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What Research Says About Reading Pages 6-11

Reading Disability and the Brain

Neurological science and reading research provide the scientific knowledge we need to ensure that almost every child becomes a successful reader.

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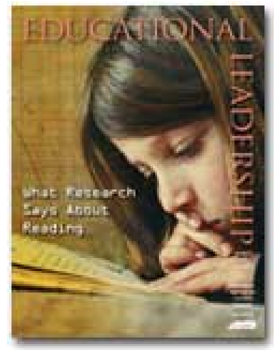

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The past decade has witnessed extraordinary progress in our understanding of the nature of reading and reading difficulties. Never before have rigorous science (including neuroscience) and classroom instruction in reading been so closely linked. For the first time, educators can turn to well-designed, scientific studies to determine the most effective ways to teach reading to beginning readers, including those with reading disability (National Reading Panel, 2000).

What does the evidence tell us? Several lines of investigation have found that reading originates in and relies on the brain systems used for spoken language. In addition, accumulating evidence sheds light on the nature of reading disability, including its definition, prevalence, longitudinal course, and probable causes. Although the work is relatively new, we have already made great progress in identifying the neural systems used for reading, identifying a disruption in these systems in struggling readers, and understanding the neural mechanisms associated with the development of fluent reading.

Reading and Spoken Language

Spoken language is instinctive—built into our genes and hardwired in our brains. Learning to read requires us to take advantage of what nature has provided: a biological module for language.

For the object of the reader's attention (print) to gain entry into the language module, a truly extraordinary transformation must occur. The reader must convert the print on the page into a linguistic code: the phonetic code, the only code recognized and accepted by the language system. Unless the reader-to-be can convert the printed characters on the page into the phonetic code, these letters remain just a bunch of lines and circles, totally devoid of meaning. The written symbols have no inherent meaning of their own but stand, rather, as surrogates for the sounds of speech (Shaywitz, 2003).

To break the code, the first step beginning readers must take involves spoken language. Readers must develop *phonemic awareness*: They must discover that the words they hear come apart into smaller pieces of sound (Shaywitz, 2003).

On the basis of highly reliable scientific evidence, investigators in the field have now reached a strong consensus: Reading reflects language, and reading disability reflects a deficit within the language system. Results from large and well-studied populations with reading disability confirm that in young school-age children (Fletcher et al., 1994; Stanovich & Siegel, 1994) and in adolescents (Shaywitz et al., 1999), a weakness in accessing the sounds of spoken language represents the most robust and specific correlate of reading disability (Morris et al., 1998). Such findings form the foundation for the most successful, evidence-based interventions designed to improve reading (National Reading Panel, 2000).

Understanding Reading Disability

Reading disability, or *developmental dyslexia*, is characterized by an unexpected difficulty in reading in children and adults who otherwise possess the intelligence, motivation, and education necessary for developing accurate and fluent reading (Lyon, 1995; Lyon, Shaywitz, & Shaywitz, 2003). Dyslexia is the most common and most carefully studied of the learning disabilities, affecting 80 percent of all individuals identified as learning disabled and an estimated 5–17 percent of all children and adults in the United States (Shaywitz, 2003).

Incidence and Distribution of Dyslexia

Recent epidemiological data indicate that like hypertension and obesity, reading ability occurs along a continuum. Reading disability falls on the left side of the bell-shaped curve representing the normal distribution of reading ability (Shaywitz, Escobar, Shaywitz, Fletcher, & Makuch, 1992).

Dyslexia runs in families: One-fourth to one-half of all children who have a parent with dyslexia also have the disorder (Scarborough, 1990), and if dyslexia affects one child in the family, it is likely to affect half of his or her siblings. Recent studies have identified a number of genes involved in dyslexia (Fisher & DeFries, 2002).

Good evidence, based on surveys of randomly selected populations of children, now indicates that dyslexia affects boys and girls equally (Flynn & Rahbar, 1994; Shaywitz, Shaywitz, Fletcher, & Escobar, 1990; Wadsworth, DeFries, Stevenson, Gilger, & Pennington, 1992). Apparently, the long-held belief that only boys suffer from dyslexia reflected bias in school-identified samples: The more disruptive behavior of boys results in their being referred for evaluation more often, whereas girls who struggle to read are more likely to sit quietly in their seats and thus be overlooked.

