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THE LITERARY AGENDA

TALES of
LITERACY
for the
21ST CENTURY

Maryanne Wolf

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Introduction

“Nothing is unaltered in the brain.”¹ So begins the epic poem, *Mozart’s Third Brain*, by Swedish poet Göran Sonnevi, and so begins our narrative about what it means to be literate—cognitively, linguistically, socially, emotionally, and neurologically. Literacy alters the brain in profoundly transformative ways, which alters the person, which alters the species, which alters humanity itself. There is little more important for the future of our species’ intellectual development.

The history of how we came to be a literate species only six millennia ago still contains as much mystery as fact. There are clues to the mystery of its origins to be found in ancient places like the Wadi el Hol (Gulch of Terror) where Egyptian hieroglyphs have been discovered that might have preceded the Sumerian script, long thought to be our first writing system. By contrast, the rapidly unfolding science of the reading brain may well outpace what we know of its history. We have much to learn from both our past and our present as we move from a deeply literate culture into a digital culture insufficiently cognizant of the contributions of past forms of literacy and of the changes digital reading will bring.

What we know about our past and what we are learning about the present reading brain can help us address three issues that will be leitmotifs in this book: what it means to be literate or non-literate in human development; how the future of the expert reading brain is intimately connected to *what* and *how* we read and write; and what the effects of a digital “screen culture” may be for the development of children and adults in literate and in non-literate environments. In a world where almost 200 million children and 600 million adults will never attain anything approaching true literacy, the waste of human potential is incalculable. The reality, however, is that we are on the cusp of being able to change that waste in ways unimaginable only a decade ago, if we possess the will to do so.

In this book I wish to bring together research from multiple disciplines to shed light on how literacy develops; what happens when it does not; and how literacy transforms brain, mind, and culture in highly significant, deeply consequential ways. For this I will be using

“tales” from literature and from cognitive neurosciences, psycholinguistics, developmental sciences, education, philosophy, and technology. To ensure that this material, particularly on the reading brain and language, will be accessible, I have prepared three somewhat unusual introductory chapters that will acquaint the reader with core concepts from psycholinguistics about language, from child development about language and reading development, and from neuroscience about the reading brain. Few reading-related neurons will be left unturned by the end of these pages; and, it is our hope, few children will be left to remain illiterate by 2040. This is our literacy agenda.

Working assumptions

Though threatened with extinction, we who are today’s readers don’t know what reading is.²

Alberto Manguel, *A History of Reading*

Few people—whether linguist, educator, or writer—understand the importance of reading and literacy better than Alberto Manguel. It is, therefore, all the more striking to encounter his perspicacious assessment of how little most people understand what reading is. We wish to contribute to changing this assessment in this book and in work that we describe here. But before we do, a few basic assumptions are needed to ground our approach and to make concrete why an understanding of reading and literacy at this moment in our history is critical for all of us.

The first assumption begins with how we use the often interchangeably used terms *reading* and *literacy* and how both of these terms will be distinguished from the term *literary*. For our purposes, *literacy* refers to the attainment by an individual or a society of the full panoply of reading and writing skills. *Reading* refers more specifically to the multiple perceptual, cognitive, linguistic, affective, and physiological processes involved in the act of decoding and comprehending written language. For our purposes here, it is not as important as in other contexts if these two terms become conflated.

What is more important here is to underscore that for us reading is not just about “decoding” the information before our eyes. Rather, reading is ultimately about an encounter between a reader and another mind that leads to *thinking beyond ourselves*. Philip Davis, in his introduction to the Literary Agenda series, made an important distinction between the “literal” and the “literary” that also helps to clarify the important leap between decoding text and entering into an

exchange with text and author. He wrote that “the ‘*literary*’ offers to human discourse something more than the opinionated, the informative, the finished and the explicit—an extra dimension achieved in the processes of thinking out into language, with both its hesitations and its surprises; in the contextual feeling of a thought—its nuance, resonance and richness for further development; and thus in the increased capacity for realization and discovery.”³ It is this capacity for realization, insight, and discovery that is the apex of the reading act and our goal for literacy around the world.

