The New Science of Dyslexia

Why some children struggle so much with reading used to be a mystery. Now researchers know what's wrong-and what to do about it.

When Sean Slattery, 17, looks at a page of text, he can see the letters. He can tell you the letters' names. He can even tell you what sounds those letters make. But it often takes a while for the articulate high school student from Simi Valley, Calif., to tell you what words those letters form. "I see a wall," he says. "I see a hurdle I have to get over." Some words are easier for Sean to figure out than others. "I can get longer words, like electricity," he says. "But I have trouble with shorter words, like four or year."

Slattery has dyslexia, a reading disorder that persists despite good schooling and normal or even above-average intelligence. It's a handicap that affects up to 1 in 5 schoolchildren. Yet the exact nature of the problem has eluded doctors, teachers, parents and dyslexics themselves since it was first described more than a century ago. Indeed, it is so hard for skilled readers to imagine what it's like not to be able to effortlessly absorb the printed word that they often suspect the real problem is laziness or obstinacy or a proud parent's inability to recognize that his or her child isn't that smart after all.

The mystery—and perhaps some of the stigma—may finally be starting to lift. The more researchers learn about dyslexia, the more they realize it's a flaw not of character but of biology—specifically, the biology of the brain. No, people with dyslexia are not brain damaged. Brain scans show their cerebrums are perfectly normal, if not extraordinary. Dyslexics, in fact, seem to have a distinct advantage when it comes to thinking outside the box.

But a growing body of scientific evidence suggests there is a glitch in the neurological wiring of dyslexics that makes reading extremely difficult for them. Fortunately, the science also points to new strategies for overcoming the glitch. The most successful programs focus on strengthening the brain's aptitude for linking letters to the sounds they represent. (More later on why that matters.) Some studies suggest that the right kinds of instruction provided early enough may rewire the brain so thoroughly that the neurological glitch disappears entirely.

The new science may even be starting to change public policy. When the U.S. government launched an education initiative in 2001 called No Child Left Behind, its administrators made clear that their funding would go only to reading programs that are based on solid evidence of the sort that has been uncovered in dyslexia research. "In education, the whole idea that there is evidence that some programs are more effective than others is new," says Dr. Sally Shaywitz, a Yale neuroscientist who has written a fascinating new book, Overcoming Dyslexia (Alfred A. Knopf; April 2003), that details the latest brain-scan research—much of it done in her lab. "The good news is we really understand the steps of how you become a reader and how you become a skilled reader," she says.

Along the way, a number of myths about dyslexia have been exploded. You may have heard, for example, that it's all about flipping letters, writing them backward, Toys "R" Us style. Wrong. Practically all children make mirror copies of letters as they learn to write, although dyslexics do it more. You may believe that more boys than girls are dyslexic. Wrong again. Boys are just more likely to get noticed because they often vent their frustration by acting out. You may think that dyslexia can be outgrown. This is perhaps the most damaging myth, because it leads parents to delay seeking the extra instruction needed to keep their children from falling further behind. "The majority of students who get identified with learning disorders get identified between the ages of 11 and 17," says Robert Pasternack, assistant secretary for Special Education and Rehabilitative Services. "And that's too late." They can still learn to read, but it will always be a struggle.

This is not to say that dyslexics can't succeed despite their disability. In fact, dyslexics are overrepresented in the top ranks of artists, scientists and business executives. Perhaps because their brains are wired differently, dyslexics are often skilled problem solvers, coming at solutions from novel or surprising angles and making conceptual leaps that leave tunnel-visioned, step-by-step sequential thinkers in the dust. They talk about being able to see things in 3-D Technicolor or as a multidimensional chess game. It may also be that their early struggle with reading better prepares them for dealing with adversity in a volatile, fast-changing world.

But that struggle can cut both ways. Dyslexics are also overrepresented in the prison population. According to Frank Wood, a professor of neurology at Wake Forest University in Winston-Salem, N.C., new research shows that children with dyslexia are more likely than nondyslexics to drop out of school, withdraw from friends and family or attempt suicide.

