How the Science of Reading Informs 21st Century Education

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Abstract

The science of reading should be informed by an evolving evidence base built upon the scientific method. Decades of basic research and randomized controlled trials of interventions and instructional routines have formed a substantial evidence base to guide best practices in reading instruction, reading intervention, and the early identification of at-risk readers. The recent resurfacing of questions about what constitutes the science of reading is leading to misinformation in the public space that may be viewed by educational stakeholders as merely differences of opinion among scientists. Our goals in this paper are to revisit the science of reading through an epistemological lens to clarify what constitutes evidence in the science of reading and to offer a critical evaluation of the evidence provided by the science of reading. To this end, we summarize those things that we believe have compelling evidence, promising evidence, or a lack of compelling evidence. We conclude with a discussion of areas of focus that we believe will advance the science of reading to meet the needs of all children in the 21st century.

How the Science of Reading Informs 21st Century Education

For more than 100 years, the question of how best to teach children to read has been debated in what has been termed the "reading wars". The debate cyclically fades into the background only to reemerge, often with the same points of conflict. We believe that this cycle is not helpful for promoting the best outcomes for children's educational success. Our goal in this paper is to make an honest and critical appraisal of the science of reading, defining what it is, how we build a case for evidence, summarizing those things for which the science of reading has provided unequivocal answers, providing a discussion of things we do not know but that may have been "oversold," identifying areas for which evidence is promising but not yet compelling, and thinking ahead about how the science of reading can better serve all stakeholders in children's educational achievements.

> At its core, scientific inquiry is the same in all fields. Scientific research, whether in education, physics, anthropology, molecular biology, or economics, is a continual process of rigorous reasoning supported by a dynamic interplay among methods, theories, and findings. It builds understandings in the form of models or theories that can be tested. Advances in scientific knowledge are achieved by the self-regulating norms of the scientific community over time, not, as sometimes believed, by the mechanistic application of a particular scientific method to a static set of questions (National Research Council, 2002, p. 2).

What is the Science of Reading and Why are we Still Debating it?

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. We recognize that the accrual of scientific knowledge related to reading is ever evolving, at times circuitous, and not without controversy. Nonetheless, the knowledge base on the science of reading is vast. In the last decade alone, over 14,000 peer-reviewed articles have been published in journals that included the keyword “reading” based on a PsycINFO search. Although many of these studies likely focused on a sliver of the reading process individually, collectively, research studies with a focus on reading have yielded a substantial knowledge base of stable findings based on the science of reading. Taken together, the science of reading helps a diverse set of educational shareholders across institutions (e.g., preschools, schools, universities), communities, and families to make informed choices about how to effectively promote literacy skills that foster healthy and productive lives (DeWalt & Hink, 2009; Rayner et al., 2001).

An interesting question concerning the science of reading is “Why is there a debate surrounding the science of reading?” Although there are certainly disputes within the scientific community regarding best practices and new areas of research inquiry, most of the current debate seems to settle upon 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 (Brady, 2020). The current disagreement in what constitutes the scientific evidence of reading (e.g., Calkins, 2020) is not new. During the last round of the “reading wars” in the late 1990’s and early 2000’s these same issues were discussed and debated. Much of the debate focused on conflicting views in epistemology between constructivists and positivists on the basic mechanisms associated with reading development. Constructivists, such as Goodman (1967) and Smith (1971), believed that reading was a “natural act” akin to learning language and thus emphasized giving children the opportunity to discover meaning through experiences in a literacy-rich environment. In contrast, positivists, such as Chall (1967) and Flesch (1955), made strong distinctions between innate language learning and the effortful learning required to acquire reading skills. Positivists argued for explicit instruction to help foster understanding of how the written code mapped onto language, whereas constructivists encouraged children to engage in a “psycholinguistic guessing game” in which readers use their graphic, semantic, and syntactic knowledge (known as the three cuing system) to guess the meaning of a printed word.

Research clearly indicates that skilled reading involves the consolidation of orthographic and phonological word forms (Dehene, 2011). Work in cognitive neuroscience indicates that a small region of the left ventral visual cortex becomes specialized for this purpose. As children learn to read, they recruit neurons from a small region of the left ventral visual cortex within the left occipitotemporal cortex region (i.e., visual word form area) that are tuned to language-dependent parameters through connectivity to perisylvian language areas (Dehaene-Lambertz et al., 2018). This provides an efficient circuit for grapheme-phoneme conversion and lexical access allowing efficient word-reading skills to develop. These studies provide direct evidence for how teaching alters the human brain by repurposing some visual regions toward the shapes of letters, suggesting that cultural inventions, such as written language, modify evolutionarily older brain regions. Furthermore, studies suggest that instruction focusing on the link between orthography and phonology promote this brain reorganization (e.g., Dehaene, 2011). Yet, arguments between philosophical constructivists and philosophical positivists on what constitutes the science of reading and how it informs instruction remain active today (e.g., Castles et al., 2018). In a recent interview with Emily Hanford, Ken Goodman defended his advocacy for the three cuing system saying that the three-cueing theory is based on years of observational research. In his view, three cueing is perfectly valid, drawn from a different kind of evidence than what scientists collect in their lab and later he stated that “my science is different” (Hanford, 2019).

As scientists at the Florida Center for Reading Research, we are often frustrated when what we view to be the empirically supported evidence base about the reading process are distorted or denied in communications directed to the public and to teachers. However, Stanovich (2003) posited that “in many cases, the facts are secondary—what is being denied are the styles of reasoning that gave rise to the facts; what is being denied is closer to a worldview than an empirical finding. Many of these styles are implicit; we are not conscious of them as explicit rules of behavior” (pp. 106-107). Stanovich proposed five different dimensions that represent “styles” of generating knowledge about reading. For our purposes, here, we focus on the first dimension: the correspondence versus coherence theory of truth. It hits at the heart of how people believe something to be true. People who believe that a real world exists independent of their beliefs, and that interrogating this world using rigorous principles to gain knowledge is a fruitful activity are said to subscribe to the correspondence theory of truth. In contrast, those who subscribe to the coherence theory of truth believe that something is “true” if the beliefs about something fit together in a logical way. In essence, something is true if it makes sense.

Stanovich believed these differing truth systems might lie at the heart of the disagreements surrounding the science of reading. One side shouting, “Look at this mountain of evidence! How can you not believe it?” and the other side shouting, “It doesn’t make sense! It doesn’t match up with our experiences! Why should we value your knowledge above our own?!” By approaching the science of reading from the perspective of the correspondence theory of truth, we consider how compelling evidence can be generated, what we believe is the compelling evidence, what we think lacks evidence, and what we think is promising evidence.

How We Build a Case for Compelling Evidence

Research is the means by which we acquire and understand knowledge about the world (Dane, 1990) to create scientific principles. Relatively few scientists would argue with the importance of using research evidence to support a principle or to make claims about reading development and the quality of reading instruction. Where significant divergence often occurs is in response to policy statements that categorize research claims and instructional strategies into those with greater or lesser levels of evidence. This divergence is typically rooted in applied epistemology, which can be understood as the study of whether the *means by which we study evidence* are themselves well designed to lead to valid conclusions. Researchers often frame the science of reading from divergent applied epistemological perspectives. Thus, two scientists who approach the science of reading with different epistemologies will both suggest that they have principled understandings and explanations for how children learn to read; yet, the *means* by which those understandings and explanations were derived are often distinct.

The correspondence and coherence theories of truth described above are examples of explanations from contrasting epistemological perspectives. Consistent with these perspectives, researchers approaching the science of reading using a correspondence theory typically prioritize deductive methods, which embed hypothesis testing, precise operationalization of constructs, and efforts to decouple the researchers' beliefs from their interpretation and generalization of empirical evidence. Researchers approaching the science of reading using a coherence theory of truth typically prioritize more inductive methods, such as phenomenological, ethnographic, and grounded theory approaches that embed focus on the meaning and understanding that comes through a person's lived experience and where the scientist's own observations shape meaning and principles (e.g., Israel & Duffy, 2014).

When the National Research Council published *Scientific Research in Education* (2002), a significant amount of criticism levied against the report boiled down to differences in epistemological perspectives. Yet, these genuine contrasts can often obscure contributions to the science of reading that derive from multiple applied epistemologies. Observational research, using both inductive (e.g., case studies) and deductive (e.g., correlational studies) approaches, substantively informs the development of theories and of novel instructional approaches (e.g., Scruggs et al., 2007). Public health research offers a useful parallel. As it would be unethical to establish a causal link from smoking cigarettes to lung cancer through a randomized controlled trial, that field instead used well-designed observational studies to derive claims and principles. These findings then informed later stages in the broader program of research, including randomized controlled trials of interventions for smoking cessation.

In the science of reading, principles and instructional strategies should indeed capitalize on a program of research inclusive of multiple methodologies. Yet, as the public health domain ultimately takes direction from the efficacy of smoking cessation programs, so too must the science of reading take direction from theoretically informed and well-designed experimental and quasi-experimental studies of promising strategies when the intention is to evaluate instructional practices. The use of experimental (i.e., randomized trials) and quasi-experimental (e.g., regression discontinuity, propensity score matching, interrupted time series) designs, in which an intervention is competed against counterfactual conditions, such as typical practice or alternative interventions, provides the strongest causal credibility regarding which instructional strategies are effective. The What Works Clearinghouse (WWC) of the Institute of Education Sciences (e.g., What Works Clearinghouse, 2020) and the Every Student Succeeds Act (ESSA; Every Student Succeeds Act, 2015) are efforts by the US Department of Education to hierarchically characterize the levels of evidence currently available for instructional practices in education. The WWC uses a review framework, developed by methodological and statistical experts, for evaluating the quality and scope of evidence for specific instructional practices based on features of the design, implementation, and analysis of studies. Similarly, ESSA uses four tiers that focus on both the design of the study and the results of the study in which the tiers differ based on the quantity of evidence and quality of evidence supporting an approach. For both WWC and ESSA, quantity of evidence refers to the number of well-designed and well-implemented studies, and quality of evidence is defined by the ability of a study's methods to allow for alternative explanations of a finding to be ruled out, for which the randomized controlled trial provides the strongest method.