In similar vein, Marcel Proust once wrote, “we always like to be taken out of ourselves a little, to *travel*, when we read.”⁴ It is an apt metaphor for what we do both as individual readers—*we travel a little beyond ourselves*; and as societies—we learn to travel beyond the shifting borders of our cognitive capacities and cultural domains. Literacy allows us, indeed invites us, to use the backdrop of our previous knowledge in order to go beyond it to somewhere new, beyond both author and the readers themselves. It is within the process of transforming individuals into literate beings, that society itself is transformed. Through processes whose examination will reveal as much about the brain’s design as the reader’s skills, literacy propels the ever deepening expansion of thought, as whatever is read becomes integrated with what is known, felt, inferred, hoped, and imagined by the reader. That is our starting point in this book.

The second assumption here concerns the simple insight I came to years ago: *we were never born to read*. The brain that reads is not a given.⁵ Literacy is a cultural invention, which means that there is no genetic program that can dictate its design—a reality with many implications and consequences. The first implication is that because the acquisition of reading is not biologically determined (like language or taste), there exists no one, ideal, universal design. Rather, the brain of an individual reader will be shaped by its environment in particular ways, beginning with the writing system, the manner taught, the medium, and the unique development of that individual’s expertise and preferences over the lifespan.

How this relatively new cultural invention came to shape our brain in the process of its acquisition is a still undertold story. It is less known not because it is less studied, as you will see in these pages, but in part because it continues to unfold like a slippery thing under our very fingertips as we become, many of us, digital readers. The development of a “brain that reads” represents one of the more astonishing manifestations of the brain’s plastic ability to form new circuits from older, genetically programmed circuits that underlie vision and language, cognition and emotion. This plasticity—with its intrinsic ability to adapt and reflect the environmental milieu—contains within itself the

foreknowledge of change.

Joseph Epstein's admonition, that "we are what we read," is as physiologically real as it is figuratively correct for an individual.⁶ When we learn to read, our brain has to create a totally new circuitry that reflects many important influences, beginning with the type of writing system to be learned. Our addendum to Joseph Epstein is that we are also "how we read." That is, the very ways we learn to read—for example, on print or digital mediums—will influence the formation of the reading brain circuit in ways we do not yet fully understand, but that are imperative to research in this moment of cultural change.

A second implication amplifies these social consequences. Because literacy is not genetically programmed in the young of our species, between 50 and 70 million children (the exact figure is still uncertain) on the planet may never become literate through no fault of their own. They are often called the "pastoral children" who simply have no access to schools or teachers. Another 150 to 200 million children have such inadequate schooling that they will never reach literacy beyond the third grade level.

Yet another implication is less obvious. Again, because there is no biologically given, ideal program for reading, the brain that learns to read "deeply" cannot be assumed, either in otherwise totally literate children, or in literate adults. During our present transition, with its emergence of a "digital reading brain," unknown changes have begun to accompany the co-occurring emergence of a new reading style—one that is able to integrate multiple sources of information, but that often appears fragmented, less focused, and potentially less able to attain previously achieved depths of concentration, comprehension, and even immersion in reading. It is critical to understand this form of the reading brain, lest it begin to threaten the very kind of intelligence that has flourished from the historical development of sophisticated, expert reading. There are many unresolved questions at this moment in our transition from a literate to a digital culture: helping to articulate the critical questions is a major goal in this book where we hope to illumine the role of literacy in the arc of human development, and how this transition will impact what we think of as the "literary" dimension in our lives.

The third assumption concerns an unusual method of approaching the study of literacy. We believe that an important way of envisioning what it means to be literate involves the study of peoples who are like one another in every typical way—from social-cultural to intellectual factors—except that some of these individuals acquired literacy, and the others did not, for no reasons save the chance environment where they were born.

We want to know, therefore, what happens when groups of human

beings never acquire literacy, particularly with regard to their strengths, capacities, and differences in the use of language. With Socrates as a timeless example of a person who was not fully literate and indeed who eschewed literacy, we want to preface any aspect of our exploration of non-literate peoples with the following statement. We are uninterested in any examination of literate and non-literate peoples that either explicitly or implicitly aims through comparison to show that a literate mind is “better” than a non-literate mind. Rather, we want to deepen our understanding of literacy by learning the *unique, additive* properties of literacy through a comparison with its absence in non-literate peoples who possess their own unique cognitive capacities.