The stakes have never been higher. Right now in the U.S. there are almost 3 million students in special-education classes specifically because they can't read. Most of them are probably dyslexic. But there are other slow readers who are simply overlooked—ignored in crowded classrooms or dismissed as discipline problems. Unless corrective action is taken, their self-confidence often crumbles as they see other students progressing. Even worse, their peers may taunt or ostracize them—a situation that Sean Slattery's mother Judy remembers all too well. "Sean cried for four hours every day after kindergarten," she says. "He was so unhappy."

To be sure, researchers still don't understand everything there is to know about learning disabilities. Dyslexia, for one, may consist of several subtypes. "It would be very dangerous to assume that every child with reading problems is uniform and has the same kinds of breakdowns preventing him from learning to read," says Dr. Mel Levine, a pediatrician and author of several influential books about learning disabilities and dyslexia, including A Mind at a Time. But whatever the exact nature of the deficit, the search for answers begins with the written word.

When you think about it, that anyone can read at all is something of a miracle. Reading requires your brain to rejigger its visual and speech processors in such a way that artificial markings, such as the letters on a piece of paper, become linked to the sounds they represent. It's not enough simply to hear and understand different words. Your brain has to pull them apart into their constituent sounds, or phonemes. When you see the written word cat, your brain must hear the sounds /k/ ... /a/... /t/ and associate the result with an animal that purrs.

Unlike speech, which any developmentally intact child will eventually pick up by imitating others who speak, reading must be actively taught. That makes sense from an evolutionary point of view. Linguists believe that the spoken word is 50,000 to 100,000 years old. But the written word—and therefore the possibility of reading—has probably been around for no more than 5,000 years. "That's not long enough for our brains to evolve certain regions for just that purpose," says Guinevere Eden, a professor of pediatrics at Georgetown University in Washington, who also uses brain scans to study reading. "We're probably using a whole network of areas in the brain that were originally designed to do something slightly different." As Eden puts it, the brain is moonlighting—and some of the resulting glitches have yet to be ironed out.

To understand what sorts of glitches we're talking about, it helps to know a little about how the brain works. Researchers have long been aware that the two halves, or hemispheres, of the brain tend to specialize in different tasks. Although the division of labor is not absolute, the left side is particularly adept at processing language while the right is more attuned to analyzing spatial cues. The specialization doesn't stop there. Within each hemisphere, different regions of the brain break down various tasks even further. So reading a sonnet, catching a ball or recognizing a face requires the complex interaction of a number of different regions of the brain.

Most of what neuroscientists know about the brain has come from studying people who were undergoing brain surgery or had suffered brain damage. Clearly, this is not the most convenient way to learn about the brain, especially if you want to know more about what passes for normal. Even highly detailed pictures from the most advanced computer-enhanced X-ray imaging machines could reveal only the organ's basic anatomy, not how the various parts worked together. What researchers needed was a scanner that didn't subject patients to radiation and that showed which parts of the brain are most active in healthy subjects as they perform various intellectual tasks. What was needed was a breakthrough in technology.

That breakthrough came in the 1990s with the development of a technique called functional magnetic resonance imaging (fMRI). Basically, fMRI allows researchers to see which parts of the brain are getting the most blood—and hence are the most active—at any given point in time.

Neuroscientists have used fMRI to identify three areas of the left side of the brain that play key roles in reading. Scientifically, these are known as the left inferior frontal gyrus, the left parieto-temporal area and the left occipito-temporal area. But for our purposes,

it's more helpful to think of them as the "phoneme producer," the "word analyzer" and the "automatic detector." We'll describe these regions in the order in which they are activated, but you'll get closer to the truth if you think of them as working simultaneously, like the sections of an orchestra playing a symphony.

Using fMRI, scientists have determined that beginning readers rely most heavily on the phoneme producer and the word analyzer. The first of these helps a person say things—silently or out loud—and does some analysis of the phonemes found in words. The second analyzes words more thoroughly, pulling them apart into their constituent syllables and phonemes and linking the letters to their sounds.

As readers become skilled, something interesting happens: the third section—the automatic detector—becomes more active. Its function is to build a permanent repertoire that enables readers to recognize familiar words on sight. As readers progress, the balance of the symphony shifts and the automatic detector begins to dominate. If all goes well, reading eventually becomes effortless.