As outlined above, the "science of reading" utilizes multiple research approaches to generate ideas about reading. Ultimately, 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. In this manner, the accumulated evidence is built on a research foundation by which theories, principles, and hypotheses have been subjected to rigorous empirical scrutiny to determine the degree to which they hold up across variations in samples, measures, and contexts. In the following sections, we summarize issues related to the nature, development, and instruction of reading for which we believe the science of reading either has or has not yielded compelling evidence, identify what we believe are promising areas for which sufficient evidence has not yet accumulated, and suggest a number of areas that we believe will help move the science of reading forward, increasing knowledge and enhancing its positive impacts for a variety of stakeholders.

Compelling Evidence in the Science of Reading

In this section, we focus on a number of findings centrally important for understanding the development and teaching of reading in alphabetic languages. The evidence base provides answers varying across orthographic regularity (e.g., English vs. Spanish), reading subskill (i.e., decoding vs. comprehension), grade range or developmental level (e.g., early childhood, elementary, adolescence), and linguistic diversity (e.g., English language learners, dialect speakers).

There are large differences among alphabetic languages in the rules for how graphemes represent sounds in words (i.e., a language's orthography). In languages like Spanish and Finnish there is a near one-to-one relation between letters and sounds. The letter-sound coding in these languages is transparent, and they have shallow orthographies. In other languages, most notably English, there is often not a one-to-one relation between letters and sounds. The letter-sound coding in these languages is opaque, and they have deep orthographies. Children must learn which words cannot be decoded based solely on letter-sound correspondence (e.g., two, knight, laugh) and learn to match these irregular spellings to the words they represent. Where a language's orthography falls on the shallow-deep dimension affects how quickly children develop accurate and fluent word-reading skills (Ellis et al., 2004; Ziegler & Goswami, 2005) and how much instruction on foundational reading skills is likely needed. Studies indicate that children learning to read in English are slower to acquire decoding skills (e.g., Caravolas et al., 2013). Ziegler et al. (1997) reported that 69% of monosyllabic words in English were consistent in spelling-to-phonology mappings and 31% of the phonology-to-spelling mappings were consistent. Thus, in teaching children to read in English, the "grain size" of phoneme, onsetrime, and whole word matters (Ziegler & Goswami, 2005) and the preservation of morphological regularities in English spelling matters (e.g., *vine* vs. *vineyard*).

Gough and Tunmer's (1986) "simple view of reading" model, which is supported by a significant amount of research, provides a useful framework for conceptualizing the development of reading skills across time. It also frames the elements for which it is necessary to provide instructional support. The ultimate goal of reading is to extract and construct meaning from text for a purpose. For this task to be successful, however, the reader needs skills in both word decoding and linguistic comprehension. Weaknesses in either area will reduce the capacity to achieve the goal of reading. Decoding skills and linguistic comprehension make independent contributions to the prediction of reading comprehension across diverse populations of readers (Kershaw & Schatschneider, 2012; Sabatini et al., 2010; Vellutino, et al., 2007). Results of several studies employing measurement strategies that allow modeling of each component as a latent variable indicate that decoding and linguistic comprehension account for almost all of the variance in reading comprehension (e.g., Foorman et al., 2015; Lonigan et al., 2018). The relative influence of these skill domains, however, changes across development. The importance of decoding skill in explaining variance in reading comprehension decreases across grades whereas the importance of linguistic comprehension increases (e.g., Catts et al., 2005; Foorman et al., 2018; García & Cain, 2014; Lonigan et al., 2018). By the time children are in high school linguistic comprehension and reading comprehension essentially form a single dimension (e.g., Foorman et al., 2018).

Children's knowledge of the alphabetic principle (i.e., how letters and sounds connect) and knowledge of the morphophonemic nature of English are necessary to create the high-quality lexical representations essential to accurate and efficient decoding (Ehri, 2005; Perfetti, 2007).

Acquiring the alphabetic principle is dependent on understanding that words are composed of smaller sounds (i.e., phonological awareness, PA) and alphabet knowledge (AK). Both PA and AK are substantial correlates and predictors of decoding skills (e.g., Wagner & Torgesen, 1987; Wagner et al., 1994). Prior to formal reading instruction, children are developing PA and AK as well as other early literacy skills that are related to later decoding skills following formal reading instruction (Lonigan et al., 2009; Lonigan et al., 1998; National Early Literacy Panel [NELP], 2008; Whitehurst & Lonigan, 1998). Reading comprehension takes advantage of the reader's ability to understand language. In most languages, written language and spoken language have high levels of overlap in their basic structure. Longitudinal studies indicate that linguistic comprehension skills from early childhood predict reading comprehension at the end of elementary school (Catts et al., 2015; Language and Reading Research Consortium & Chiu, 2018; Mancilla-Martinez & Lesaux, 2010; Storch & Whitehurst, 2002; Verhoeven & Van Leeuwe, 2008). The developmental precursors to skilled reading are present prior to school entry. Consequently, differences between children in the development of these skills forecast later differences in reading skills and are useful for identifying children at risk for reading difficulties.

The science of reading provides numerous clear answers about the type and focus of reading instruction for the subskills of reading, depending on where children are on the continuum of reading development and children's linguistic backgrounds. Much of this knowledge is summarized in the practice guides produced by the Institute of Education Sciences (Baker et al., 2014; Foorman et al., 2016a; Gersten et al., 2007, 2008; Kamil et al., 2008; Shanahan et al., 2010) and in meta-analytic summaries of research (e.g., Berkeley et al., 2012; Ehri, Nunes, Stahl et al., 2001; Ehri, Nunes, Willows et al., 2001; NELP, 2008; Therrien, 2004;

Wanzek et al., 2013, 2016). Whereas the practice guides list several best practices, here we emphasize those practices classified as supported by strong or moderate evidence based on WWC standards.

Since the publication of the *Report of the National Reading Panel* (National Institute of Child Health and Human Development, 2000) and supported by subsequent research (e.g., Gersten et al., 2017a; Foorman et al., 2016a), it is clear that a large evidence base provides strong support for the explicit and systematic instruction of the component and foundational skills of decoding and decoding itself. That is, teaching children phonological awareness and letter knowledge, particularly when combined, results in improved word-decoding skills. Teaching children to decode words using systematic and explicit phonics instruction results in improved word-decoding skills. Such instruction is effective both for monolingual English-speaking children and children whose home language is other than English (i.e., dual-language learners; Baker et al., 2014; Gersten et al., 2007) as well as children who are having difficulties learning to read or who have an identified reading disability (Ehri, Nunes, Stahl et al., 2001; Gersten et al., 2008). Additionally, providing children with frequent opportunities to read connected text supports the development of word-reading accuracy and fluency as well as comprehension skills (Foorman et al., 2016a; Therrien, 2004).

Similarly, a number of instructional activities to promote the development of reading comprehension have strong or moderate supporting evidence. For younger children, teaching children how to use comprehension strategies and how to utilize the organizational structure of a text to understand, learn, and retain content supports better reading comprehension (Shanahan et al., 2010). For older children, teaching the use of comprehension strategies also enhances reading comprehension (Kamil et al., 2008) as does explicit instruction in key vocabulary, providing opportunities for extended discussion of texts, and providing instruction on foundational reading skills when children lack these skills; such instructional approaches are also effective for children with significant reading difficulties (Berkeley et al., 2012; Kamil et al., 2008).

Lack of Compelling Evidence in the Science of Reading

In the above section, practices were highlighted that have sufficient evidence to warrant their widespread use. In this section, we address reading practices for which there is a lack of compelling evidence. Some practices have simply not yet been scientifically evaluated. Other practices have been evaluated, but either the evidence does not support their use based on the generalizability of the results or the studies in which they were evaluated were not of sufficient quality to meet a minimal standard of evidence (e.g., WWC standards). Although we lack sufficient space to present a comprehensive list of practices that do not have compelling evidence, we provide examples of practices that are commonplace and vary in the degree to which they have been scientifically studied.

Evidence-based decision making regarding effective literacy programs and practices for classroom use can be difficult. Often, there is no evidence of effectiveness for a program or the evidence is of poor quality. For instance, of the five most popular reading programs used nationwide (i.e., Units of Study for Teaching Reading, Journeys, Into Reading, Leveled Literacy Intervention and Reading Recovery; Schwartz, 1999) only Leveled Literacy Intervention and Reading Recovery, both interventions for struggling readers, have studies that meet WWC standards. The evidence indicates that there were mixed effects across outcomes for Leveled Literacy Intervention and positive or potentially positive effects for Reading Recovery (e.g., Chapman & Tunmer, 2016). Classroom reading programs are typically built around the notion of evidence-informed practices – teaching approaches that are grounded in quality research – but have not been subjected to direct scientific evaluation. As a consequence, it is currently impossible for schools to select basal reading programs that adhere to strict evidence-based standards (e.g., ESSA, 2015). As an alternative, schools must develop selection criteria for choosing classroom reading programs informed by the growing scientific evidence on instructional factors that support early reading development (e.g., Castles et al., 2018; Foorman et al.2017; Rayner et al., 2001).

Common instructional approaches that lack generalizable empirical support include such practices as close reading (Welsch et al., 2019), use of decodable text (Jenkins et al., 2004), sustained silent reading (NICHD, 2000), multisensory approaches (Birsh, 2011), and the three-cueing system to support word recognition development (Seidenberg, 2017). Some of these instructional approaches rest on sound theoretical and pedagogical grounds. For example, giving beginning readers the opportunity to read decodable texts provides practice applying the grapheme-phoneme relations they have learned to successfully decode words (Foorman et al., 2016a), thus building lexical memory to support word reading accuracy and automaticity (Ehri, this issue). However, the only study to experimentally examine the impact of reading more versus less decodable texts as part of an early intervention phonics program for at risk first graders found no differences between the two groups on any of the posttest measures (Jenkins et al., 2004). Such a result does not rule out the possibility of the usefulness of decodable texts but rather indicates the need to disentangle the active ingredients of effective interventions to specify what to use, when, how often, and for whom.

Similarly, multisensory approaches (e.g., Orton-Gillingham) that teach reading by using multiple senses (i.e., sight, hearing, touch, and movement) to help children make systematic connections between language, letters, and words (Birsh, 2011) are commonplace and have considerable clinical support for facilitating reading development in children who struggle to learn to read. However, there is little scientific evidence that indicates that a multisensory approach is more effective than similarly structured phonological-based approaches that do not include a strong multisensory component (e.g., Boyer & Ehri, 2011; Ritchey & Goeke, 2006; Torgesen et al., 2001). With further research, we may find that a multisensory component is a critical ingredient of intervention for struggling readers, but we lack this empirical evidence currently.