Such is the case with a group of former revolutionaries in Colombia studied by Manuel Carreiras, Director of the Basque Center on Cognition, Brain, and Language.⁷ His group studied forty-two former revolutionaries who had never learned to read, but who in peacetime were given the opportunity to become literate through adult literacy courses. By comparing brain scans of those revolutionaries who became literate versus those who chose not to, Carreiras and his team found significant differences for those subjects who became literate in areas of the brain important for visual and linguistic processes. Studies like these help us to understand how becoming literate as an adult strengthens new, never before experienced connections between vision and language areas of the brain, just as it would in young children who learn to read.

Structure of the book

Before we begin, a word about pronouns here will be helpful. The “I” refers to the first author, whose past and present work on the reading brain serves as the foundation for this book. The “we” refers to the collaborative work with members of the Center for Reading and Language Research, particularly linguist Dr Stephanie Gottwald, whose work with me spans the writing of several books and multiple research projects, in particular, the global literacy project described in the last chapter of the book. She supplied much of the content of the third chapter on child language, which we wrote together, and she “looked over my shoulder” on the last chapter.

With a nod to Chaucer’s *Canterbury Tales*, the book itself will be divided into three conceptual sections. In the first section, based on research in psycholinguistics, child development, and cognitive neuroscience, there will be several tales that give particular perspectives on the various aspects of oral language; on the development of oral and written language in literate and non-literate children; and on the reading brain. More specifically, an overview of

language in [Chapter 2](#) (“A Linguist’s Tale”) presents what we hope will be an entertaining “linguistic primer” that provides the reader with the “vocabulary” of language and reading development, so as better to appreciate the critical importance of specific aspects of early language development for the development of literacy.

In [Chapter 3](#) (“A Child’s Tale”) we use the science of language and reading to understand some of the differences in the development of a literate versus a non-literate child. We will consider how the literate world changes everything from children’s play to the need for ever more demanding varieties of linguistic sophistication for work and leisure. What was sufficient for the demands of a non-literate environment is alarmingly inadequate for both the present literate world and the emerging digital world. We will consider how this reality creates a vast and growing divide between the literacy haves and have-nots.

My earlier attempt to describe the reading brain in some detail for the lay audience was found in *Proust and the Squid: The Story and Science of the Reading Brain*. [Chapter 4](#) (“A Neuroscientist’s Tale of Words”) will, to be sure, involve new additions to this research, but in a rather unusual way that has as much to do with Plato and Walter Benjamin as with neuroscience. The purposes of this last “primer” chapter are threefold. First, I wish to provide a foundation for understanding the changes to the present and future literate brain. Second, I hope to illumine how much goes on beneath the surface of our brains when we read either a single word or a poem by Yeats or Keats, whose names will never be pronounced the same despite every surface reason that they should be. Third, I envision this material as the best preparation for what I consider the heart of reading, which will be the material in [Chapter 5](#). Using examples in literature from Emily Dickinson to Thomas Mann to Marilynne Robinson, I hope to illustrate what I have come to call the “deep reading” processes, their variousness and their essential role in the formation of an expert reading circuit, that is the basis for a literary mind. Although I will endeavor to buttress my thoughts on deep reading with work in the cognitive neurosciences, this chapter is not so much about the brain that reads as about how reading propels our best thoughts.

Indeed, at no time in this book—that owes its very foundation to work in the neurosciences—do I differ from a statement made by Philip Davis, a professor of literature: “In all its youthful mix of imitations, possibilities, and even fantasies, brain imaging is no more and no less than one ... part of a greater aspiration that must do its exploratory work at various levels and by diverse methods. The aspiration is to find what unrecognized or neglected powers the mind employs ... in the most personal forms of reading.”⁸ I am a scholar of words who has found their study usually enhanced, and occasionally limited by the efforts of my field of cognitive neuroscience to depict their physiological

reality. But more than anything else, I am uplifted by the collective efforts of varied fields to use our growing knowledge of written words to preserve their inestimable role in the evolution of our species.

