Literacy Studies: Perspectives from Cognitive Neurosciences, Linguistics, Psychology and Education

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The Cognitive Foundations of Reading and Its Acquisition

A Framework with Applications Connecting Teaching and Learning

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While language defines humanity, literacy defines civilization. Understandably, illiteracy or difficulties in acquiring literacy skills have become a major concern of our technological society. A conservative estimate of the prevalence of literacy problems would put the figure at more than a billion people in the world. Because of the seriousness of the problem, research in literacy acquisition and its breakdown is pursued with enormous vigor and persistence by experts from diverse backgrounds such as cognitive psychology, neuroscience, linguistics and education. This, of course, has resulted in a plethora of data, and consequently it has become difficult to integrate this abundance of information into a coherent body because of the artificial barriers that exist among different professional specialties.

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We dedicate this work to those who were so instrumental in enabling us to complete it:

- *To Philip B. Gough, our mentor, who brought together deep insights about reading and an unflinching commitment to subject them to the tests of science and whose relentless press to learn so expanded our intellectual passions and discipline*
- *To wilderness, especially the Bridger Wilderness, which has long centered another of our passions*
- *To our many colleagues who have generously shared with us themselves and their wisdoms*
- *To our respective wives, Susan and Jane, and children, Clayton and Kyle, and Ross, Adrien, and Alec, who have sustained us as our foundations*

Preface

In 1992, the National Assessment of Educational Progress (NAEP) found that 38% of fourth-grade students in the United States read *below* its basic level. And while significant improvements have been made, this number has fallen only to 34% in the most recent NAEP findings from 2019 (National Assessment of Educational Progress, 2020, January 25). Given all the resources expended over these years to change this outcome, why is it so difficult to make progress in supporting children to read? Though there is great diversity in the issues faced by the third of students who fail to read at the basic level (e.g., poverty and its accompanying conditions, limited skills in English, learning difficulties, limited opportunities to learn, poor instruction), we believe there is one overarching persistent obstacle to their progress: our general failure to effectively develop the abilities of reading professionals to connect what is known about the cognitive capacities required for reading to the professional use of the tools employed to develop those capacities in children. In short, we have yet to provide our professional staffs with the capability to judiciously connect the *whys* underlying reading competence to the *whats* used to develop it, resulting in reading practices wanting for both coherence and effectiveness. This capacity to connect within reading practice is the central issue we address here.

The book is focused on supporting reading professionals – reading teachers, specialists, interventionists, coordinators, and coaches – as well as those preparing to serve in these roles and the teacher educators preparing them for such service. It is designed to help these professionals develop an understanding of the cognitive capacities upon which reading depends and to apply that understanding in ways that will enable them to bring coherence to their practices. Achieving coherence in reading practices based on the cognitive requirements of reading will help them better support all students learning to read, including those who encounter little difficulty with reading, but especially those who struggle to read.

This book first describes the structure of cognitive components underlying reading and learning to read. This is achieved through the Cognitive Foundations Framework, which depicts the set of critical cognitive capacities, as well as their interrelationships, that must be in place if successful reading is to be realized. The

book references (though not exhaustively) and sometimes highlights key research, but it does not attempt to bring full research detail to that which underlies the broad picture, which is the central focus. The book next shows how this view of reading and its development can be linked to the main tools reading professionals use in their everyday work – reading standards, assessments, and curriculum and instruction. It does this by providing detailed examples of such linkages through applications of the framework to some widely used materials:

- Reading-relevant standards from the *Common Core State Standards* (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010)
- A kindergarten through 12th-grade assessment portfolio used in one school district
- The subtasks of the *DIBELS Next* (Good & Kaminski, 2012) assessment of reading skills
- Evidence-based recommendations regarding the content of reading instruction from the reports of three expert panels, namely,
  - *Report of the National Reading Panel: Teaching Children to Read – Reports of the Subgroups* (National Institute of Child Health and Human Development, 2000)
  - *Foundational skills to support reading for understanding in kindergarten through third grade* (Foorman et al., 2016)
  - *Improving reading comprehension in kindergarten through third grade* (Shanahan et al., 2010)
- A kindergarten curricular sequence from the *SRA Open Court Reading* program (McGraw-Hill, 2018, November 11)

For each of these examples, the book details their linkages to the cognitive foundations underlying reading to show how these connections may be made for other materials that may be in use within a given setting.