Instruction in reading comprehension is another area where despite some studies showing moderate or strong support (see section on compelling evidence) other practices are employed despite limited support for them (e.g., Boulay et al., 2015). The complexity of reading comprehension relies on numerous cognitive resources and background knowledge; as a result, intervention directed exclusively at one component or another is not likely to be that impactful. For example, research shows a clear relation between breadth and depth of vocabulary and reading comprehension (Wagner et al., 2007). One implication of this relation is that teaching vocabulary could improve reading comprehension. Numerous studies have tested this implication using instructional approaches that vary from teaching words in isolation to practices that involve instruction in the use of context to learn the meaning of unfamiliar words. Instruction has also included strategies to determine meaning of words through word study and morphological analysis (e.g., Beck & McKeown, 2007; Lesaux et al., 2014). Although these practices have been effective in increasing vocabulary knowledge of the words taught, there is limited evidence of transfer to untaught words (as measured by standardized measures) or to improvement in general reading comprehension (Elleman et al., 2009; Lesaux et al., 2010). Such findings do not mean that vocabulary instruction is not a useful practice; rather, by itself, it is not sufficient to improve reading comprehension. To make meaningful gains, intervention for reading comprehension likely requires addressing multiple components of language as well as teaching content knowledge (see next section) to make sizable gains.

Other instructional practices go directly against what is known from the science of reading. For example, the three-cueing approach to support early word recognition (i.e., relying on a combination of semantic, syntactic, and graphophonic cues simultaneously to formulate an intelligent hypothesis about a word's identity) ignores 40 years of overwhelming evidence that orthographic mapping involves the formation of letter-sound connections to bond spelling, pronunciation, and meaning of specific words in memory (see Ehri, this issue). Moreover, relying on alternative cuing systems impedes the building of automatic word-recognition skill that is the hallmark of skilled word reading (Stanovich, 1990; 1991). The English orthography, being both alphabetic-phonemic and morpho-phonemic, clearly privileges the use of various levels of grapheme-phoneme correspondences to read words (Frost, 2012), with rapid context-free word recognition being the process that most clearly distinguishes good from poor readers (Perfetti, 1992; Stanovich, 1980). Guessing at a word amounts to a lost learning trial to help children learn the orthography of the word and thus reduce the need to guess the word in the future (Castles et al., 2018; Share, 1995).

Similarly, alternative approaches to improving reading skills for struggling readers often fall well outside the scientific consensus regarding sources of reading difficulties. Some of these approaches are based on the tenet that temporal processing deficits in the auditory (e.g., Tallal, 1984) and visual (e.g., Stein, 2019) systems of the brain are causally related to poor word-reading development. Although there is some evidence that typically developing and struggling readers differ on measures tapping auditory (Casini et al., 2018; Protopapas, 2014) and visual (e.g., Eden et al., 1995; Olson & Datta, 2002) processing skill, there is little evidence to support the use of instructional programs designed to improve auditory or visual systems to ameliorate reading problems (Strong et al., 2011). Further, interventions designed to decrease visual confusion (e.g., Dyslexie font) or modify transient channel processing (e.g., Irlen lenses) to improve reading skill for children with reading disability have also failed to garner scientific support (Hyatt et al., 2009; Iovino et al., 1998; Marinus et al., 2016). Similarly, although use of video games to improve reading via enhanced visual attention is reported to be an effective intervention for children with reading disability (Peters et al., 2019), studies of this supplemental intervention approach have not compared it to standard supplemental approaches. Finally, studies of interventions designed to enhance other cognitive processes, such as working memory, also lack evidence effectiveness in terms of improved reading-related outcomes (e.g., Melby-Lervåg et al., 2016).

Promising but Not (Yet) Compelling Evidence in the Science of Reading

There are many promising areas of research that are poised to provide compelling evidence to inform the science of reading in the coming years. As we do not have space to provide a comprehensive list, we highlight only a few promising areas in prevention research and elementary education research.

Promising Directions in Prevention Research

Research on the prevention of reading problems is critical for our ability to reduce the number of children who struggle learning to read. One area of prevention research that has great promise but needs more evidence is how to more fully develop preschoolers' language abilities that support later reading success. Both correlational and experimental findings indicate that providing children with opportunities to engage in high-quality conversations, coupled with exposure to advanced language models, matters for language development (Cabell et al., 2015; Dickinson & Porche, 2011; Lonigan et al., 2011; Wasik & Hindman, 2018). Yet, most programs have a more robust impact on children's proximal language learning (i.e., learning taught words) than on generalized language learning as measured with standardized assessments (Marulis & Neuman, 2010).

Promising studies that have demonstrated significant effects on children's general language development elucidate potential points of leverage. First, improving the connection between the school and home contexts by including parents as partners can promote synergistic learning for children as language-learning activities in school and home settings are increasingly aligned (e.g., Lonigan & Whitehurst, 1998). A second leverage point is increasing attention to children's active use of language in the classroom to promote a rich dialogue between children and adults (e.g., Lonigan et al., 2011; Wasik & Hindman, 2018). A third leverage point is integrating content area instruction into early literacy instruction to improve language learning, for example, building children's conceptual knowledge of the social and natural world and teaching vocabulary words within the context of related ideas (e.g., Gonzalez et al., 2011).

Promising Directions in Elementary Education Research

We present two promising areas in reading research with elementary-age students, one focused on improving linguistic comprehension and one focused on improving decoding, consistent with the simple view of reading.

The knowledge a reader brings to a text is the chief determinant of whether the reader will understand that text (Anderson & Pearson, 1984). Thus, building knowledge is an essential, yet neglected, part of improving linguistic comprehension (Cabell & Hwang, this issue). Teaching reading is most often approached in early elementary classrooms as a subject that is independent from other subjects, such as science and social studies (Palinscar & Duke, 2004). As such, reading is taught using curricula that do not systematically build children's knowledge of the social and natural world. Instruction in reading and the content areas does not have to be an either/or proposition. Rather, the teaching of reading and of content-area learning can be simultaneously taught and integrated to powerfully impact children's learning of both reading and content knowledge (e.g., Connor et al., 2017; Kim et al., 2020; Williams et al., 2014). This area of research is promising but not yet compelling, due to the small number of experimental and quasi-experimental studies that have examined either integrated content-area and literacy instruction or content-rich English Language Arts instruction in K-5 settings (approximately 31 studies). Through meta-analysis, this corpus of studies demonstrates that combining knowledge building and literacy approaches has a positive impact on both vocabulary and comprehension outcomes for elementary-age children (Hwang et al., 2019). Further rigorous studies are needed that test widely used content-rich English Language Arts curricula (Cabell & Hwang, 2020, this issue); also required is new development of integrative and interdisciplinary approaches in this area.

There is also promising research on helping students to decode words more efficiently. It is widely accepted that students with reading difficulties often have underlying deficits in phonological processing (e.g., Brady & Schankweiler, 1991; Stanovich & Siegel, 1994; Torgesen, 2000; Vellutino et al., 1996) and these deficits are believed to disrupt the acquisition of spelling-to-sound translation routines that form the basis of early decoding-skill development (e.g.,van IJzendoorn & Bus, 1994; Rack et al., 1992). For developing readers, decoding an unfamiliar letter string can result in either full or partial decoding. During partial decoding, the reader must match the assembled phonology from decoding with their lexical representation of a word (Venezky, 1999). For example, encountering the word *island* might render the incorrect but partial decoding attempt, "izland". A child's flexibility with the partially decoded word is referred to as their "set for variability" or their ability to go from the decoded form to the correct pronunciation of a word. This skill serves as a bridge between decoding and lexical pronunciations and may be an important second step in the decoding process (Elbro et al., 2012).

The matching of partial phonemic-decoding output is facilitated by the child's decoding skills, the quality of the child's lexical word representation, and by the potential contextual support of text (Nation & Castles, 2017). Correlational studies indicate that students' ability to go from a decoded form of a word to a correct pronunciation (their set for variability) predicts the reading of irregular words (Tunmer & Chapman, 2012), regular words (Elbro, et al., 2012), and nonwords (Steacy et al., 2019a). Set for variability has also been found to be a stronger predictor of word reading than phonological awareness in students in grades 2-5 (e.g., Steacy et al., 2019b). Recent studies in this area suggest that children can benefit from being encouraged to engage with the irregularities of English (Dyson et al., 2017) to promote the implicit knowledge structures needed to read and spell these complex words. Additional research suggests that set for variability training can be effective in promoting early word reading skills (e.g., Savage et al., 2018; Zipke, 2016). The work done in this area to date suggests that set for variability requires child knowledge structures and strategies, which can be developed through instruction, that allow successful matching of partial phonemic-decoding output with the corresponding phonological, morphological, and semantic lexical representations.

Where Do We Go Next in the Science of Reading?

Basic Science Research

The science of reading has reached some consensus on the typical development of reading skill and how individual differences may alter this trajectory (e.g., Boscardin et al., 2008; Hjetland et al., 2019; Peng et al., 2019). Less is known about factors and mechanisms related to reading among diverse learners, a critical barrier to the field's ability to address and prevent reading difficulty when it arises. Investigations with large and diverse participant samples are needed to improve understanding of how child characteristics additively and synergistically affect reading acquisition (Hernandez, 2011; Lonigan et al., 2013). Insufficient research disentangles the influence of English-learner status for children who also have identified disabilities (Solari et al., 2014; Wagner et al., 2005). Greater attention to how language variation (e.g., dialect use) and differences in language experience affect reading development is crucial (Patton Terry et al., 2010; Seidenberg & MacDonald, 2018; Washington et al., 2018). New realizations of the interaction between child characteristics and the depth of the orthography have also highlighted the importance of implicit learning in early reading (Seidenberg, 2005; Steacy et al., 2019). Innovative cross-linguistic research is exploring how diverse methods of representing pronunciation and meaning within different orthographies, and children's developing awareness of these methods, jointly predict reading skills (e.g., Kuo & Anderson, 2006; Wade-Woolley, 2016). Furthermore, a better understanding of the role of executive function, socio-emotional resilience factors, and biopsychosocial risk variables (e.g., poverty and trauma) on reading development is critical. Additional research like this, in English and across languages, is needed to develop effective instruction and assessments for all leaners.