Such a statement contains, like the first hint of autumn, a harbinger of concern. With knowledge of deep reading and the present reading brain as the foundation, the sixth chapter represents the denouement of this book in which many concerns will be raised about future reading brains. In it everything from the earlier chapters prepares the readers to evaluate for themselves a cognitive neuroscience-based framework for understanding the affordances of print and screen culture for new readers (young and old). Within that framework, three extremely important questions will be raised: first, what is the reality of our culture's *digital habits* from the earliest years on? Second, what are the consequences of these digital habits for the *nature of attention*? Specifically, what are the relationships between *how we attend* and *how and what we read* (e.g. decisions about text length and complexity for both reader *and* writer)? And third, given the immediacy and overwhelming volume of easily accessed information, what are our relationships to our culture's *information overload*, and its effects on *knowledge and learning*?

Ongoing research from child development, cognitive science, technology, and philosophy will be employed to create a kind of first algorithm of the critical factors necessary to evaluate: first, what needs to be sustained for the preservation of some of our most important human values; and second, what needs to be advanced to ensure that every child will acquire the skills necessary for the twenty-first century. Throughout the chapter I will discuss the implications of digital culture on the literary mind, on writing, and on text. By the end of [Chapter 6](#) and throughout [Chapter 7](#), the earlier direction of this book will change, like the tacking of a sailboat to harness the wind. Here we will consider the leaps in cognition and perception that can be *gained* in a transition from a more literate, print-based culture to a pervasively digital, screen-based culture.

Thus, the third and most unusual part of the book represents a cerebral turnabout in which we examine the positive affordances of the digital medium for the “democratization of knowledge” and the acquisition of literacy. It will describe an ongoing attempt to use insights from research on the literate- and digital-reading brain to address the issue of global literacy in non-literate children. We will examine how the sum of this knowledge may help usher in new forms of literacy for pastoral children who might otherwise remain non-literate members of society, and also for those children whose impoverished environment has not prepared them for full literacy.

More specifically, insights from the earlier chapters will be used to describe one of the most positive, indeed hopeful applications of our

knowledge about the reading brain. I will describe a radical study of a digitally based, learning-to-read experience, conducted by a team of researchers and technology experts from our Center for Reading and Language Research at Tufts University, the MIT Media Lab in Boston (with technology design expert Tinsley Galyean and robotics scientist Cynthia Breazeal), and Georgia State University in Atlanta (with eminent methodologist and neuropsychologist Robin Morris). [Chapter 7](#) will document how children in remote regions of Ethiopia, settlement schools in South Africa, and preschools in Uganda, India, and the rural United States are learning pre-reading skills from digital tablets designed to encourage the development of oral and written language in young children.

The growth of the children's social, linguistic, and cognitive skills in these different environments is providing an unexpected source of information about what occurs in literacy's early acquisition when there are no or few teachers available. Although our deployments in these areas were initiated as an attempt to bring literacy to remote places in the world, this work provides us with an unanticipated petri dish for studying the emergence of literacy and its consequences in a group of children who have never seen symbolic text. As such, it has given our group a new, unexpected vehicle for studying over the next decade how access to literacy can become a means of increasing the health, economic development, and educational achievement of children both in developing regions of the world and also in our own backyard.

The final goal in this project will be beyond the reach of our present data. We wish to understand if technology can be used in these settings in such a way that children reach not just basic pre-literacy skills, but achieve what reading scholar and my former teacher Jeanne Chall often called the "transition from learning to read to reading to learn."⁹

Within the context of this ongoing work, we are confronted with questions that go beyond our prior knowledge, even as we build upon it. For example, we know that literacy can open the mind of a child to whole new areas of learning and that the very process of becoming literate can contribute to the new reader's creativity, personal growth, and critical thought. We also know that developing such forms of thinking in a society can fuel discovery, productivity, and innovation, which, in turn, can drive economic growth, public health, and the well-being of that society.