Longitudinal studies (Bruck, 1992; Fletcher, 1996; Francis, Shaywitz, Stuebing, Shaywitz, & Scarborough, 1984; Shaywitz et al., 1995) indicate that dyslexia is a persistent, chronic condition rather than a transient "developmental lag." Children do not outgrow reading difficulties. The evidence-based interventions now available, however, can result in improved reading in virtually all children.

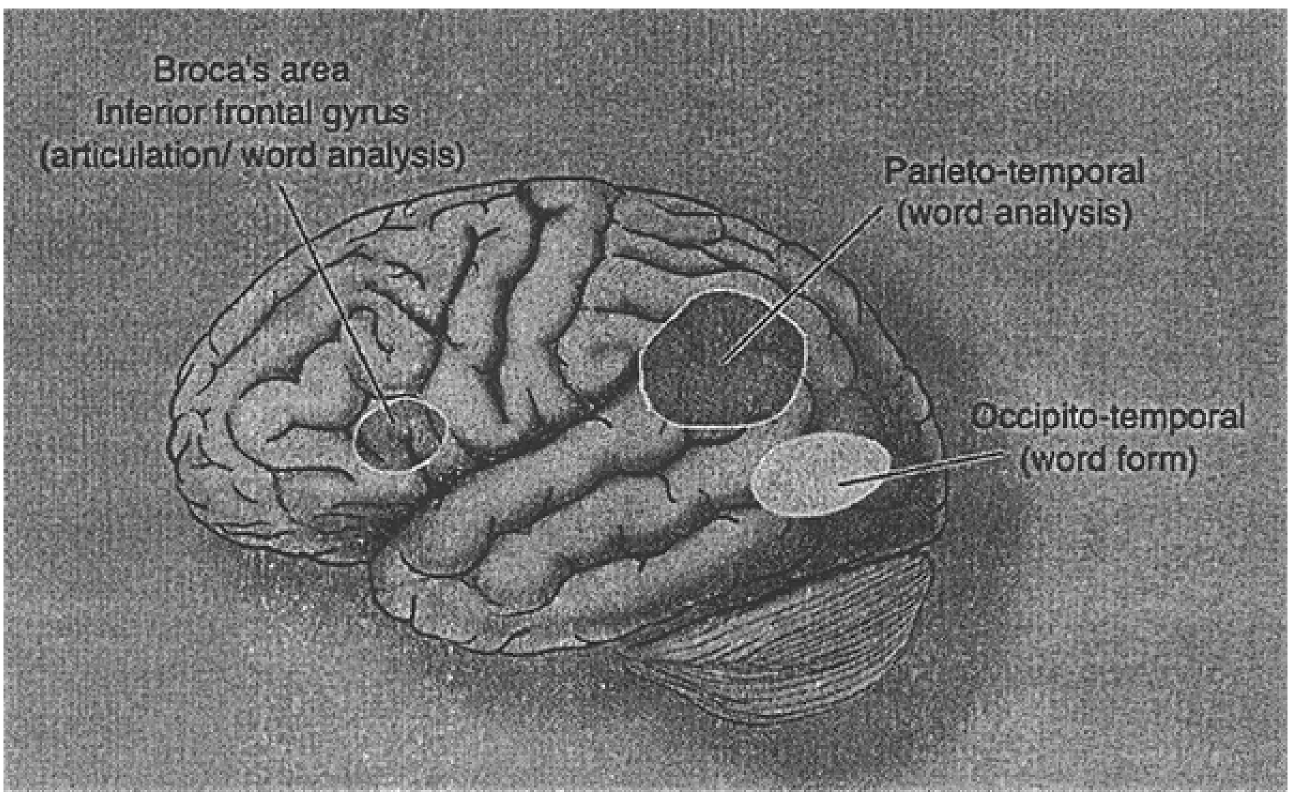
Neurobiological Origins of Dyslexia

For more than a century, physicians and scientists have suspected that dyslexia has neurobiological origins. Until recently, however, they had no way to examine the brain systems that we use while reading. Within the last decade, the dream of scientists, educators, and struggling readers has come true: New advances in technology enable us to view the working brain as it attempts to read.