A clearer understanding of child and contextual influences on the development of reading also will support improvements in how early and accurately children at risk for reading difficulties and disabilities are identified. Currently, numerous challenges remain in identifying children early enough to maximize benefits of interventions (Colenbrander et al., 2018; Gersten et al., 2017b). Investigators often use behavioral precursors or correlates of reading to estimate children's risk for reading failure. Whereas this work has shown some promise (Catts et al., 2015; Compton et al., 2006, 2010; Lyytinen et al., 2015; Thompson et al., 2015), identification of risk typically involves high error rates, especially for preschoolers and kindergarteners who might benefit most from early identification and intervention. Similar challenges to accuracy have emerged when identifying older children with reading disabilities. Historically, this process has relied on discrepancy models (e.g., such as between reading skill and general cognitive aptitude), often yielding a just single comparison on which decisions are based (Waesche et al., 2011).

Challenges to identification for both younger and older children may be best met with frameworks that recognize the multifactorial casual basis of reading problems (Pennington et al., 2012). Newer models of identification that combine across multiple indicators of risk derived from current skill, and that augment these indicators with other metrics of potential risk, may yield improved identification and interventions (e.g., Erbeli et al., 2018; Spencer et al., 2011). In particular, future research will need to consider and combine, while considering both additive and interactive effects, a wide array of measures, which may include genetic, neurological, and biopsychosocial indicators (Wagner et al., 2019). Furthermore, more evaluation is needed of some new models of identification that integrate both risk and protective, or resiliency, factors, to see if these models increase the likelihood of correctly identifying those children most in need of additional instructional support (e.g., Catts & Petscher, 2020; Haft et al., 2016). Even if beneficial, it is likely that for early identification to be maximally effective, early risk assessments will need to be combined with progress monitoring of response to instruction

(Miciak & Fletcher, 2020). Of course, for such an approach to be successful, all children must receive high-quality reading instruction from the beginning and interventions need to be in place to address children who show varying levels of risk (Foorman et al., 2016a). Identifying children at risk and providing appropriate intervention early on has the potential to significantly improve reading outcomes and reduce the negative consequences of reading failure.

Intervention Innovations

Despite successes, too many children still struggle to read novel text with understanding, and intervention design efforts have not fully met this challenge (Compton et al., 2014; Phillips et al., 2016; Vaughn et al., 2017). Greater creativity and integration of research from a broader array of complementary fields, including cognitive science and behavioral genetics may be required to deal with long-standing problems. For example, genetic information may have causal explanatory power; randomized trials are needed to evaluate the efficacy of using such information to select and individualize instruction and intervention (Hart, 2016).

The field would benefit from increased attention to the problem of fading intervention effects over time. Although there can be detectable effects of interventions several years after they are completed (e.g., Blachman et al., 2014; Vadasy et al., 2011; Vadasy & Sanders, 2013), invariably effect sizes reduce over time. A meta-analysis of long-term effects of interventions for phonemic awareness, fluency, and reading comprehension found a 40 percent reduction in effect sizes within one year post-intervention (Suggate, 2016). Perhaps reading interventions with larger initial effects or sequential reading interventions with smaller but cumulating effects would be more resistant to fade-out.

Solutions to the problem of diminishing effects may be inspired by examples from other fields. The field of memory includes examples of content that appears immune from forgetting.

This phenomenon has been called permastore (Bahrick, 1984). For example, people only meaningfully exposed to a foreign language in school classes will still retain some knowledge of the language 50 years later. Additionally, expertise in the form of world-class performance appears to result from cumulative effects of long-term deliberate practice (Ericsson, 1996), and skilled reading can be viewed as an example of expert performance (Wagner & Stanovich, 1996). Informed by these concepts and by advances in early math instruction (e.g., Sarama et al., 2012; Kang et al., 2019), reading intervention studies should prioritize follow-up evaluations, including direct comparisons of follow-through strategies aimed at sustaining benefits from earlier instruction. For example, studies should evaluate booster interventions, professional development that better aligns cross-grade instruction, and how re-teaching and cumulative review may consolidate skill acquisition across time (e.g., Cepeda et al., 2006; Smolen et al., 2016).

Translational and Implementation Science

If the science of reading is to be applied in a manner resulting in achievement for all learners, the field must increase its focus on processes supporting implementation of evidence-based reading practices in schools. The field can leverage its considerable evidence-base to systematically investigate, with replication, both the effectiveness of reading instructional practices with diverse learners and to investigate processes that facilitate or prevent adoption, implementation, and sustainability of these practices (National Research Council, 2002; Schneider, 2018; Slavin, 2002). Research on these processes in educational contexts may be best facilitated by making use of methodological and conceptual tools developed within the traditions of translation and implementation science research (Gilliland et al., 2019; Eccles & Mittman, 2006). For example, these frameworks can support studies on whether and how educators and policymakers use information about evidence to inform decision making (e.g., Farley-Ripple et al., 2018) and studies on how institutional routines may need to be adapted to best integrate new procedures and practices (e.g., scheduling changes in the school day; Foorman et al., 2016b).

Reading research that uses translational and implementation science frameworks and methodologies will make more explicit the processes of adoption, implementation and sustainability and how these interact within diverse settings and with multiple populations (Brown et al., 2017; Fixsen et al., 2005, 2013). This work will be guided by new questions, not only asking "what works" but also "what works for whom under what conditions" and "what factors promote sustainability of implementation." Innovative studies would adhere to rigorous scientific standards, prioritize hypothesis testing within a deductive, experimental framework, and leverage qualitative methodologies to systematically explore implementation processes and factors (Brown et al., 2017). Results could iteratively inform the breadth of scientific reading research, including basic mechanisms related to reading and the development of novel assessments and interventions to support achievement among diverse learners in diverse settings (Cook & Odom, 2013; Douglas et al., 2015; Forman et al., 2013).

Conclusion

There has recently been a resurgence of the debate on the science of reading, and in this article, we described the existing evidence base and possible future directions. Compelling evidence is available to guide understanding of how reading develops and identify proven instructional practices that impact both decoding and linguistic comprehension. Whereas there is some evidence that is either not compelling or has yet to be generated for instructional practices and programs that are widely used, the scientific literature on reading is ever-expanding through contributions from the fields education, psychology, linguistics, communication science, neuroscience, and computational sciences. As these additions to the literature mature and contribute to an evidence base, we anticipate they will inform and shape the science of reading as well as the science of teaching reading.

References

Anderson, R. C., & Pearson, P. D. (1984). A schema-theoretic view of basic processes in reading comprehension. In P.D. Pearson, R. Barr, M.L. Kamil, & P. Mosenthal (Eds.), *Handbook of reading research* (1st ed., pp. 255–291). New York: Longman.

Baker, S., Lesaux, N., Jayanthi, M., Dimino, J., Proctor, C. P., Morris, J., … Newman-Gonchar, R. (2014). *Teaching academic content and literacy to English learners in elementary and middle school* (NCEE 2014-4012). Washington, DC: National Center for Education Evaluation and Regional Assistance (NCEE), Institute of Education Sciences, U.S. Department of Education. Retrieved from https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/english_learners_pg_040114.pdf.

Bahrick, H. P. (1984). Semantic memory content in permastore: Fifty years of memory for Spanish learned in school. *Journal of Experimental Psychology: General, 113,* 1-29. DOI: 10.1037//0096-3445.113.1.1

Beck, I. L., & McKeown, M. G. (2007). Increasing young low-income children's oral vocabulary repertoires through rich and focused instruction. *The Elementary School Journal, 107(3),* 251-271. DOI: 10.1086/511706

Berkeley, S., Scruggs, T. E., & Mastropier, M. A. (2012). Reading comprehension instruction for student with learning disabilities, 1995-2006: A meta-analysis. *Remedial and Special Education, 31,* 423-436. https://doi.org/10.1177/0741932509355988

Birsh, J. R. (2011). *Multisensory teaching of basic language skills*. Brookes Publishing Company. PO Box 10624, Baltimore, MD 21285.

Blachman, B. A., Schatschneider, C., Fletcher, J. M., Francis, D. J., Clonan, S. M., Shaywitz, B. A., & Shaywitz, S. E. (2004). Effects of intensive reading remediation for second and third graders and a 1-year follow-up. *Journal of Educational Psychology, 96*(3), 444-461. doi:http://dx.doi.org.proxy.lib.fsu.edu/10.1037/0022-0663.96.3.444

Blachman, B. A., Schatschneider, C., Fletcher, J. M., Murray, M. S., Munger, K. A., & Vaughn, M. G. (2014). Intensive reading remediation in grade 2 or 3: Are there effects a decade later? *Journal of Educational Psychology, 106*(1), 46-57. doi:http://dx.doi.org.proxy.lib.fsu.edu/10.1037/a0033663

Boscardin, C. K., Muthén, B., Francis, D. J., & Baker, E. L. (2008). Early identification of reading difficulties using heterogeneous developmental trajectories. *Journal of Educational Psychology, 100*, 192-208. https://doi:10.1037/0022-0663.100.1.192

Boulay, B., Goodson, B., Frye, M., Blocklin, M., & Price, C. (2015). *Summary of Research Generated by Striving Readers on the Effectiveness of Interventions for Struggling Adolescent Readers. NCEE 2016-4001.* National Center for Education Evaluation and Regional Assistance.

Boyer, N., & Ehri, L. C. (2011). Contribution of phonemic segmentation instruction with letters and articulation pictures to word reading and spelling in beginners. *Scientific Studies of Reading, 15(5),* 440-470. https://doi.org/10.1080/10888438.2010.520778

Brady, S. (2020). Strategies used in education for resisting the evidence and implications of the science of reading. *The Reading Journal, 1(1),* 33-40.

Brady, S. A., & Shankweiler, D. P. (Eds.). (1991). *Phonological processes in literacy: A tribute to Isabelle Y. Liberman*. Hillsdale, NJ: Erlbaum.