What we do not know is whether we can germinate the process of learning to read in such a way that it encourages more sophisticated forms of reading in the absence of a teacher, by only self- and child-driven learning. If we can prove that children can learn to read well through this approach, we estimate that 100 million children could, with

concerted global efforts, become literate in the next generation, with implications that give increased hope for the species' development. If we cannot prove this, we hope in the process to contribute to efforts to find what will. If H. G. Wells is correct that "human history becomes more and more a race between education and catastrophe,"¹⁰ then this initiative provides new hope that together we can contribute to bringing new and educated members in our world to that "race." As Pope Francis stated, "Without a solution to the problems of the poor, we cannot resolve the problems of the world."¹¹

An overarching goal of this book, therefore, will be to bring to life—linguistically, cortically, cognitively, emotionally, and societally—what it means to become literate for a child, an individual, and human society. From this view, literacy represents one of the most powerful cultural inventions that the species has ever created. Furthermore, if the act of reading goes beyond the species' biological endowment, it increases in the process the species' intelligence, and perhaps, its survival. By addressing both the known and unknown promise of literacy across time, across mediums, and, perhaps most unexpectedly, across vastly different cultures, my hope at the time of writing this book is that the unfolding story of a literacy initiative begun in tiny, remote villages and overcrowded slums in distant places of our world will underscore the profound, *intellectual transformation* that literacy propulses and why we must never lose it as we move ever forward.

Notes

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2

A Linguist's Tale

“The Franklyn's Prologue”

But sires by cause I am a burel man
At my bigynnyng first I yow biseche
Haue me excused of my rude speche
I lerned neuere rethorik certeyn
Thyng that I speke it moot be bare and pleyn
But, sirs, because I am a simple man,
Right at the very start I would beseech
That you excuse my ignorant form of spech.
I've never studied rhetoric, no way,
So plain and bare must be what I've to say.

Geoffrey Chaucer, *Canterbury Tales*¹

It is fitting that we begin this chapter and indeed the formal part of this book with an excerpt from the *Canterbury Tales*. One glance at Chaucer's Franklyn, who six centuries later still bemoans his plain, “rude speche” and lack of “rethorik,” shows both how different our spoken language and written language have become and also how much remains of our Middle English roots. *Beowulf*, on the other hand, represents our best-known example of written Old English and would be almost indecipherable, except by English literature majors and those who have studied its varied roots, as Irish poet Seamus Heaney's translation and his writing about this translation make beautifully clear.² Although the poem may well date back centuries earlier, a time-traveler to tenth-century England would be both frustrated and intrigued at the extent to which the language we call English has changed its pronunciation and spelling systems, even though a core of basic words and many aspects of grammar remain the same.

The interdigitation of these *word fossils* alongside the “new”

words, which came from over a millennium of conquests, cultural shifts, cross-linguistic influences, and technological inventions, has produced an oral and written language whose roots and parts bear the stamp of many centuries, cultures, and languages. Words from Old and Middle English, French, German, Latin, and Greek, as well as from the newest influx of words based on our technologies, have commingled to produce a dynamic, thriving, changing written language that wears its history on its sleeve: that is, the very spelling of its words. An understanding of this living language and how our words carry within them the history of our language is essential to an understanding both of literacy and of the changing reading brain.

This chapter will introduce terms and concepts about language and literacy that come from linguistics, psycholinguistics,³ and cognitive neuroscience.⁴ Our goal is to provide a working vocabulary that will serve the reader as a foundation for the rest of the book. With this said, we wish to follow the worried example of another researcher who had to introduce basic linguistic concepts only partially known to his readership. He graciously invoked Doris Lessing's preface to the *Golden Notebook*,⁵ where she exhorted her readers to *skip whatever was necessary to keep their interest going!*

A linguistic primer for oral and written language

My friend and colleague, linguist Ray Jackendoff, wrote a singularly elegant, very scholarly book, *Foundations of Language*,⁶ in which he used one simple sentence about a little star and a big star to illustrate many of the extraordinary properties of language. Most recently, he wrote one of the most whimsically written and accessible works of erudition I have ever read on the topic of language and thought, *A User's Guide to Thought and Meaning*.⁷ With no small amount of time with his tongue held firmly in cheek, he created a new genre for discussing some of the most complex issues about language and consciousness, and for describing what a *cognitive perspective* on both entails. With his permission we shamelessly follow his lead, albeit with just one word and with far more modest goals.