Perhaps the most convincing evidence for a neurobiological basis of dyslexia comes from the rapidly accumulating and converging data from functional brain imaging investigations. The process of functional brain imaging is quite simple. When we ask an individual to perform a discrete cognitive task, that task places processing demands on specific neural systems in the brain. Through such techniques as functional magnetic resonance imaging (fMRI), we can measure the changes that take place in neural activity in particular brain regions as the brain meets those demands. Because fMRI uses no ionizing radiation and requires no injections, it is noninvasive and safe. We can use it to examine children or adults on multiple occasions.

Using functional brain imaging, scientists around the world have discovered not only the brain basis of reading but also a glitch in the neural circuitry for reading in children and adults who struggle to read. Our studies and those of other investigators have identified three regions involved in reading, all located on the left side of the brain (see fig. 1, p. 10). In the front of the brain, Broca's area (technically the inferior frontal gyrus) is involved in articulation and word analysis. Two areas located in the back of the brain are involved in word analysis (the parieto-temporal region) and in fluent reading (the occipito-temporal region, also referred to as the word form area).

Figure 1. Three Regions of the Brain involved in Reading



Studies of dyslexic readers document an underactivation of the two systems in the back of the brain together with an overactivation of Broca's area in the front of the brain. The struggling readers appear to be turning to the frontal region, which is responsible for articulating spoken words, to compensate for the fault in the systems in the back of the brain.

Researchers have observed this neurobiological signature of dyslexic readers across cultures and across different languages (Paulesu et al., 2001). The observation of this same pattern in both children and adults supports the view that reading difficulties, including the neural disruption, do not go away with maturity. To prevent failure for students with reading disability, we must identify the disability early and provide effective reading programs to address the students' needs.

The Importance of Fluency

In addition to identifying the neural systems used for reading, research has now revealed which systems the brain uses in two important phases in the acquisition of literacy.

Beginning reading—breaking the code by slowly, analytically sounding out words—calls on areas in the front of the brain (Broca's area) and in the back of the brain (the parieto-temporal region).

But an equally important phase in reading is fluency—rapid, automatic reading that does not require attention or effort. A fluent reader looks at a printed word and instantly knows all the important information about that word. Fluent reading develops as the reader builds brain connections that eventually represent an exact replica of the word—a replica that has integrated the word's pronunciation, spelling, and meaning.

Fluency occurs step-by-step. After systematically learning letters and their sounds, children go on to apply this knowledge to sound out words slowly and analytically. For example, for the word "back," a child may initially represent the word by its initial and final consonants: "b—k." As the child progresses, he begins to fill in the interior vowels, first making some errors—reading "back" as "bock" or "beak," for example—and eventually sounding out the word correctly. Part of the process of becoming a skilled reader is forming successively more detailed and complete representations of familiar words (Shaywitz, 2003).

After the child has read the word "back" correctly over and over again, his brain has built and reinforced an exact model of the word. He now reads that word fluently—accurately, rapidly, and effortlessly. Fluency pulls us into reading. A student who reads fluently reads for pleasure and for information; a student who is not fluent will probably avoid reading.

In a study involving 144 children, we identified the brain region that makes it possible for skilled readers to read automatically (Shaywitz et al., 2002). We found that the more proficiently a child read, the more he or she activated the occipito-temporal region (or word form area) in the back of the brain. Other investigators have observed that this brain region responds to words that are presented rapidly (Price, Moore, & Frackowiak, 1996). Once a word is represented in the word form area, the reader recognizes that word instantly and effortlessly. This word form system appears to predominate when a reader has become fluent. As a result of this finding, we now know that development of the word form area in the left side of the brain is a key component in becoming a skilled, fluent reader.

Helping Struggling Readers Become More Fluent

Our study of 144 children also revealed that struggling readers compensate as they get older, developing alternate reading systems in the front of the brain and in the *right* side of the brain—a functioning system, but, alas, not an automatic one (Shaywitz, 2003). These readers do not develop the critical left-side word form region necessary for rapid, automatic reading. Instead, they call on the alternate secondary pathways. This strategy enables them to read, but much more slowly and with greater effort than their classmates.