Brown, C. H., Curran, G., Palinkas, L. A., Aarons, G. A., Wells, K. B., Jones, L., Collins, L. M., Duan, N., Mittman, B. S., Wallace, A., Tabak, R. G., Ducharme, L., Chambers, D. A., Neta, G., Wiley, T., Landsverk, J., Cheung, K., & Cruden, G. (2017). An overview of research and evaluation designs for dissemination and implementation. *Annual Review of Public Health, 38,* 1-22. https://doi.org/10.1146/annurev-publhealth-031816-044215

Cabell, S. Q., Justice, L. M., McGinty, A. S., DeCoster, J., & Forston, L. (2015). Teacher-child conversations in preschool classrooms: Contributions to children's vocabulary development. *Early Childhood Research Quarterly, 30,* 80-92. DOI: 10.1016/j.ecresq.2014.09.004

Calkins, L. (2020). *No one gets to own the term "The Science of Reading"*. Retrieved from: https://readingandwritingproject.org/news/no-one-gets-to-own-the-term-the-science-of-reading

Caravolas, M., Lervåg, A., Defior, S., Málkova, G., S., & Hulme, C. (2013). Different patterns, but equivalent predictors, of growth in reading in consistent and inconsistent orthographies. *Psychological Science, 24*, 1398-1407. https://doi.org/10.1177/0956797612473122

Casini, L., Pech-Georgel, C., & Ziegler, J. C. (2018). It's about time: Revisiting temporal processing deficits in dyslexia. *Developmental Science, 21(2)*, 1-14. DOI: 10.1111/desc.12530

Castles, A., Rastle, K., & Nation, K. (2018). Ending the reading wars: Reading acquisition from novice to expert. *Psychological Science in the Public Interest, 19(1),* 5-51. http://dx.doi.org/10.1177/1529100618772271

Catts, H., Adlof, S., & Weismer, S. E. (2006). Language deficits in poor comprehenders: A case for the simple view of reading. *Journal of Speech, Language, and Hearing Research, 49,* 278-293. https://doi:10.1044/1092-4388(2006/023)

Catts, H., Herrera, S., Nielsen, D., & Bridges, 2015. Early prediction of reading comprehension within the simple view framework. *Reading and Writing: An Interdisciplinary Journal, 28,* 1407-1425. http://dx.doi.org/10.1007/s11145-015-9576-x

Catts, H., Hogan, T., & Adlof, S. (2005). Developmental changes in reading and reading disabilities. In H. Catts & A. Kamhi, A. (Eds.). *Connections between language and reading disabilities*. Mahwah, NJ: Erlbaum

Catts, H. W., & Petscher, Y. (2020, March 25). A cumulative risk and protection model of dyslexia. https://doi.org/10.35542/osf.io/g57ph

Cepeda, N. J., Pashler, H., Vul, E., Wixted, J. T., & Rohrer, D. (2006). Distributed practice in verbal recall tasks: A review and quantitative synthesis. *Psychological Bulletin, 132(3),* 354-380. https://doi.org/10.1037/0033-2909.132.3.354

Chall, J. (1967). *Learning to read: The great debate*. New York: McGraw-Hill.

Chapman, J. W., & Tunmer, W. E. (2016). Is Reading Recovery an effective intervention for students with reading difficulties? A critique of the i3 scale-up study. *Reading Psychology, 37(7),* 1025-1042. https://doi.org/10.1080/02702711.2016.1157538

Colenbrander, D., Ricketts, J., & Breadmore, H. L. (2018). Early identification of dyslexia: Understanding the issues. *Language, Speech, and Hearing Services in Schools, 49,* 817-828. https://dx.doi.org/10.1044/2018_LSHSS-DYSLC-18-0007

Compton, D. L., Fuchs, D., Fuchs, L. S., & Bryant, J. D. (2006). Selecting at-risk readers in first grade for early intervention: A two-year longitudinal study of decision rules and procedures. *Journal of Educational Psychology, 98,* 394-409.

Compton, D. L., Fuchs, D., Fuchs, L. S., Bouton, B., Gilbert, J. K., Barquero, L. A., Cho, E., & Crouch, R. C. (2010). Selecting at-risk readers in first grade for early intervention: Eliminating false positives and exploring the promise of a two-stage screening process. *Journal of Educational Psychology. 102,* 327-340. https://doi.org/10.1037/0022-0663.98.2.394

Compton, D. L., Miller, A. C., Elleman, A. M., & Steacy, L. M. (2014). Have we forsaken reading theory in the name of "quick fix" interventions for children with reading disability? *Scientific Studies of Reading, 18*(1), 55-73. doi:http://dx.doi.org/10.1080/10888438.2013.836200

Connor, C. M. D., Dombek, J., Crowe, E. C., Spencer, M., Tighe, E. L., Coffinger, S., … Petscher, Y. (2017). Acquiring science and social studies knowledge in kindergarten through fourth grade: Conceptualization, design, implementation, and efficacy testing of content-area literacy instruction (CALI). *Journal of Educational Psychology, 109(3),* 301–320. doi:10.1037/edu0000128

Cook, B. G., & Odom, S. L. (2013). Evidence-based practices and implementation science in special education. *Exceptional Children, 79,* 135-144. https://doi:10.1177/001440291307900201

Dane, F. C. (1990). *Research methods* (Vol. 120). Pacific Grove, CA: Brooks/Cole Publishing Company.

Dehaene, S. (2011). The massive impact of literacy on the brain and its consequences for education. *Human Neuroplascticity and Education*, *117*, 19-32.

Dehaene-Lambertz, G., Monzalvo, K., & Dehaene, S. (2018). The emergence of the visual word form: Longitudinal evolution of category-specific ventral visual areas during reading acquisition. *PLoS biology*, *16*(3), e2004103.

DeWalt, D. A., & Hink, A. (2009). Health literacy and child health outcomes: a systematic review of the literature. *Pediatrics*, *124*(Supplement 3), S265-S274. https://doi.org/10.1542/peds.2009-1162B

Dickinson, D. K., & Porche, M. V. (2011). Relation between language experiences in preschool classrooms and children's kindergarten and fourth-grade language and reading abilities. *Child Development, 82,* 870-886. doi: 10.1111/j.1467-8624.2011.01576.x

Douglas, N.F., Campbell, W.N., & Hinckley, J. (2015). Implementation science: Buzzword or game changer? *Journal of Speech, Language, and Hearing Research, 58,* S1827-S1836. doi: 10.1044/2015_JSLHR-L-15-0302.

Dyson, H., Best, W., Solity, J., & Hulme, C. (2017). Training mispronunciation correction and word meanings improves children's ability to learn to read words. *Scientific Studies of Reading*, 1-16. doi:http://doi.org/10.1080/10888438.2017.1315424

Eccles, M.P. & Mittman, B.S. (2006). Welcome to implementation science. *Implementation Science, 1,* 1-3. https://doi.org/10.1186/1748-5908-1-1

Eden, G. F., VanMeter, J. W., Rumsey, J. M., Maisog, J. M., Woods, R. P., & Zeffiro, T. A. (1996). Abnormal processing of visual motion in dyslexia revealed by functional brain imaging. *Nature, 382(6586),* 66-69. DOI: 10.1038/382066a0

Ehri, L. C. (2005). Learning to read words: Theory, findings, and issues. *Scientific Studies of Reading, 9,* 167-188. https://doi.org/10.1207/s1532799xssr0902_4

Ehri, L. C. (2014). Orthographic mapping in the acquisition of sight word reading, spelling memory, and vocabulary learning. *Scientific Studies of Reading, 18(1),* 5-21. https://doi.org/10.1080/10888438.2013.819356

Ehri, L. C., Nunes, S. R., Stahl, S. A., & Willows, D. M. (2001). Systematic phonics instruction helps students learn to read: Evidence from the National Reading Panel's meta-analysis. *Review of Educational Research, 71,* 393-447. https://doi.org/10.3102/00346543071003393

Ehri, L.C., Nunes, S. R., Willows, D., M., Schuster, B. V., Yaghoub-Zadeh, Z., & Shanahan, T. (2001). Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta-analysis. *Reading Research Quarterly, 36,* 250-287. https://doi.org/10.1598/RRQ.36.3.2

Elbro, C., de Jong, P. F., Houter, D., & Nielsen, A. (2012). From spelling pronunciation to lexical access: A second step in word decoding? *Scientific Studies of Reading, 16*(4), 341-359. doi:http://doi.org/10.1080/10888438.2011.568556

Elleman, A., Lindo, E., Morphy, P., & Compton, D. (2009). The impact of vocabulary instruction on passage-level comprehension of school-age children: A meta-analysis, *Journal of Research on Educational Effectiveness 2,* 1-44. https://doi.org/10.1080/19345740802539200

Ellis, N. C., Natsume, I., Stavropoulou, K., Hoxhallari, L., van Daal, V. H. P., Polyzoe, N., et al. (2004). The effects of the orthographic depth on learning to read alphabetic, syllabic, and logographic scripts. *Reading Research Quarterly, 39,* 438–468. doi: 10.1598/RRQ.39.4.5

Erbeli, F. (2019). Translating research findings in genetics of learning disabilities to special education instruction. *Mind, Brain, and Education, 13(2),* 74-79. https://doi.org/10.1111/mbe.12196

Erbeli, F., Hart, S.A., Wagner, R.W., & Taylor, J. (2018). Examining the etiology of reading disability as conceptualized by the hybrid model. *Scientific Studies of Reading, 22(2),* 167-180. doi: 10.1080/10888438.2017.1407321.

Ericsson, K. A. (1996). *The road to excellence: The acquisition of expert performance in the arts and sciences, sports, and games*. Mahwah, NJ: Erlbaum.

Every Student Succeeds Act (2015). Pub. L. No. 114-95 § 114 Stat. 1177 (2015-2016).Farley-Ripple,May, H., Karpyn, A., Tilley, K., & McDonough, K. (2018). Rethinking connections between research and practice in education: A conceptual framework. *Educational Researcher*, *47* (4), 235-245.

Fixsen, D., Blase, K., Metz, A., & Van Dyke, M. (2013). Statewide implementation of evidence-based programs. *Exceptional Children, 79,* 213-230. https://doi-org.proxy.lib.fsu.edu/10.1177/001440291307900206

Fixsen, D. L., Naoom, S. F., Blase, K. A., Friedman, R. M. & Wallace, F. (2005). *Implementation research: A synthesis of the literature*. Tampa, FL: University of South Florida, Louis de la Parte Florida Mental Health Institute, The National Implementation Research Network (FMHI Publication #231).

Flesch, R. (1955). *Why Johnny can't read - and what you can do about it*. NY: Harper & Brothers.

Foorman, B., Beyler, N., Borradaile, K., Coyne, M., Denton, C., Dimino, J., …Wissel, S. (2016a). *Foundational skills to support reading for understanding in kindergarten* *through 3rd grade* (NCEE 2016-4008). Washington, DC: National Center for Education Evaluation and Regional Assistance (NCEE), Institute of Education Sciences, U.S. Department of Education. Retrieved from https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/wwc_foundationalreading_070516.pdf

Foorman, B., Dombek, J., & Smith, K. (2016b). Seven elements important to successful implementation of early literacy intervention. *New Directions for Child and Adolescent Development*, *2016* (154), 49-65.