We will begin with the word *bear*. With over one million possible words in the English lexicon, it may be surprising that I wish to redeploy the word *bear*, which I have used as an example for one

thing or another upon many occasions. The reality is that *bear* is one of my favorite (and easiest) words to illustrate multiple linguistic concepts, and in the process, bring to life what poets knew long before contemporary linguistics: the world that is contained in every word.

Analyze what you know about this single word, and you'll have your own bird's eye perch from which to view many of the different linguistic systems important to language study by linguists, psycholinguists, educators, and neuroscientists. There are five major linguistic systems that are basic to an understanding of the many dimensions contained within a spoken or written word: *phonology*, *morphology*, *syntax*, *semantics*, and *pragmatics*. An additional system, *orthography*, is necessary for written words, but as we will see later, in the mind of the fully literate individual, what one *hears* while processing oral language is influenced by what one *sees* almost automatically.

All these linguistic systems play pivotal roles in the acquisition, development, and sometimes demise of oral and written language. To keep all six systems handily in memory, we use the underloved, nocturnal "possum" as an acronym and aide-memoire for this approach: P for phonology and pragmatics; O for orthography; S for semantics; S for syntax; M for morphology. As for the <u>, well—it stands for *und*, which means *and*, at least in German. Naming a linguistic approach after an oft-misunderstood possum (Pogo Possum does come to mind!) may seem a poor aesthetic judgment, but memory research tells us that we recall novel, and sometimes downright silly things better than more sensible ones. Our hope is that this marsupial mnemonic will help keep the major language systems in memory. Later on, we will chronicle the gradual amalgamation of all of these systems in a child's reading, along with the potential impediments that any or all of these systems could bring to reading acquisition.

Phonology

The brain is just the weight of God,
For Heft them Pound for Pound
And they will differ if they do
Like Syllable from Sound.

Emily Dickinson⁸

In the beginning is sound: the sound of the human voice—its melody, rhythm, sonority, stresses, and pauses, all of which help the ear discriminate the large and small units of speech, our *syllables* and *phonemes*. These units of sound are integral to everything we do and think, and they have more layers and tacit rules than meets the eye—or ear. Phonology involves the study of all of these layers in the sound system of a language, as well as the rules governing how phonemes form syllables and words. Many people understandably confuse or conflate phonology, phonemes, and *phonetics* with the more frequently heard word, *phonics*, and indeed all these words share the same Greek root, *phon*, for sound. Phonics, however, refers to a method of teaching reading that emphasizes the sounds represented by letters and letter patterns, and is something very separate from the rest of these linguistic terms, which are our principal foci here.

Our chosen word *bear* is made up of a particular sequence of tiny individual sounds, called *phonemes*. Each spoken language has its own particular, limited set of phonemes. English has approximately forty-four to forty-six phonemes with the “approximate” based on the regional and dialectal differences that influence this number. By contrast, Italian has thirty phonemes and the Hawaiian language has only twelve, which is why that language contains so many words with unusual-sounding repetitions of syllables and phonemes. The colorful Hawaiian state fish, *humuhumunukunukuapua’a*, is my personal favorite. Some phonemes are unique to a particular language. For example, the multiple African click sounds—which are made by moving your tongue rapidly down from the roof or palate of your mouth—are unique to certain African languages like Hottentot in Southwest Africa and in Xhosa, one of the official languages of South Africa. Many believe that the click sounds were present in the first human languages. Numerous phonemes, like our common vowel sounds, are shared across multiple languages.

Four tiers of sound

Human speech is like a cracked kettle on which we beat crude rhythms for bears to dance to, while we long to make music that will melt the stars.