The book is unique in that it provides a broad-stroke model of the cognitive capacities underlying reading as well as those cognitive capacities needed to master these cognitive requirements for reading. It describes the main evidence-based interrelationships of these cognitive capacities and explicitly represents them through structured graphic displays that aid overall understanding. And finally, it demonstrates how knowledge of these cognitive capacities can be connected to the available tools used in reading practice so that reading professionals can build a justified, coherent approach to their work. These relationships, discussed in detail, are also represented graphically through maps that overlay tool content onto the cognitive foundations of reading, further enhancing the understanding of both. The innovative approach of this book is on using knowledge of the cognitive requirements of reading and learning to read as a mechanism for brining coherence to the use of reading practice tools. In short, for reading, the book provides a framework whose applications can bind teaching and learning, allowing one to guide what children must be taught based on what they have so far learned.

While the book is based on understanding reading and reading development in English, it also presents a more general model representing the cognitive requirements of reading and learning to read in any phonologically based writing system. This makes it useful for understanding what is required for learning to read other languages employing such systems and what the cognitive implications are for learning to read in a second language given the cognitive requirements for reading in the first language.

Finally, the book aids understanding of the cognitive dimensions of reading difficulty and disability and provides a detailed focus on understanding and executing response-to-intervention approaches for struggling readers based on the cognitive issues faced. It follows this with a discussion of how to create coherent reading practices based on the previous material presented and ends with a summary of what has been covered and work that remains to be done.

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Contents

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Wesley A. Hoover earned his PhD in Human Experimental Psychology from the University of Texas at Austin with a specialty in psycholinguistics. He worked at the Southwest Educational Development Laboratory (SEDL) for 35 years in the areas of early reading, bilingual reading, language acquisition, and mathematics and science education, leading research, research application, and several large-scale education dissemination and professional development projects. His main research centered on the *simple view of reading* and its cognitive underpinnings and was focused on detailing the specifications and predictions of these conceptual models and testing them in the context of early grade reading. In his last 18 years at SEDL, he served as its President and CEO, directing the overall work of some 100 staff supported through competitively won awards. His culminating work at SEDL was leading its 2015 merger with the American Institutes for Research (AIR). Within AIR, he served as Executive Vice President and Senior Advisor, working on merger transition issues and special projects within the field of literacy, before retiring in 2019.

William E. Tunmer is Distinguished Professor of Educational Psychology at the Massey University, Institute of Education. He received his PhD in Experimental Psychology from the University of Texas at Austin in 1979, specializing in the areas of theoretical linguistics, psycholinguistics, and cognitive development. From 1980 to 1988, he held the positions of Research Fellow, Lecturer, and Senior Lecturer at the University of Western Australia. In 1988, he was appointed Professor of Educational Psychology at Massey University, where he served as Head of Department and Dean of the Faculty of Education. He has published over 150 journal articles, book chapters, and books on early literacy development, literacy learning difficulties, and reading intervention. He has served on the editorial boards of *Reading Research Quarterly*, *Language and Education*, *Reading and Writing: An Interdisciplinary Journal*, and *Journal of Learning Disabilities*, and in 2012, he completed a 5-year term as Associate Editor of *Reading and Writing: An Interdisciplinary Journal*. In 1999, he was co-winner of the International Reading Association's Dina Feitelson Award for Excellence in Research and in 2019 was the recipient of the Eminent Researcher Award of the *Australian Journal of Learning Difficulties*.

List of Acronyms

AAE	African American English
ASSR	Assisting students struggling with reading: Response to Intervention and multi-tier intervention for reading in the primary grade
C	Language comprehension
CAI	computer-assisted instruction
CCSS	Common Core of State Standards
D	Word recognition (decoding)
Daze	DIBELS maze comprehension
DIBELS	Dynamic Indicators of Basic Early Literacy Skills
DORF	DIBELS Oral Reading Fluency
fMRI	Functional magnetic resonance imaging
FSF	First Sound Fluency (DIBELS)
LNF	Letter Naming Fluency (DIBELS)
MAE	Mainstream American English
MLU	mean length of utterance
MTSS	Multi-tiered systems of support
NAEP	National Assessment of Educational Progress
NRP	National Reading Panel
NWF	Nonsense Word Fluency (DIBELS)
PGFS	Practice Guide for Foundational Skills
PGRC	Practice Guide for Reading Comprehension
PSF	Phoneme Segmentation Fluency (DIBELS)
R	Reading comprehension
RTI	Response-to-intervention
SVR	Simple View of Reading