Foorman, B. R., Koon, S., Petscher, Y., Mitchell, A., & Truckenmiller, A. (2015). Examining general and specific factors in the dimensionality of oral language and reading in 4th–10th grades. *Journal of Educational Psychology, 107*, 884-899. DOI: 10.1037/edu0000026

Foorman, B., Petscher, Y., Herrera, S. (2018). Unique and common effects of decoding and language factors in predicting reading comprehension in grades 1-10. *Learning and Individual Differences, 63*, 12-23. http://dx.doi.org/10.1016/j.lindif.2018.02.011

Foorman, B. F., Smith, K. G., & Kosanovich, M. L. (2017). *Rubric for evaluating reading/language arts instructional materials for kindergarten to grade 5* (REL 2016-219). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southeast.

Forman, S. G., Shapiro, E. S., Codding, R. S., Gonzales, J. E., Reddy, L. A., Rosenfield, S. A., Sanetti, L. M. H., & Stoiber, K. C. (2013). Implementation science and school psychology. *School Psychology Quarterly, 28,* 77-100. https://doi:10.1037/spq0000019

Frost, R. (2012). Toward a universal model of reading. *Behavioral & Brain Sciences, 35,* 263–279. doi:10.1017/S0140525X11001841

García, J.R., & Cain, K. (2014). Decoding and reading comprehension: A meta-analysis to identify which reader and assessment characteristics influence the strength of the relationship in English. *Review of Educational Research, 84(1),* 74-111. http://dx.doi.org/10.3102/0034654313499616

Gersten, R., Baker, S.K., Shanahan, T., Linan-Thompson, S., Collins, P., & Scarcella, R. (2007). *Effective literacy and English language instruction for English learners in the elementary grades: A practice guide* (NCEE 2007-4011). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/20074011.pdf.

Gersten, R., Compton, D., Connor, C.M., Dimino, J., Santoro, L., Linan-Thompson, S., & Tilly, W.D. (2008). *Assisting students struggling with reading: Response to Intervention and multi-tier intervention for reading in the primary grades. A practice guide*. (NCEE 2009-4045). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/rti_math_pg_042109.pdf

Gersten, R., Jayanthi, M., & Dimino, J. (2017a). Too much, too soon? Unanswered questions from national response to intervention evaluation. *Exceptional Children, 83,* 244-254. https://doi.org/10.1177/0014402917692847

Gersten, R., Newman-Gonchar, R., Haymond, K., & Dimino, J. (2017b). *What is the evidence base for Response to Intervention in reading in grades 1–3?* (REL 2016-129).

Washington, DC: U.S. Department of Education, Institute of Education Sciences. National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southeast. Retrieved from https://files.eric.ed.gov/fulltext/ED573686.pdf

Gillam, R. B., Loeb, D. F., Hoffman, L. M., Bohman, T., Champlin, C. A., Thibodeau, L., ... & Friel-Patti, S. (2008). The efficacy of Fast ForWord language intervention in school-age children with language impairment: A randomized controlled trial. *Journal of Speech, Language, and Hearing Research*, *51(1),* 97-119. https://doi.org/10.1044/1092-4388(2008/007)

Gilliland, C. T., White, J., Gee, B., Kreeftmeijer-Vegter, R., Bietrix, F., Ussi, A. E., Hajduch, M., Kocis, P., Chiba, N., Hirasawa, R., Suematsu, M., Bryans, J., Newman, S., Hall, M. D., & Austin, C. P. (2019). The fundamental characteristics of a translational scientist. *ACS Pharmacology & Translational Science, 2,* 213-261. https://doi.org/10.1021/acsptsci.9b00022

Gonzalez, J. E., Pollard-Durodola, S., Simmons, D. C., Taylor, A. B., Davis, M. J., Kim, M., & Simmons, L. (2011). Developing low-income preschoolers' social studies and science vocabulary knowledge through content-focused shared book reading. *Journal of Research on Educational Effectiveness, 4(1),* 25-52. doi: 10.1080/19345747.2010.487927

Goodman, K.S. (1967). Reading: A psycholinguistic guessing game, *Literacy Research and Instruction, 6(4)*, 126-135, https://doi.org/10.1080/19388076709556976

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. Remedial and *Special Education, 7,* 6-10. https://doi.org/10.1177/074193258600700104

Haft, S. L., Myers, C. A., & Hoeft, F. (2016). Socio-emotional and cognitive resilience in children with reading disabilities. *Current Opinion in Behavioral Sciences, 10,* 133-141.

Hanford, E. (2019). *At a loss for words: How a flawed idea is teaching millions of kids to be poor readers.* Retrieved from: https://www.apmreports.org/story/2019/08/22/whats-wrong-how-schools-teach-reading

Hart, S. A. (2016). Precision education initiative: Moving toward personalized education. *Mind, Brain, and Education, 10(4),* 209-211.doi: 10.1111/mbe.12109

Hernandez, D. J. (2011). *Double jeopardy: How third-grade reading skills and poverty influence high school graduation*. Annie E. Casey Foundation. https://files-eric-ed-gov.proxy.lib.fsu.edu/fulltext/ED518818.pdf
https://psycnet.apa.org/doi/10.1097/00011363-200501000-00004

Hwang, H., Cabell, S. Q., White, T. G., & Joiner, R. (2019, December). *A systematic review of the research on the effect of knowledge building in literacy instruction on comprehension and vocabulary in the elementary years*. Presentation at the annual meeting of the Literacy Research Association, Tampa, FL.

Hyatt, K. J., Stephenson, J., & Carter, M. (2009). A review of three controversial educational practices: Perceptual motor programs, sensory integration, and tinted lenses. *Education & Treatment of Children, 32*(2), 313-342. doi:http://dx.doi.org/10.1353/etc.0.0054

Iovino, I., Fletcher, J. M., Breitmeyer, B. G., & Foorman, B. R. (1998). Colored overlays for visual perceptual deficits in children with reading disability and attention deficit/hyperactivity disorder: Are they differentially effective? *Journal of Clinical and Experimental Neuropsychology, 20(6),* 791-806. DOI: 10.1076/jcen.20.6.791.1113

Israel, S. E., & Duffy, G. G. (Eds.). (2014). *Handbook of Research on Reading Comprehension*. New York: Routledge.

Jenkins, J. R., Peyton, J. A., Sanders, E. A., & Vadasy, P. F. (2004). Effects of reading decodable texts in supplemental first-grade tutoring. *Scientific Studies of Reading, 8,* 53–85. https://doi.org/10.1207/s1532799xssr0801_4

Joyce, E. (2020, January 22). *Scientific Racism 2.0 (SR2.0): An erroneous argument from genetics which inadvertently refines scientific racism*. https://doi.org/10.35542/osf.io/f7jnh

Kamil, M. L., Borman, G. D., Dole, J., Kral, C. C., Salinger, T., & Torgesen, J. (2008). *Improving adolescent literacy: Effective classroom and intervention practices: A practice guide* (NCEE #2008-4027). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/adlit_pg_082608.pdf.

Kang, C. Y., Duncan, G. J., Clements, D. H., Sarama, J., & Bailey, D. H. (2019). The roles of transfer of learning and forgetting in the persistence and fadeout of early childhood mathematics interventions. *Journal of Educational Psychology, 111,* 590-603. http://dx.doi.org/10.1037/edu0000297

Kershaw, S. & Schatschneider, C. (2012). A latent variable approach to the simple view of reading. *Reading and Writing, 25,* 433-464. https://doi.org/10.1177/0741932518764833

Kim, J. S., Burkhauser, M. A., Mesite, L. M., Asher, C. A., Relyea, J. E., Fitzgerald, J., & Elmore, J. (2020). Improving reading comprehension, science domain knowledge, and reading engagement through a first-grade content literacy intervention. *Journal of Educational Psychology.* Advance online publication. http://dx.doi.org/10.1037/edu0000465.

Kuo, L. J., & Anderson, R. C. (2006). Morphological awareness and learning to read: A cross-language perspective. *Educational Psychologist, 41,* 161-180. https://doi:10.1207/s15326985ep4103_3

Language and Reading Research Consortium & Chiu, Y.D. (2018). The simple view of reading across development: Prediction of grade 3 reading comprehension from prekindergarten skills. *Remedial and Special Education, 39(5),* 289-303. http://dx.doi.org/10.1177/0741932518762055

Lee, J. J., Wedow, R., Okbay, A., Kong, E., Maghzian, O., Zacher, M., ... & Fontana, M. A. (2018). Gene discovery and polygenic prediction from a 1.1-million-person GWAS of educational attainment. *Nature Genetics, 50(8),* 1112-1121.doi: 10.1038/s41588-018-0147-3

Lesaux, N. K., Kieffer, M. J., Faller, S. E., & Kelley, J. G. (2010). The effectiveness and ease of implementation of an academic vocabulary intervention for linguistically diverse students in urban middle schools. *Reading Research Quarterly,45 (2),* 196–228. http://dx.doi.org/10.1598/RRQ.45.2.3

Lesaux, N. K., Kieffer, M. J., Kelley, J. G., & Harris, J. R. (2014). Effects of academic vocabulary instruction for linguistically diverse adolescents: Evidence from a randomized field trial. *American Educational Research Journal, 51(6),* 1159-1194. https://doi.org/10.3102/0002831214532165

Little, C. W., Haughbrook, R., & Hart, S. A. (2017). Cross-study differences in the etiology of reading comprehension: A meta-analytical review of twin studies. *Behavior Genetics, 47(1)*, 52-76.https://doi.org/10.1007/s10519-016-9810-6

Lonigan, C. J., Anthony, J. L., Phillips, B. M., Purpura, D. J., Wilson, S. B., & McQueen, J. (2009). The nature of preschool phonological processing abilities and their relations to vocabulary, general cognitive abilities, and print knowledge. Journal of Educational Psychology, 101, 345-358. https://doi.org/10.1037/a0013837

Lonigan, C. J., Burgess, S. R., Anthony, J. L., & Barker, T. A. (1998). Development of phonological sensitivity in two- to five-year-old children. Journal of Educational Psychology, 90, 294-311. https://doi.org/10.1037/0022-0663.90.2.294

Lonigan, C., Burgess, S., & Schatschneider, C. (2018). Examining the Simple View of Reading with elementary school children: Still simple after all these years. *Remedial and Special Education, 39(5),* 260-273. http://dx.doi.org/10.1177/0741932518764833

Lonigan, C. J., Farver, J. M., Nakamoto, J., & Eppe, S. (2013). Developmental trajectories of preschool early literacy skills: A comparison of language-minority and monolingual-English children. *Developmental Psychology, 49,* 1943-1957. https://doi:10.1037/a0031408

Lonigan, C. J., Farver, J. M., Phillips, B. M., & Clancy-Menchetti, J. (2011). Promoting the development of preschool children's emergent literacy skills: A randomized evaluation of a literacy-focused curriculum and two professional development models. *Reading and Writing: An Interdisciplinary Journal, 24,* 305-337. doi: 10.1007/s11145-009-9214-6

Lonigan, C. J., & Whitehurst, G. J. (1998). Relative efficacy of parent and teacher involvement in a shared-reading intervention for preschool children from low-income backgrounds. *Early Childhood Research Quarterly, 13,* 263-290. doi: 10.1016/S0885-2006(99)80038-6

Lyytinen, H., Erskine, J., Hämäläinen, J., Torppa, M & Ronimus, M. (2015). Dyslexia-early identification and prevention: Highlights of the Jyvaskyla longitudinal study of dyslexia. *Current Developmental Disorders Report, 2,* 330-338.