Gustave Flaubert, *Madame Bovary*⁹

Ray Jackendoff describes four levels or *tiers* that make up a word's sounds. We like to think of the first tier as *melody*—that is, the word's *prosodic* structure. Perhaps we may never attain what Flaubert recognizes as part of the yearning of humans, but it is the case that music or melody is the first aspect of language that babies hear in speech, at least as early as six weeks before they are born, and one of the first things they produce after they come into the world. Prosody or melody is the aspect of speech that is conveyed by the rhythm, intonation, and *stress patterns* in our pronunciation. There were wonderfully clever experiments by French scientist Jacques Mehler and his colleagues¹⁰ that show that prenatal babies hear and recognize the prosodic contours of their mother's speech in the womb, much like we would be able to hear the muffled ups and downs of conversations from in the next room.

Further, both four-day-old newborn humans *and* our little tamarin monkey cousins can recognize and respond to the rhythm and melody of their own language and not respond to those of another language. A creative dissertation study by Juan Toro¹¹ showed that this capacity extends to another mammalian species—rats. Just by using the rhythmic contours of Dutch vs Japanese, the rats could detect which language was which—for a nice reward, of course. Such experiments indicate how very much the child is learning prenatally about this earliest phonological tier, which can be processed by several mammals. The first dimension of language, therefore, is melody.

In one-syllable words like *bear*, stress and intonation are not so obvious, but in multi-syllable words and sentences, they can be key. They both help convey not only a word's correct pronunciation, but also at times the speaker's underlying message. For example, in “No one guessed that the bear had eaten the zookeeper,” it is the stress on *bear*, *eat*, and *zoo* that provides extra clarifying information to the listener. These stress patterns in oral language also help listeners and readers detect the second tier in a word's phonological structure, the *syllabic* structure. Each syllable has a *nucleus*, a *rhyme*, and an *onset*. The nucleus is usually the vowel that the syllable revolves around, and a rhyme is almost always just what it sounds like—the vowel-consonant pattern that rhymes in any word (e.g. the <ear> in *bear*, and the <ap> in *trap*). The onset is the first phoneme or phoneme cluster that precedes the rhyme (e.g. in *bear* and <tr> in *trap*).

British researchers Usha Goswami and Jenny Thomson¹²

demonstrate how important it is for young children who are first learning to read to be able to use stress information to detect the syllable boundaries in words. They have found that children at risk for reading disabilities have particular difficulty detecting some of the important acoustic information in what is called the *speech amplitude envelope* that helps us perceive phonemes in words. Their research highlights the layers of tacit knowledge important for producing or perceiving sounds in words for children learning to read with or without extra challenges like dyslexia.

The third and fourth tiers involve the *segmental* structure, including the phonemes and their distinctive features. Each phoneme in every language has a set of distinctive features used to categorize it—like whether it makes a voiced (e.g. /b/) or unvoiced sound (e.g. /p/), or where the phoneme is articulated (e.g. at the front or back of the mouth). The feature of voicing depends on how and when air is vibrated across our vocal folds. For /b/ the vocal folds start vibrating very early into the next vowel at around 20 milliseconds; for /p/ the vibrations occur later. Try putting your hand on your throat as you make a /p/ or a /b/. In voiced sounds like /b/, you can feel vibrations in your throat, while in unvoiced sounds like /p/, you should not be able to feel any vibrations.

To visually transcribe these individual sounds, there is a *phonetic* system that can be used to depict every human phoneme. Thus *bear* becomes /b+/ɛ+/r/. Notice that the /r/ makes what is called an r-controlled vowel, that is actually something between one and two sounds. When a voiced /r/ follows a vowel, it changes the sound of the vowel considerably more than an unvoiced letter like /t/ (e.g. *bat*). Words aren't a matter of a strict, serial production of one discrete sound following another; rather, spoken words follow a system for *connecting* their sounds in such a way that each phoneme affects the one following it. There are important phonological rules in each language that speakers are unaware of, but that govern how phonemes work together to form words in speech. The reality we will return to, especially in a child's development, is that the way we speak has rules we never knew we followed.

To illustrate, a major principle in how phonemes are connected to form words is called *coarticulation*. It describes the reality of how phonemes are “shingled together” to make continuous speech, an apposite description first made by Isabelle Liberman, Don Shankweiler, and their colleagues at Haskins Laboratory.¹³ The process of shingling phonemes together changes how each one