This research evidence of a disruption in the normal reading pathways provides a neurobiological target for reading interventions. In a new study (Shaywitz et al., 2003), we hypothesized that an evidence-based, phonologically mediated reading intervention would help dyslexic readers develop the fast-paced word form systems serving skilled reading, thus improving their reading accuracy and fluency. Under the supervision of Syracuse University professor Benita Blachman, we provided 2nd and 3rd grade struggling readers daily with 50 minutes of individual tutoring that was systematic and explicit, focusing on helping the students understand the *alphabetic principle*, or how letters and combinations of letters represent the sounds of speech.

Students received eight months (105 hours) of intervention during the school year in addition to their regular classroom reading instruction. The experimental intervention replaced any additional reading help that the students might have received in school. Certified teachers who had taken part in an intensive training program provided the tutoring.

Immediately after the yearlong intervention, students in the experiment made significant gains in reading fluency and demonstrated increased activation in left hemisphere regions, including the inferior frontal gyrus and the parieto-temporal region. One year after the experimental intervention ended, these students were reading accurately and fluently and were activating all three left-side brain regions used by good readers. A control group of struggling readers receiving school-based, primarily nonphonological reading instruction had not activated these reading systems.

These data demonstrate that an intensive, evidence-based reading intervention brings about significant and durable changes in brain organization so that struggling readers' brain activation patterns come to resemble those of typical readers. If we provide inter-vention at an early age, then we can improve reading fluency and facilitate the development of the neural systems that underlie skilled reading.

Evidence-Based Effective Reading Instruction

In addition to new neurological research on the nature of reading, educators can draw on a body of rigorous, well-designed, scientific studies to guide reading instruction. In 1998, the U.S. Congress mandated the National Reading Panel to develop rigorous scientific criteria for evaluating reading research, apply these criteria to existing reading research, identify the most effective teaching methods, and then make findings accessible for parents and teachers. As a member of the Panel, I can attest to its diligence. After two years of work, the Panel issued its report (2000).

The major findings of the report indicate that in order to read, all children must be taught alphabetics, comprising phonemic awareness and phonics; reading fluency; vocabulary; and strategies for reading comprehension. These elements must be taught systematically, comprehensively, and explicitly; it is inadequate to present the foundational skills of phonemic awareness and phonics incidentally, casually, or fragmentally. Children do not learn how letters represent sounds by osmosis; we must teach them this skill explicitly. Once a child has mastered these foundational skills, he or she must be taught how to read words fluently.

Good evidence now indicates that we can teach reading fluency by means of repeated oral reading with feedback and guidance. Using these methods (described in detail in Shaywitz, 2003, pp. 176–246), we can teach almost every child to read. It is crucial to align all components of a program with one another—for example, to provide so-called decodable booklets that give the student practice in the specific letter-sound linkages we are teaching. The use of decodable booklets enables the repeated practice necessary to build the automatic systems in the word form region that lead to fluent reading.

Neuroscience and Reading Research Agree

We are now in an era of evidence-based education. Objective scientific evidence—provided by brain imaging studies and by the National Reading Panel's rigorous scientific review of the literature—has replaced reliance on philosophy or opinion.

In considering a reading program, educators should ask several key questions:

- Is there scientific evidence that the program is effective?
- Was the program or its methodology reviewed by the National Reading Panel?
- In reading instruction, are phonemic awareness and phonics taught systematically and explicitly?
- How are students taught to approach an unfamiliar word? Do they feel empowered to try to analyze and sound out an unknown word first rather than guess the word from the pictures or context?
- Does the program also include plenty of opportunities for students to practice reading, develop fluency, build vocabulary, develop reading comprehension strategies, write, and listen to and discuss stories (Shaywitz, 2003)?

Children are only 7 or 8 years old once in their lifetime. We cannot risk teaching students with unproven programs. We now have the scientific knowledge to ensure that almost every child can become a successful reader. Awareness of the new scientific knowlege about reading should encourage educators to insist that reading programs used in their schools reflect what we know about the science of reading and about effective reading instruction.

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