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Professional Article

The New Science of Reading and Its Implications for the Classroom

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The past decade has witnessed the emergence of new findings about the nature of reading and reading difficulties with important implications for the classroom teacher. There is now overwhelming and converging evidence from many lines of investigation that reading originates in and relies upon the brain systems used for spoken language, that is, the neural systems used for processing the sounds of language. In addition, there is a great deal of converging evidence about the nature of reading disability (developmental dyslexia), including how reading disability is defined, its prevalence, its longitudinal course, and its probable causes or etiology. Although the work is relatively new, great progress has been made in identifying the neural systems for reading in good readers, in identifying a disruption in these systems in struggling readers, and in understanding the neural mechanisms associated with the development of skilled (fluent) reading. Perhaps most importantly, scientific studies are now being used to determine the most effective ways to teach reading to beginning readers and the most effective interventions to help disabled readers learn not only to decode the printed word but to become fluent, skilled readers. For the first time there are now, in the words of the Report of the National Reading Panel, "evidence-based" interventions that educators can turn to with assurance that the methods have met scientific standards of effectiveness.

Reading Reflects Language

Why do the lines and squiggles on a page have any meaning at all? There is now a strong consensus among investigators in the field that reading reflects language and that the central difficulty in reading disability reflects a deficit within the language system. This evidence begins with the recognition that spoken language is instinctive and built into our genes. "In order to read, man has 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 somehow convert the print on the page into a linguistic code—the phonetic code, the only code recognized and accepted by the language system. The written symbols have no meaning of their own but, rather, stand as surrogates for speech or, to be more exact, for the sounds of speech" (Shaywitz, 2003). In order to break the code, the first step a beginning reader must take involves *spoken* language—he must discover that spoken words have parts, he comes to appreciate " . . . that the word he hears comes apart into smaller pieces of sound: he has developed phonemic awareness" (Shaywitz, 2003, p. 51).

There is now incontrovertible scientific evidence that problems in getting to the sounds of spoken language are at the very heart of reading difficulties. Results from large and well-studied populations with reading disability confirm that in young school-age children (Fletcher et al.,1994; Stanovich & Siegel, 1994) as well as in adolescents (Shaywitz et al., 1999), a deficit in phonology represents the most robust and specific correlate of reading disability. Such findings form the basis for the most successful and evidence-based interventions designed to improve reading (NRP, 2000). More about this below.

Definition and Prevalence of Reading Disability

Reading disability (developmental dyslexia) is characterized by an unexpected difficulty in reading in children and adults who otherwise possess the intelligence, motivation, and education considered necessary for developing accurate and fluent reading. (Lyon, 1995; Lyon et al., in press). Dyslexia (or specific reading disability) represents one of the most common problems affecting children and adults; in the United States the prevalence of dyslexia is estimated to range from 5% to 17% with up to 40% of school-aged children not reading proficiently. Dyslexia is the most common and most carefully studied of the learning disabilities (LDs), affecting 80% of all individuals identified as LD (Shaywitz, 2003, 25–31).

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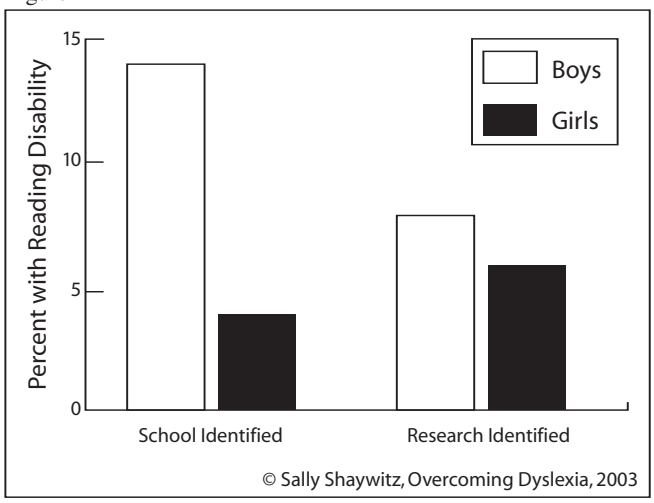
Figure 1



Prevalence of Reading Disability in Boys and Girls. Schools identify many more boys than girls. In contrast, when each child is tested, comparable numbers of boys and girls are identified as having a reading disability. Reproduced from Sally Shaywitz, *Overcoming Dyslexia*, published by Alfred A. Knopf, 2003, with permission.

Epidemiology of Dyslexia

Recent epidemiologic data indicate that, like hypertension and obesity, dyslexia fits a dimensional model: within the population, reading and reading disability occur along a continuum, with reading disability representing the left side of the bell-shaped curve of normal distribution. Good evidence, based on sample surveys of randomly selected populations of children, now indicates that dyslexia affects boys and girls equally (Figure 1); the long-held belief that only boys suffer from dyslexia reflected sampling bias in school-identified samples.