List of Figures

List of Tables

List of Boxes

Chapter 1
The Rationale, Focus, Features, and Uses of the Book

Acronyms

MTSS Multi-tiered systems of support
RtI Response-to-intervention

1.1 Introduction

In this chapter we first describe our rationale for writing the book: To help reading professionals bring an empirically grounded coherence to their practices through an understanding of the cognitive requirements underlying reading and learning to read. We discuss the book's focus and unique features, including its descriptions of the major cognitive components underlying reading, their interrelationships, and the capacities that must be developed within them to advance reading. We then discuss the book's intended uses and describe processes for linking the cognitive foundations to the primary tools reading professionals have available to support reading development – reading standards, assessments, and curriculum and instruction. We argue that bringing coherence to the use of such tools will help reading professionals better support all students learning to read but especially those who struggle – and we further argue that the framework can specifically strengthen use of response-to-intervention approaches. We end with a brief description of the topics covered in each of the book's chapters and the common chapter structure used in presenting each topic.

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1.2 The Rationale Behind the Cognitive Foundations Framework and Its Applications

For many children, success in learning to read comes only through their own purposeful efforts coupled with those of a skilled and dedicated teacher focused on teaching reading effectively. We know much about what is required of both children and teaching in this shared endeavor, but cohesively linking these requirements has been difficult, for several reasons. First, the science around reading and its teaching is multi-faceted. Studies are focused on many different aspects of reading and learning to read, covering diverse learners, ages, and conditions, carried out under different theoretical perspectives, approaches, and methods. This makes it difficult to generate a broad, coherent, well-founded overview of what reading is, what is required to master it, and how best to support its development. Second, teaching reading is a complex undertaking. It can differ in the purposes it is to serve, the dimensions of its core instructional programs and supplementary activities, the capacities needed by those who teach it, and the decision-making required about which students would best benefit from what and when. Third, the primary tools using in teaching – standards, assessments, and regimens of curriculum and instruction – have different origins and focus on different aspects and content of education practice. They are based on separate, often divergent knowledge bases; they are designed to serve distinct educational ends; and they are generally applied within unique contexts and constraints.

The convergence of these circumstances – in different states (indeed, different countries), school districts, schools, and classrooms – can result in inefficient and ineffective support when teaching children to read. While all children must acquire the same set of cognitive capacities to become readers in any alphabetically rendered language (capacities which we will describe), both how these are mastered and on what developmental timelines vary. For optimal success of teaching practices under such conditions, understanding the cognitive requirements of reading and learning to read can help teachers bring evidence-based coherence to their use of the tools available to them. This is not a trivial undertaking as their use of teaching tools must be appropriate for all children, including those who show little difficulty in learning to read, but especially for those struggling with such learning.

As we shall see, there are several concepts that are critical to an understanding of the cognitive requirements of reading, for example, the notions of phonology and phonemes. And research indicates that both understanding and appropriately applying many of these concepts have been lacking in teachers (see Moats, 1994; Moats & Foorman, 2003; Moats & Lyon, 1996). Indeed, one study found that teachers with low knowledge of literacy concepts who nonetheless gave lots of appropriate, explicit instruction directed at recognizing words achieved lower word-reading achievement outcomes for their students than teachers who also gave lots of such instruction but had high knowledge of these concepts (Piasta, Connor, Fishman, & Morrison, 2009).

One implication of these circumstances is captured in the *Peter effect*,[1] named from a biblical passage where the Apostle Peter, when asked for alms by a beggar, replies that he has none himself to give (Acts 3:5). This term was first used in reading research to summarize a finding that a majority of sampled teacher candidates did not enjoy reading, leading to the question of whether such soon-to-be teachers could be expected to heighten reading enjoyment in their future students (Applegate & Applegate, 2004). Use of the term was extended into teacher education based on a finding that teacher candidates' knowledge of the linguistic constructs critical for understanding the cognitive basis of reading was related to their teacher educators' knowledge levels of these constructs (Binks-Cantrell, Washburn, Joshi, & Hougen, 2012). This implies that if we want teachers to understand the cognitive foundations of reading we must make efforts to ensure that those responsible for their development also understand them.

