses for each category ■ Accounts for moderators that may impact reading comprehension (i.e., number of text structures, type of implementer, grade level, student classification, dosage) and includes texts in science or social studies content	■ Instructional features (e.g., scaffolding, adapting instruction, providing feedback) appears to be effective, but not necessary, in text structure instruction to support comprehension ■ Text structure instruction that gradually increases text difficulty provides a positive approach for supporting reading development, though evidence is inconclusive concerning the easiest or most challenging structures ■ Expository text structure interventions to support the comprehension component of literacy indicate potential for enabling students to organize main ideas, identify connections in a text, and locate or recall content more easily ■ Researchers conclude that "It is likely that text structure instruction is effective because it presents students with an organizational framework for approaching expository text that is often complex and dense with academic vocabulary"

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[177] Pyle et al., Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Wijekumar et al. (2017)[178] ▪ Analyzes the contributing factors and impact of a web-based reading program on students overall and by characteristics	▪ *Conducts a randomized controlled trial with a sample of students from 108 Grade 7 classrooms* ▪ Applies the Intelligent Tutoring System for the Text Structure Strategy (ITSS) web-based reading program as a partial substitute for language instruction for randomly selected classrooms while control group used the standard curriculum ▪ Teachers using ITSS receive training to use the program and researchers administer student assessments ▪ ITSS focuses on text structure instruction to "read and comprehend expository texts by selecting and encoding strategic memory, summarizing, inferring, elaborating, and monitoring comprehension" ▪ Multilevel quantitative data analyses use pre- and post-test results from standardized and researcher-based assessments ▪ Limitations reference the sample and recommend different populations in future analyses (e.g., students receiving pull-out services)	▪ Text structure instruction for reading comprehension demonstrates a range of effect sizes but still significant effects on student reading comprehension according to standardized and researcher-designed assessments ▪ Positive post-test results show that most students can benefit from text structure comprehension interventions as tools for literacy development ▪ Direct and indirect scaffolding within text structure instruction supports the formation and use of strategic memory skills, which may connect to similar reading comprehension skills
Foorman et al. (2016)[179] *As referenced in Petscher et al. (2020)* ▪ Provides recommendations for teaching practices along with the evidence used to support these recommendations	▪ *Conducts a meta-analysis of 56 randomized control trial and quasi-experimental studies published between January 2000 and November 2014 regarding reading instruction for Kindergarten through Grade 3 students* ▪ Limits acceptable studies to those who's sample comprises at least 50 percent general education and native English-speaking students ▪ Labels each recommendation with a "level of evidence" that shows the strength of evidence for the instructional practices contained in the studies	▪ Recommendation 1: "Teach students academic language skills, including the use of inferential and narrative language, and vocabulary knowledge." ▪ Recommendation 2: "Develop awareness of the segments of sounds in speech and how they link to letters." ▪ Recommendation 3: "Teach students to decode words, analyze word parts, and write and recognize words." ▪ Recommendation 4: "Ensure that each student reads connected text every day to support reading accuracy, fluency, and comprehension."

[178] Wijekumar, Meyer, and Lei, Op. cit.
[179] Foorman et al., Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Hebert et al. (2016)[180] ■ Analyzes studies to understand the impact of text structure instruction as a method for improving reading comprehension	■ *Presents a meta-analysis of 45 studies with samples of students ranging from Grade 2 through 12* ■ Reviews effects of text structure instruction on "proximal measures of comprehension" while accounting for potential moderators and differences among students with disabilities or at-risk for reading disabilities ■ Reviews text structure instruction as an approach for supporting students' transfer of skills in three contexts: temporal contexts (i.e., maintenance), near-contexts (i.e., untaught structures), and far contexts (i.e., general comprehension)	■ Text structures demonstrate positive impacts on reading comprehension with moderators, including the number of texts and inclusion of writing instruction ■ Text structure as a reading comprehension tool effectively supports the three transfer contexts
Rasinski et al. (2016)[181] *As referenced in Rupley et al. (2020)* ■ Analyzes reading fluency	■ *Conducts an assessment-based study with a sample of 81 college freshman* ■ Uses a 443-word passage from "The Legend of Sleepy Hollow" to test word recognition accuracy and reading fluency, and researchers mark incorrect words at the end of one minute and the whole passage ■ Includes a post-reading question to ensure that participants read for meaning in addition to fluency ■ Assess fluency assessment in conjunction with students' ACT scores	■ Accuracy and automaticity significantly and positively correlate with ACT scores, and researchers produce an equation to predict ACT reading score based on automaticity ■ Researchers' predictive equation can support teachers in assessing students' fluency and potential outcomes as well as identifying reading challenges and inform interventions, along with other measures ■ Word reading accuracy and automaticity function as key factors in secondary and post-secondary achievement ■ Automaticity outcomes suggest that trying to improve automaticity and reading rate after reaching a certain level is not productive