Longitudinal studies, both prospective and retrospective, indicate that dyslexia is a persistent, chronic condition; it does not represent a transient "developmental lag (Figure 2)" (Shaywitz, 2003, pp. 25–35).

Etiology of Dyslexia

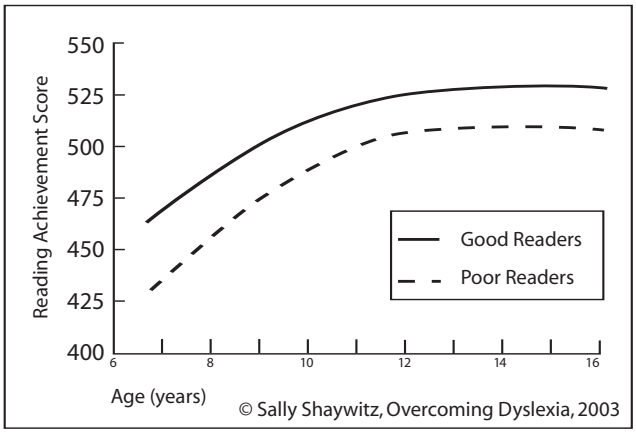
Dyslexia runs in families: one quarter to one half of children who have a parent with dyslexia also have the disorder and if one child in the family is affected, chances are that half of his or her siblings will also be affected. Dyslexia not only runs in families, it is also carried as a genetic trait, and recent studies implicate a number of genes involved in dyslexia (Shaywitz, 2003, pp. 98–100).

Neurobiologic Influences

Though the neurobiological origins of dyslexia were suspected over a century ago, perhaps the most convincing evidence comes from the accumulating data from functional brain imaging investigations. In principle, functional brain imaging is quite simple. When an individual is asked to perform a discrete cognitive task, that task places processing demands on particular neural systems in the brain. To meet those demands requires activation of neural systems in specific brain regions, and those changes in neural activity can be measured by techniques such as functional magnetic resonance imaging (fMRI). Since fMRI is non-invasive and safe, it can be used repeatedly, making it ideal for studying people, especially children.

Using functional brain imaging techniques, a range of neurobiological investigations from scientists around the world has documented the disruption of neural systems for reading in dyslexia that cross languages and cultures. Converging evidence, using

Figure 2



Dyslexia is persistent. Over time, reading performance improves in both good readers (upper curve) and poor readers (lower curve). However, the gap between the two groups remains. Reproduced from Sally Shaywitz, *Overcoming Dyslexia*, published by Alfred A. Knopf, 2003, with permission.

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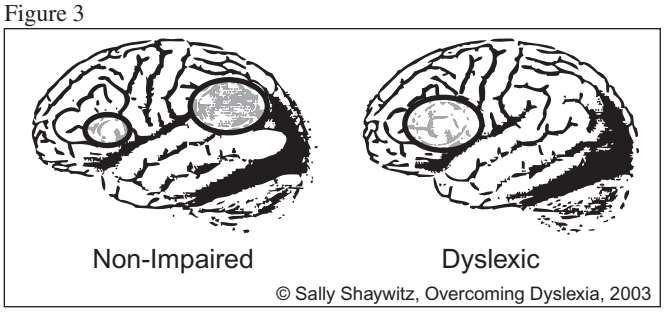
Figure 3



A neural signature for dyslexia—underactivation of neural systems in the back of the brain. When asked to rhyme nonsense words, nonimpaired readers (left image) activate 3 neural systems for reading, one in the front of the brain and two in the back of the brain. In contrast, dyslexic readers underactivate the reading systems in the back of the brain and overactivate the system in the front of the brain. Reproduced from Sally Shaywitz, *Overcoming Dyslexia*, published by Alfred A. Knopf, 2003, with permission.

functional brain imaging in adult dyslexic readers, shows a failure of brain systems in the back of the left side of the brain to function properly during reading (Figure 3). Many individuals with a reading disability learn to use other, compensatory brain systems and are able to read accurately. However, because they have not developed the brain systems for skilled reading, their reading is usually not fluent or automatic. The good news is that results of recent studies indicate that the provision of an evidence-based, phonologically mediated reading intervention at an early age not only improves reading accuracy and fluency but also results in the development of brain systems responsible for skilled reading" (Shaywitz, 2003, pp. 71–89).

Recognizing a Reading Problem in a School Age Child

"The diagnosis of dyslexia reflects a reading difficulty that is unexpected for a person's age, intelligence, level of education or profession. It is a clinical diagnosis based on a thoughtful synthesis of information from the child's personal and family history, from observations of speaking and reading and from tests of reading and language" (Shaywitz, 2003, pp. 71–89). The pattern of test results includes difficulty reading single words, especially difficulty decoding nonsense words or other unfamiliar words. At the same time, because of strengths in, for example, reasoning, and problem solving, reading comprehension is often superior to decoding individual words. One of the most prominent symptoms is difficulty with oral reading, and students with reading disability try to avoid oral reading any way they can, including running out to the restroom when it is their turn to read aloud or becoming the class clown in order to avoid oral reading. Other characteristics include slow reading, so that homework seems to take forever. Spelling is very difficult for poor readers; in fact, the dyslexic's spelling may be so far removed from the actual word that spell checkers are unable to help.