Maher, B. (2008). Personal genomes: The case of missing heritability. *Nature, 456,* 18-21. doi: 10.1038/456018a.

Mancilla-Martinez, J., & Lesaux, N. (2010). Predictors of reading comprehension for struggling readers: The case of Spanish-speaking language minority children. *Journal of Educational Psychology, 102(3),* 701-711. http://dx.doi.org/10.1037/a0019135.

Marinus, E., Mostard, M., Segers, E., Schubert, T. M., Madelaine, A., & Wheldall, K. (2016). A special font for people with dyslexia: Does it work and, if so, why? *Dyslexia, 22(3),* 233-244. doi: 10.1002/dys.1527

Marulis, L. M., & Neuman, S. B. (2010). The effects of vocabulary intervention on young children's word learning: A meta-analysis. *Review of Educational Research, 80(3),* 300-335. doi: 10.3102/0034654310377087

Melby-Lervåg, M., Redick, T. S., & Hulme, C. (2016). Working memory training does not improve performance on measures of intelligence or other measures of "far transfer" evidence from a meta-analytic review. *Perspectives on Psychological Science, 11(4),* 512-534. doi: 10.1177/1745691616635612

Miciak, J., & Fletcher, J. M. (2020). The critical role of instructional response for identifying dyslexia and other learning disabilities. *Journal of Learning Disabilities*. Advance online publication. doi:10.1177/0022219420906801

Nation, K., & Castles, A. (2017). Putting the learning into orthographic learning. *Theories of reading development*, 148-168.

National Institute of Child Health and Human Development (2000). *National reading panel—Teaching children to read: Reports of the subgroups* (NIH Pub. No. 00-4754). Washington, DC: U.S. Department of Health and Human Services. Retrieved from https://www.nichd.nih.gov/sites/default/files/publications/pubs/nrp/Documents/report.pdf

National Institute for Literacy (2008). *Developing early literacy: Report of the National Early Literacy Panel*. Retrieved at https://lincs.ed.gov/publications/pdf/NELPReport09.pdf

Neuman, S. B., & Kaefer, T. (2018). Developing low-income children's vocabulary and content knowledge through a shared book reading program. *Contemporary Educational Psychology, 52,* 15-24. doi: 10.1016/j.cedpsych.2017.12.001

Olson, R. & Datta, H. (2002). Visual-temporal processing in reading-disabled and normal twins. *Reading and Writing: An Interdisciplinary Journal, 15(1-2),* 127-149.

Palinscar, A. S., & Duke, N. K. (2004). The role of text and text-reader interactions in young children's reading development and achievement. *The Elementary School Journal, 105(2),* 183–197. doi:10.1086/428864

Patton-Terry, N., Connor, C. M., Thomas-Tate, S., & Love, M. (2010). Examining relationships among dialect variation, literacy skills, and school context in first grade. *Journal of Speech, Language, and Hearing Research, 53*(1), 126-145. doi:http://dx.doi.org/10.1044/1092-4388(2009/08-0058)

Peng, P., Fuchs, D., Fuchs, L. S., Elleman, A. M., Kearns, D. M., Gilbert, J. K., ... & Patton III, S. (2019). A longitudinal analysis of the trajectories and predictors of word reading and reading comprehension development among at-risk readers. *Journal of Learning Disabilities, 52,* 195-208. https://doi.org/10.1177/00222194188090

Pennington BF, Santerre-Lemmon L, Rosenberg J, MacDonald B, Boada R, et al. (2012). Individual prediction of dyslexia by single versus multiple deficit models. *Journal of Abnormal Psychology, 121,* 212–224. doi: 10.1037/a0025823

Perfetti, C. (2007). Reading ability: Lexical quality to comprehension. *Scientific Studies of Reading, 11(4),* 357-383. http://dx.doi.org/10.1080/10888430701530730

Perfetti, C. A. (1992). The representation problems in reading acquisition. In P. B. Gough, L. C. Ehri, & R. Treiman (Eds.), *Reading acquisition* (pp. 145–174). Hillsdale, NJ: Erlbaum.

Peters, J. L., De Losa, L., Bavin, E. L., & Crewther, S. G. (2019). Efficacy of dynamic visuo-attentional interventions for reading in dyslexic and neurotypical children: A systematic review. *Neuroscience & Biobehavioral Reviews, 100,* 58-76. https://doi.org/10.1016/j.neubiorev.2019.02.015

Phillips, B. M., Connor, C. M., Lonigan, C. J., Willis, K. B., & Crowe, E. (presented 2016, July). *Supporting language and comprehension in second grade: Results from a Tier 2 efficacy trial*. Presentation at Annual Meeting of the Society for the Scientific Study of Reading, Society for the Scientific Study of Reading, Porto, Portugal.

Protopapas, A. (2014). From temporal processing to developmental language disorders: Mind the gap. *Philosophical Transactions of the Royal Society B: Biological Sciences, 369(1634),* 20130090.

Rack, J. P., Snowling, M. J., & Olson, R. K. (1992). The nonword reading deficit in developmental dyslexia: A review. *Reading Research Quarterly, 27*(1), 28-53. doi:http://doi.org/10.2307/747832

Rayner, K., Foorman, B. R., Perfetti, C. A., Pesetsky, D., & Seidenberg, M. S. (2001). How psychological science informs the teaching of reading. *Psychological Science in the Public Interest, 2(2),* 31-74. doi:http://dx.doi.org/10.1111/1529-1006.00004

Reutzel, D. R., Petscher, Y., & Spichtig, A. N. (2012). Exploring the value added of a guided, silent reading intervention: Effects on struggling third-grade readers' achievement. *The Journal of Educational Research, 105(6),* 404-415. https://doi.org/10.1080/00220671.2011.629693

Ritchey, K. D., & Goeke, J. L. (2006). Orton-Gillingham and Orton-Gillingham—based reading instruction: A review of the literature. *The Journal of Special Education, 40(3),* 171-183. https://doi.org/10.1177/00224669060400030501

Sabatini, J. P., Sawaki, Y., Shore, J. R., & Scarborough, H. S. (2010). Relationships among reading skills of adults with low literacy. Journal of Learning Disabilities, 43, 122-138. https://doi.org/10.1177/0022219409359343

Sarama, J., Clements, D. H., Wolfe, C. B., & Spitler, M. E. (2012). Longitudinal evaluation of a scale-up model for teaching mathematics with trajectories and technologies. *Journal of Research on Educational Effectiveness, 5,* 105-135. https://doi.org/10.3102/0002831212469270

Savage, R., Georgiou, G., Parrila, R., & Maiorino, K. (2018). Preventative reading interventions teaching direct mapping of graphemes in texts and set-for-variability aid at-risk learners. *Scientific Studies of Reading, 22*(3), 225-247. doi:http://dx.doi.org/10.1080/10888438.2018.1427753

Schneider, M. (2018, December 17). *A more systematic approach to replicating research*. Institute of Education Sciences. https://ies.ed.gov/director/remarks/12-17-2018.asp

Schwartz, S. (2019, December). *The most popular reading programs aren't backed by science*. Retrieved from EDWeek https://www.edweek.org/ew/articles/2019/12/04/the-most-popular-reading-programs-arent-backed.html

Scruggs, T. E., Mastropieri, M. A., & McDuffie, K. A. (2007). Co-teaching in inclusive classrooms: A meta-synthesis of qualitative research. *Exceptional Children, 73(4),* 392-416. https://doi.org/10.1177/001440290707300401

Seidenberg, M. S. (2005). Connectionist models of word reading. *Current Directions in Psychological Science, 14(5),* 238-242. https://doi.org/10.1111/j.0963-7214.2005.00372.x

Selzam, S., Dale, P. S., Wagner, R. K., DeFries, J. C., Cederlöf, M., O'Reilly, P. F., ... & Plomin, R. (2017). Genome-wide polygenic scores predict reading performance throughout the school years. *Scientific Studies of Reading, 21(4),* 334-349.doi: 10.1080/10888438.2017.1299152

Seymour, P. H., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in european orthographies. *British Journal of Psychology, 94*(2), 143-174. doi:http://dx.doi.org.proxy.lib.fsu.edu/10.1348/000712603321661859

Shanahan, T., Callison, K., Carriere, C., Duke, N. K., Pearson, P. D., Schatschneider, C., & Torgesen, J. (2010). Improving reading comprehension in kindergarten through 3rd grade: A practice guide (NCEE 2010-4038). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. Retrieved from https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/readingcomp_pg_092810.pdf

Share, D. L. (1995). Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition, 55,* 151–218. https://doi.org/10.1016/0010-0277(94)00645-2

Slavin, R. E. (2002). Evidence-based education policies: Transforming educational practice and research. *Educational Researcher, 31,* 15-21. https://doi:10.3102/0013189x031007015

Smith (1971). *Understanding Reading*. New York: Holt, Rhinehart & Winston.