This book, through the framework it presents, provides a way for reading professionals – reading teachers, specialists, interventionists, coordinators, and coaches – as well as those preparing to become such professionals and the teacher educators preparing them for such service, to understand reading and its development. Further the book details mechanisms that, coupled with such understanding, will help them link what children must know to become strong readers to what teaching can best provide through the coherent, competent use of available tools. In this way, the book will help reading professionals be both efficient and effective in what they provide all their students – and will better equip them to support those students who find learning to read so difficult. In sum, for reading, the book provides a framework whose applications can bind teaching and learning, showing what children must be taught based on what they have so far learned.

For children, we know what the most critical cognitive competences are that underlie successful reading. Similarly, we know the general, sequenced cognitive capacities that must be developed to successfully transform the non-reader into a competent reader. We lay out both these aspects – reading and learning to read – in broad strokes in this book.

For teaching, we know that effective beginning reading teachers share three competencies (Snow, Burns, & Griffin, 1998). First, they have a general understanding of the cognitive capacities involved in reading and in learning to read, including familiarity with the typical developmental patterns that exist within each. These understandings provide a big picture view of reading and its development and allow the teacher who has internalized them to think through developmental issues facing individual students. Second, effective beginning reading teachers can determine what beginning readers already know and what they still need to learn to become skilled readers. These understandings are critical in guiding the many instructional decisions reading teachers must make each day. And third, effective beginning reading teachers can provide their students with targeted, evidence-based

[1] We use the convention of italicizing key concepts and distinctions for emphasis, but we also italicize words, phrases, or sentences when denoting them as linguistic objects. In both cases, the context we provide should suffice to determine the particular use being served.

instruction that directly addresses their individual literacy learning needs, monitoring their students' responses to the instruction provided and adjusting it appropriately when necessary.

The book most directly addresses the first teacher competency above – building a broad understanding of the cognitive-developmental capacities involved in reading and learning to read. But it also shows how the latter two competencies – determining student learning needs and providing effective instruction – can be strengthened through the understandings represented in the first one. It does this by providing a conceptual model of reading and learning to read – the Cognitive Foundations Framework – to support critical thinking about reading and its teaching, including the use of standards, assessment, and curriculum and instruction. Building on the work of Hoover and Gough (2000) (which was the basis for an earlier framework that appeared in Wren, 2000), the book shows how this model can be used to analyze standards, assessments, and curriculum and instruction, enabling reading professionals to achieve greater coherence within their practices and, thereby, improve outcomes for students.

1.3 The Focus and Unique Features of the Book

In line with its title, this book first provides an overview of the major cognitive components upon which successful reading is based. It then turns to the cognitive elements that underlie the ability to master the major cognitive components of reading. In short, the initial sections describe the cognitive structure of reading and then the cognitive foundation upon which that structure is built. This is followed with descriptions of how the framework aides understanding of reading development, reading difficulty, and reading disability. While focused on reading in English, the book also presents a generalization of its framework to reading in non-English, phonologically-based writing systems, followed by a discussion of the cognitive implications of learning to read a second language. The book then turns to the tools of reading practice, discussing how an understanding of the cognitive requirements of reading and learning to read can be used in practice with reading standards, assessments, and curriculum and instruction, to advance the teaching of reading. The book also discusses how the framework informs the delivery of interventions for students who encounter difficulties with reading along the way, closing with a discussion of how to gain coherent usage of teaching tools through the framework.

As stated above, the book focuses on reading phonologically-based written languages, using English reading as the exemplar. Written English is based on a *deep* orthography, a writing system that contains more complex (i.e., less regular) relationships between its written units (i.e., the letters of the alphabet) and the units of speech they represent (Roberts, Christo, & Shefelbine, 2011). In more *shallow* orthographies, such as that used in written Spanish, there are much more consistent mappings between written and spoken units. This orthographic difference requires some additional elaboration in the Cognitive Foundations Framework, but the broad

cognitive requirements for reading and learning to read *any* phonologically-based orthography along the shallow-to-deep (or transparent-to-opaque) continuum are constant. This is so because orthography and phonology are intrinsically connected in the cognitive machinery responsible for word recognition under phonologically-based writing systems (Seidenberg, 2017; Share, 2011).