Tests that are often helpful in diagnosing a reading disability include reading achievement tests, such as the Woodcock Johnson test, which contains sections for reading real words and nonsense words. Another very useful test is the Gray Oral Reading Tests (GORT), which measures oral reading, providing measures of both accuracy and rate. As noted above, oral reading is often the most sensitive index of a reading problem, and an oral reading test such as the GORT is critical in this assessment.

Diagnosing Dyslexia in the Adolescent and Young Adult

The same criteria and the same mechanisms apply to the older individual as to the younger child—the only difference is in the specific symptoms that bring the individual to someone's attention. Thus, as in the younger child, dyslexia in the adult is recognized as a reading difficulty that is unexpected for a person's age, intelligence, level of education or profession. The same phonologic problems lie at the heart of reading problems in older individuals. "Science and common sense say that if a person reads extremely slowly and yet is able to comprehend materials at a college level or beyond, he has a phonologic deficit as well as significant strengths. He is dyslexic" (Shaywitz, 2003, p. 162). In establishing a reading problem in a bright young adult, "the most consistent and telling sign is slow and laborious reading and writing. The failure to recognize or to measure the

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lack of fluency in reading is probably the most common error in the diagnosis of dyslexia in bright young adults... Observing a person read aloud and administering timed tests such as the Nelson-Denny Reading Test and tests of oral reading of connected text such as the GORT-4 can establish the lack of fluency in accomplished adults" (Shaywitz, 2003, p. 163). It is also important to remember " . . . that the phonologic weakness is persistent, and that once a person is dyslexic, he is dyslexic for life" (Shaywitz, 2003, p. 164). In practical terms, what this means is that young adults with a history of dyslexia need not be retested once they have been diagnosed in childhood.

What Works in Teaching Children to Read

In 1998 the United States Congress mandated the Director of the National Institute of Child Health and Human Development, in consultation with the Secretary of Education, to appoint a National Reading Panel (NRP) to " . . . assess the status of research-based knowledge, including the effectiveness of various approaches to teaching children to read" with the goal of guiding effective instruction of reading in America's classrooms. The NRP was to develop rigorous scientific criteria for evaluating reading research, apply these criteria to existing reading research, identify most effective teaching methods, and then make findings accessible for parents and teachers. After two years work, the NRP issued its report. The major findings of the NRP report indicate that in order to read all children must be taught alphabetics, comprising phonemic awareness and phonics skills; reading fluency; vocabulary; and strategies for reading comprehension. Furthermore, it matters how these elements are taught. It is not sufficient to present these foundational skills casually and matter of factly. Rather, phonemic awareness and phonics need to be taught systematically and explicitly. Once a child has mastered these foundational skills it is critical that he or she be taught how to read words fluently, that is, to read words orally with speed, accuracy, and with good expression. Good evidence now indicates that it is possible to teach reading fluency by repeated oral reading with feedback and guidance. Using these methods, it is possible to teach just about every child to read (Shaywitz, 2003, pp. 176–246).

Teaching the Dyslexic Child to Read

"Teaching a dyslexic child to read is based on the same principles used to teach any child to read. Since the neural systems responsible for transforming print into language may not be as responsive as in other children, however, the instruction must be relentless and amplified in every way possible so that it penetrates and takes hold" (Shaywitz, 2003, p. 256). Early intervention is critical in teaching the dyslexic child to read. "Diagnosis is the essential first step . . . —the earlier the better" (Shaywitz, 2003, pp. 257). Other steps include reading instruction that is delivered with great intensity; high quality instruction provided by highly qualified teachers; and reading instruction which is of sufficient duration to allow the dyslexic reader " . . . to close the reading gap between himself and his peers" (Shaywitz, 2003, pp. 259).

The Critical Role of Teachers in Teaching All Children to Read

Not surprisingly, the new science of reading and reading disability emphasizes the critical role of teachers in providing the scientific, evidence-based reading programs that will ensure that all children can be taught to read. As we have noted above, teaching phonemic awareness and phonics requires that the children be taught explicitly and systematically, teaching that requires highly trained and highly skilled teachers. Teaching children to read fluently requires skilled teachers to provide the feedback and guidance necessary for guided, repeated oral reading. Finally, experienced, skilled teachers are critical in making sure the student is actively engaged in learning vocabulary and in providing the individualized instruction so critical in teaching comprehension strategies.

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Summary

The past decade has witnessed an unprecedented collaboration between science and education, so that there has now been a sea change, not only in understanding the underlying basis for reading and reading disability, but perhaps most critically, in the recognition that teaching reading must be driven by science. For the first time it is now possible to begin to talk about evidence-based education. This new era in education demands knowledgeable teachers who understand the science of reading and how critical their own role is in teaching children to read.

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