[180] Hebert et al., Op. cit.
[181] Rasinski et al., Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Suggate (2016)[182] ■ Analyzes reading interventions' and intervention features' long-term effectiveness on all students and subgroups	■ *Conducts a meta-analysis of 71 intervention-based treatment-control group studies with 8.161 pre-Kindergarten through Grade 6 students* ■ Analyzes follow-up study results to determine long-term effectiveness of interventions, where the average duration between the initial and follow-up study is 11.17 months ■ Compares long-term intervention effect sizes between normal, at-risk, and low-ability readers and other sample characteristics (i.e., gender, grade, intervention language) ■ Assess transfer effects of phonemic awareness, phonics, fluency, comprehension, and mixed interventions ■ Assesses intervention characteristics' impact on effect sizes ■ Assess study design impacts on effect sizes	■ Interventions lead to an increase in student reading outcomes, demonstrated by a moderate effect size, though improvements diminished by follow-up studies ■ Phonemic awareness and comprehension demonstrate greater long-term and transferability than phonics and fluency interventions ■ Intervention type and grade appear to be the most significant moderator variables, where interventions demonstrate greater lasting impact among upper elementary students ■ Intervention duration does not significantly impact effect sizes and "booster interventions" correlated with lower effect sizes
Wade-Woolley (2016)[183] ■ Assesses how phonemic and prosodic awareness are differentially related to reading single- and multi-syllable words	■ *Conducts an assessment-based study with a sample of 110 Grade 4 and 5 students to analyze how phonemic and prosodic awareness differentially relate to word reading* ■ Measures **word reading** using the Educator's Word Frequency Guide to select 33 mono-and multi-syllabic words for students to read aloud; **nonword decoding** using 22 monosyllabic words from the Word Attack subtest of the Woodcock Reading Mastery Test—Revised; **phonemic awareness** using the phoneme Elision subtest of the Comprehensive Test of Phonological Processing; and **prosodic awareness** using the Aural Stress Assignment task where students listen to single words and indicate where the word is stressed	■ Results show that phonemic and prosodic awareness and reading outcomes are significantly correlated ■ Phonemic and prosodic awareness each predict and make independent contributions to short and long word reading abilities ■ Prosodic awareness, only, correlates with simple, long-word decoding skills, which indicates that intonation supports multisyllabic word reading

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[182] Suggate, Op. cit.
[183] Wade-Woolley, Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Wright and Cervetti (2016)[184] ▪ To explore the impact of vocabulary instruction on reading comprehension	▪ *Conducts an analysis of 36 intervention-based studies that include students from pre-Kindergarten through Grade 12* ▪ Explores studies using literature review and qualitative analysis approaches ▪ Includes studies that instruct by teaching word meanings directly and teaching word-solving strategies ▪ Analyzes differences in outcomes based on study characteristics (e.g., duration, intervention, word selection, active versus inactive processing)	▪ Teaching word meaning through vocabulary instruction leads to increased reading comprehension for passages containing the taught words ▪ Instructional methods that require active processing demonstrate greater effectiveness than passive processing (e.g., teaching definitions); however, the optimal intensity level of instruction is unclear ▪ Results provide limited evidence that direct word instruction improves general reading comprehension ▪ Results demonstrate no evidence that implementing one or two strategies for vocabulary development supports overall reading comprehension
Baker et al. (2014)[185] *As referenced in Petscher et al. (2020)* ▪ Provides recommendations for teaching practices that support English learners along with the evidence used to support these recommendations	▪ *Conducts a meta-analysis of 15 randomized control trial and quasi-experimental studies published between 1989 and 2012 regarding reading instruction for Kindergarten through Grade 8 students* ▪ Builds on a previous version of a similar practice guide on recommendations to support literacy among elementary and middle school English learners ▪ Outcome measures analyzed include pre-reading for Kindergarten students, reading, vocabulary, English language development, and writing ▪ Labels each recommendation with a "level of evidence" that shows the strength of evidence for the instructional practices contained in the studies	▪ Recommendation 1: "Teach a set of academic vocabulary words intensively across several days using a variety of instructional activities." ▪ Recommendation 2: "Integrate oral and written English language instruction into content-area teaching." ▪ Recommendation 3: "Provide regular, structured opportunities to develop written language skills." ▪ Recommendation 4: "Provide small-group instructional intervention to students struggling in areas of literacy and English language development."