The book references (though not exhaustively) and sometimes highlights key research supporting the cognitive framework, but it neither gives a detailed accounting of such research nor any contended views of it (this the object of proposed future work). While the framework is based on a substantial amount of research (for broad overviews of the relevant research, see Castles, Rastle, & Nation, 2018; Moats, 1999; Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001; Torgesen, 2004; Tunmer & Hoover, 1992) and on a fairly broad consensus within the cognitive science community about how reading generally is accomplished and acquired (Seidenberg, 2013), the added value of the framework is in how it captures these basic understandings for intended users. Because most reading professionals are not trained scientists, we chose not to provide an interpreted inventory and critique of the relevant research followed by summary statements of what could be concluded. Rather, we believed presenting a coherent model of what that research generally revealed would be a far more useful tool for helping reading professionals retain and apply it in their work without having to digest all its studied details.

It is also important to keep in mind that the book is focused on the *cognitive foundations* underlying reading and learning to read. As such it does not deal with other important factors impacting reading development and teaching. These include psychological factors such as motivation to learn to read, interest in reading, and self-efficacy, as well as ecological factors including the richness of the home literacy environment, or more broadly, the use of literate cultural capital – those literacy resources and activities available outside formal schooling that can be used to support literacy development (Aaron, Joshi, Gooden, & Bentum, 2008; Chapman & Tunmer, 2003; Guthrie, Wigfield, & You, 2012; Tunmer, Chapman, & Prochnow, 2006). We appreciate though that these all can impact reading through the cognitive domain (Tunmer & Chapman, 2012), which is our focus.

While the book is intended to be accessible to its target audience of reading professionals, full understanding and use of it in practice will likely require additional supports, some for developing deeper understandings and others for enabling stronger actions based on such understandings. These additional supports include expanded materials and offerings of professional development activities and structured field supports (work we are also planning for future development). Just raising one's awareness of the cognitive foundations underlying reading and their use in practice will be beneficial as an initial step, but it will not in itself bring about substantive changes in practice. Knowledge of the cognitive foundations needs to be *used* with knowledge of standards, assessments, and curriculum and instruction if practice is to best benefit developing readers. And bringing about changes in practice generally requires support provided in actual practice settings from those with relevant expertise and experience.

The book incorporates several advantageous features. First, it offers a description of the major cognitive components underlying both reading and learning to read, and, importantly, specifies the interrelationships between components. The book defines these components in broad terms to expose their macrostructures and avoid getting lost in all the detail contained within them. As such, it is a book about "forests" and not so much about "trees." Second, the book provides an analysis of the capacities within each cognitive component that the would-be reader must acquire in order to become a successful reader. Some of these are not the capacities that necessarily underlie the cognitive operations of skilled reading; rather they are those that underlie the learning of skilled reading. Indeed, some of these capacities, once mastered as foundational (i.e., critical) for learning to read, play relatively diminished roles in the skilled reading that is finally realized. Lastly, the book shows that some capacities must be developed to sophisticated levels before others can be acquired. This is crucial, for trying to facilitate the development of higher-order skills when the lower-order skills upon which they are based are weak, will likely be inefficient if not ineffective. And any students being so instructed will not be able to take full advantage of the supports being provided given their level of development. (We will come back to these points momentarily in our introductory discussion of understanding reading difficulty and remediation through the Cognitive Foundations Framework.)

We caution the reader to avoid thinking that the framework described in the book is prescriptive with respect to instruction. First, there are several cognitive capacities that must be acquired to become a reader, and while some developmental sequences among these are dependent, others are not. This requires that reading professionals make well-informed decisions about where to devote instructional resources to better student benefit. The book can support this decision-making process. The structure of the framework can provide the basis for systematic assessments, the results of which can help reading professionals select appropriate instructional strategies for addressing the specific learning needs of students. Second, instruction can be multifaceted, designed to advance development in several cognitive components simultaneously. Thus, while the framework defines discrete cognitive components underlying both reading and learning to read, this does not mean that instruction should necessarily target components discretely. Nor does it mean that instruction must be delivered individually – group instruction can be better focused by using the individual cognitive profiles of students to both form instructional groups and provide them appropriate instruction.

Overall, the framework implicitly distinguishes what must be known from what must be taught – reading professionals must decide where instruction will be most helpful given the level of student development. Indeed, decision-making and professional agency in reading instruction are key uses of the cognitive framework. While standards focus on the goals of learning (e.g., what students should know and be able to do) and curricula and instruction focus on what is to be taught (and when) to attain those goals, neither typically provides guidance about how they connect to a child's cognitive development as a reader. In reading classrooms, most decisions reading professionals make are dictated within the curriculum, either by the curricular design of instructional sequences or by students' responses to instruction (or