Smolen, P., Zhang, Y., & Byrne, J. H. (2016). The right time to learn: mechanisms and optimization of spaced learning. *Nature Reviews Neuroscience, 17(2),* 77-88. https://doi.org/10.1038/nrn.2015.18

Stanovich, K. E. (1980). Toward an interactive-compensatory model of individual differences in the development of reading fluency. *Reading Research Quarterly, 16(1),* 32-71. DOI: 10.2307/747348

Stanovich, K. E. (1990). Concepts in developmental theories of reading skill: Cognitive resources, automaticity, and modularity. *Developmental Review, 10(1),* 72-100. https://doi.org/10.1016/0273-2297(90)90005-O

Stanovich, K. E. (1991). Word recognition: Changing perspectives. In R. Barr, M. L. Kamil, P. B. Mosenthal, & P. D. Pearson (Eds.), *Handbook of reading research*, Vol. 2 (p. 418–452). Lawrence Erlbaum Associates, Inc.

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

Stanovich (2003). Understanding the styles of science in the study of reading. *Scientific Studies of Reading, 7(2)*, 105-126, http://dx.doi.org/10.1207/S1532799XSSR0702_1

Stanovich, K. E., & Siegel, L. S. (1994). Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable-difference model. *Journal of Educational Psychology, 86*(1), 24-53. doi:http://dx.doi.org/10.1037/0022-0663.86.1.24

Steacy, L. M., Compton, D. L., Petscher, Y., Elliott, J. D., Smith, K., Rueckl, J. G., Sawi, O., Frost, S. J., & Pugh, K. (2019a). Development and prediction of context-dependent vowel pronunciation in elementary readers. *Scientific Studies of Reading, 23(1),* 49-63. https://doi.org/10.1080/10888438.2018.1466303

Steacy, L. M., Wade-Woolley, L., Rueckl, J. G., Pugh, K. R., Elliott, J. D., & Compton, D. L. (2019b). The role of set for variability in irregular word reading: Word and child predictors in typically developing readers and students at-risk for reading disabilities. *Scientific Studies of Reading, 23*(6), 523-532. doi:http://doi.org/10.1080/10888438.2019.1620749

Stein, J. (2019). The current status of the magnocellular theory of developmental dyslexia. *Neuropsychologia, 130,* 66-77. DOI: 10.1016/j.neuropsychologia.2018.03.022

Storch, S., & Whitehurst, G.R. (2002). Oral language and code-related precursors to reading: Evidence from a longitudinal, structural model. *Developmental Psychology, 38,* 934-947 http://dx.doi.org/10.1037/0012-1649.38.6.934

Strong, G. K., Torgerson, C. J., Torgerson, D., & Hulme, C. (2011). A systematic meta-analytic review of evidence for the effectiveness of the 'fast ForWord' language intervention program. *Journal of Child Psychology and Psychiatry, 52(3),* 224-235. doi: 10.1111/j.1469-7610.2010.02329.x

Suggate, S. P. (2016). A meta-analysis of the long-term effect of phonemic awareness, phonics, fluency, and reading comprehension analyses. *Journal of Learning Disabilities, 49,* 77-96. https://doi:10.1177/0022219414528540

Tallal, P. (1984). Temporal or phonetic processing deficit in dyslexia? That is the question. *Applied Psycholinguistics, 5(2),* 167-169. https://doi.org/10.1017/S0142716400004963

Therrien, W. J. (2004). Fluency and comprehension gains as a result of repeated reading: A meta-analysis. Remedial and Special Education, 25, 253-261. https://doi.org/10.1177/07419325040250040801

Thompson, P.A., Hulme, C., Nash, H.M., Gooch, D., Hayiou-Thomas, E. & Snowling, M.J. (2015). Developmental dyslexia: Predicting risk. *Journal of Child Psychology and Psychiatry, 56*, 976-987. doi: 10.1111/jcpp.12412

Torgesen, J. K. (2000). Individual differences in response to early interventions in reading: The lingering problem of treatment resisters. *Learning Disabilities Research & Practice, 15*(1), 55-64. doi:http://doi.org/10.1207/SLDRP1501_6

Torgesen, J. K., Alexander, A. W., Wagner, R. K., Rashotte, C. A., Voeller, K. K., & Conway, T. (2001). Intensive remedial instruction for children with severe reading disabilities: Immediate and long-term outcomes from two instructional approaches. *Journal of Learning Disabilities*, *34*(1), 33-58. doi:http://dx.doi.org/10.1177/002221940103400104

Tunmer, W. E., & Chapman, J. W. (2012). Does set for variability mediate the influence of vocabulary knowledge on the development of word recognition skills? *Scientific Studies of Reading, 16*(2), 122-140. doi:http://doi.org/10.1080/10888438.2010.542527

Vadasy, P. F., Nelson, J. R., & Sanders, E. A. (2011). Longer term effects of a tier 2 kindergarten vocabulary intervention for English learners. *Remedial and Special Education, 34,* 91-101. https://doi:10.1177/0741932511420739

Vadasy, P. F., & Sanders, E. A. (2013). Two-year follow-up of a code-oriented intervention for lower-skilled first graders: The influence of language status and word reading skills on third-grade literacy outcomes. *Reading & Writing, 26,* 821-843. https://doi:10.1007/s11145-012-9393-4

van IJzendoorn, M. H., & Bus, A. G. (1994). Meta-analytic confirmation of the nonword reading deficit in developmental dyslexia. *Reading Research Quarterly, 3*, 267–275. http://dx.doi.org/10.2307/747877

Vaughn, S., Martinez, L. R., Wanzek, J., Roberts, G., Swanson, E., & Fall, A. M. (2017). Improving content knowledge and comprehension for English language learners: Findings from a randomized control trial. *Journal of Educational Psychology, 109,* 22-34. http://dx.doi.org/10.1037/edu0000069

Vellutino, F. R., Scanlon, D. M., Sipay, E. R., Small, S. G., Pratt, A., Chen, R., & Denckla, M. B. (1996). Cognitive profiles of difficult-to-remediate and readily remediated poor readers: Early intervention as a vehicle for distinguishing between cognitive and experiential deficits as basic causes of specific reading disability. *Journal of Educational Psychology 88,* 601–638. doi:http://doi.org/10.1037/0022-0663.88.4.601

Vellutino, F. R., Tunmer, W. E., Jaccard, J., & Chen, S. (2007). Components of reading ability: Multivariate evidence for a convergent skills model of reading development. Scientific Studies of Reading, 11, 3-32. DOI: 10.1080/10888430709336632

Venezky, R. L. (1999). *The American way of spelling: The structure and origins of American English Orthography.* New York, NY: Guilford Press.

Verhoeven, L., & van Leeuwe, J. (2008). Prediction of the development of reading comprehension: A longitudinal study. *Applied Cognitive Psychology, 22,* 407-423. http://dx.doi.org/10.1002/acp.1414

Wade-Woolley, L. (2016). Prosodic and phonemic awareness in children's reading of long and short words. *Reading and Writing, 29,* 371-382. https://doi.org/10.1007/s11145-015-9600-1

Wagner, R. K., Edwards, A. A., Malkowski, A., Schatschneider, C., Joyner, R. E., Wood, S., Zirps, F. A. (2019). Combining old and new for better understanding and predicting dyslexia. *New Directions for Child and Adolescent Development, 165,* 1–11. doi: 10.1002/cad.20289

Wagner, R. K., Francis, D. J., & Morris, R. D. (2005). Identifying English language learners with learning disabilities: Key challenges and possible approaches. *Learning Disabilities Research & Practice, 20(1),* 6-15. http://dx.doi.org/10.1111/j.1540-5826.2005.00115.x

Wagner, R.K., Muse, A.E., & Tannenbaum, K.R. (2007). Promising avenues for better understanding implications of vocabulary development for reading comprehension. In Wagner R.. Muse A., Tannenbaum K. (Eds). *Vocabulary acquisition: Implications for reading comprehension*. New York: Guilford Press. pp. 276–291.

Wagner, R. K., & Stanovich, K. E. (1996). Expertise in reading. In K. A. Ericsson (Ed.), The *road to excellence: The acquisition of expert performance in the arts and sciences, sports, and games* (pp. 189-225). Mahwah, NJ: Erlbaum.

Wagner, R. K., & Torgesen, J. K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101,* 192-212. https://doi.org/10.1037/0033-2909.101.2.192

Wagner, R., Torgesen, J., & Rashotte, C. (1994). Development of reading-related phonological processing abilities: New evidence of bidirectional causality from a latent variable longitudinal study. *Developmental Psychology, 30,* 73-87. https://doi.org/10.1037/0012-1649.30.1.73

Wanzek, J., Vaughn, S., Scammacca, N., Gatlin, B., Walker, M. A., & Capin, P. (2016). Meta-analyses of the effects of Tier 2 type reading interventions in grades K-3. *Educational Psychology Review, 28,* 551-576. https://doi.org/10.1007/s10648-015-9321-7

Wanzek, J., Vaughn, S., Scammacca, N. K., Metz, K., Murray, C. S., Roberts, G., & Danielson, L. (2013). Extensive reading interventions for students with reading difficulties after Grade 3. *Review of Educational Research, 83,* 163-195. https://doi.org/10.3102/0034654313477212

Wasik, B. A., & Hindman, A. H. (2020). Increasing preschoolers' vocabulary development through a streamlined teacher professional development intervention. *Early Childhood Research Quarterly, 50,* 101-113. doi: 10.1016/j.ecresq.2018.11.001

Welsch, J. G., Powell, J. J., & Robnolt, V. J. (2019). Getting to the core of close reading: What do we really know and what remains to be seen? *Reading Psychology, 40(1),* 95-116. https://doi.org/10.1080/02702711.2019.1571544

Whitehurst, G. J. & Lonigan, C. J. (1998). Child development and emergent literacy. *Child Development, 69,* 848-872. https://doi.org/10.2307/1132208

Williams, J. P., Pollini, S., Nubla-Kung, A. M., Snyder, A. E., Garcia, A., Ordynans, J. G., & Atkins, J. G. (2014). An intervention to improve comprehension of cause/effect through expository text structure instruction. *Journal of Educational Psychology, 106,* 1-17. doi: 10.1037/a0033215

Ziegler, J., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin, 131(1),* 3-29. http://dx.doi.org/10.10370033-2909.131.1.3

Ziegler, J., Stone, G., & Jacobs, A. (1997). What is the pronunciation for –ough and the spelling for /u/? A database for computing feedforward and feedback consistence in English. *Behavior Research Methods, Instruments, & Computers, 29(4),* 600-618. http://dx.doi.org/10.3758/BF03210615

Zipke, M. (2016). The importance of flexibility of pronunciation in learning to decode: A training study in set for variability. *First Language*, *36*(1), 71-86. doi:http://doi.org /10.1177/0142723716639495