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[184] Wright and Cervetti, Op. cit.
[185] Baker et al., Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
Paige et al. (2014)[186] *As referenced in Rupley et el. (2020)* ■ Analyzes the association between fluency and silent reading comprehension	■ *Conducts an assessment-based study of 108 Grade 9 students* ■ Assesses the relationship between fluency indicators (i.e., accuracy, automaticity, prosody with vocabulary) and silent reading comprehension and the extent to which the indicators accurately reflect fluency and independently contribute to comprehension ■ Measures **silent reading comprehension** using the Test of Reading Comprehension—Fourth Edition, **oral reading fluency** using the Gray Oral Reading Test–Fourth Edition, Form A, **grade-level narrative fluency** using a 408-word excerpt from *The Arabian Nights*, **grade-level expository fluency** using a social studies passage on Oliver Cromwell, **prosody** using a recording of oral reading and the Multi-Dimensional Fluency Scale, and vocabulary using the Peabody Picture Vocabulary Test–Fourth Edition.	■ Instruction that develops fluency through prosody, word accuracy, and vocabulary support silent reading comprehension among secondary students ■ Instruction to develop automaticity in isolation does not appear to positively impact reading comprehension, and instead should be developed through prosody instruction ■ Fluency requires explicit and consistent instruction and support during elementary and middle school grades and across content areas

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[186] Paige et al., Op. cit.

AUTHORS, YEAR, AND PURPOSE	OVERVIEW OF SOURCE	DISCUSSION AND DEMONSTRATION OF HOW COMPONENTS SUPPORT LITERACY*
National Reading Panel (2000)[187]** ▪ Describes results from an analysis of reading literature to assess effective instructional approaches for reading, present conclusions, show applicability to classrooms, recommend a dissemination strategy, and indicate any additional research needed	▪ *Synthesizes experimental or quasi-experimental research literature on "critical skills, environments, and early developmental interactions" for reading development* ▪ Analyzes literature on skills rather than specific practices and instructional approaches and applied a screening method to select a manageable set of publications from a pool of about 100,000 studies ▪ Considers implications of the analysis and elicits oral and written testimonies from education stakeholders, which assisted in selecting topics and subtopics of inquiry ▪ Answers seven research questions with direct reference to key reading components (i.e., phonemic awareness, phonics, fluency, vocabulary, comprehension) and instructional influences (e.g., independent reading, teachers)	This report discusses at length each key component of reading. The following bulleted quotations express overall findings for each component that summarize components' empirical and practical significance: ▪ Phonemic awareness: "PA instruction was significantly better than alternative forms of training in helping children acquire phonemic awareness and enabling them to apply this skill in their reading and spelling." ▪ Phonics: "Findings provided solid support for the conclusion that systematic phonics instruction makes a bigger contribution to children's growth in reading than alternative programs providing unsystematic or no phonics instruction." ▪ Fluency via oral reading: "The analysis of guided oral reading procedures led to the conclusion that such procedures had a consistent, and positive impact on word recognition, fluency, and comprehension as measured by a variety of test instruments and at a range of grade levels." ▪ Vocabulary: "There are age and ability effects learning gains that occur from vocabulary instruction. These findings point to the importance of selecting age- and ability-appropriate methods." ▪ Comprehension: "The Panel's review of the literature indicates that there has been an extensive effort to identify reading comprehension strategies that can be taught to students to increase their comprehension and memory for text. The instruction of cognitive strategies improves reading comprehension in readers with a range of abilities."

Source: Multiple cited within the figure.
*Sources may reference overlapping and auxiliary components of reading. This column focuses on the efficacy of the five key components defined in Section I, not general conclusions.
**This source extends beyond the methodology described in Section I. However, Hanover includes this publication due to its impact on and prevalence throughout the subsequent literature.

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[187] "Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction," Op. cit.

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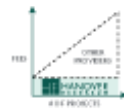200+ analysts with multiple methodology research expertise

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