In addition to the proper neurological wiring, reading requires good instruction. In a study published in the current issue of Biological Psychiatry, Shaywitz and colleagues identified a group of poor readers who were not classically dyslexic, as their phoneme producers, word analyzers and automatic detectors were all active. But the three regions were linked more strongly to the brain's memory processors than to its language centers, as if the children had spent more time memorizing words than understanding them. The situation is different for children with dyslexia. Brain scans suggest that a glitch in their brain prevents them from easily gaining access to the word analyzer and the automatic detector. In the past year, several fMRI studies have shown that dyslexics tend to compensate for the problem by over activating the phoneme producer.

Here at last is physical evidence that the central weakness in dyslexia is twofold. First, as many dyslexia experts have long suspected, there is an inherent difficulty in deriving sense from phonemes. Second, because recognizing words doesn't become automatic, reading is slow and labored. This second aspect, the lack of fluency, has for the most part not been widely appreciated outside the research community.

Imagine having to deal with each word you see as if you had never come across it before, and you will start to get the idea. That's exactly what Abbe Winn of Atlanta realized her daughter Kate, now 9, was doing in kindergarten. "I noticed that when her teacher sent home a list of spelling words, she had a real hard time," Abbe says. "We'd get to the word the and come back five minutes later, and she had no idea what it was."

So much for what dyslexia is. What many parents would like to know is what can be done about it. Fortunately, the human brain is particularly receptive to instruction. Otherwise practice would never make perfect. Different people respond to different approaches, depending on their personality and the nature of their disability. "The data we have don't show any one program that is head and shoulders above the rest," says Shaywitz. But the most successful programs emphasize the same core elements: practice

manipulating phonemes, building vocabulary, increasing comprehension and improving the fluency of reading.

This kind of instruction leaves nothing to chance. "In most schools the emphasis is on children's learning to read sentences," says Gina Callaway, director of the Schenck School in Atlanta, which specializes in teaching dyslexic students using the Orton-Gillingham approach. "Here we have to teach them to recognize sounds, then syllables, then words and sentences. There's lots of practice and repetition." And a fair number of what the kids call tricks, or rules, for reading. (Among the most important and familiar: the magic e at the end of a word that makes a vowel say its name, as in make or cute.) A particularly good route to fluency is to practice reading aloud with a skilled reader who can gently correct mistakes. That way the brain builds up the right associations between words and sounds from the start.

There is no reason to assume that the public school system, despite its myriad problems, isn't up to the task. But it's a sad fact of life, particularly in larger or cash-starved institutions, that many kids fall through the cracks. A parent may have to keep up the pressure on the child's school district.

Unfortunately, some have had to sue to get results. In extreme cases, parents can be reimbursed for private schooling, as two unanimous decisions by the Supreme Court, in 1985 and 1993, have made clear. (For help finding the right program for your child, see the accompanying story.)

It helps to tap into a student's interests. For Monique Beltran, 13, of Los Angeles, the turning point came with the computer game Pokemon. "I had to read to get to more levels," she says matter-of-factly. The computer game also showed Monique the value of reading outside of schoolwork, and she is eagerly devouring the latest Harry Potter book.

As you might expect, early intervention gives the best results. Yet for decades most schools wouldn't consider special education for a child until he or she had fallen at least a year behind. That may be changing. Congress is considering legislation that would eliminate the need to show a discrepancy between a child's IQ and his or her achievements before receiving a diagnosis of dyslexia.

Ideally, all children should be screened in kindergarten—to minimize educational delay and preserve self-confidence. How do you know someone has dyslexia before he or she has learned to read? Certain behaviors—like trouble rhyming words—are good clues that something is amiss. Later you may notice that your child is memorizing books rather than reading them. A kindergarten teacher's observation that reading isn't clicking with your son or daughter should be a call to action.

If caught soon enough, can a child's dyslexia be reversed? The evidence looks promising. In her book, Shaywitz reports that brain scans of dyslexic kindergartners and first-graders who have benefited from a year's worth of targeted instruction start to resemble those of children who have never had any difficulty reading.

That doesn't mean older folks need despair. Shaywitz's brain scans of adult dyslexics suggest that they can compensate by tapping into the processing power on their brain's right side. Just don't expect what works for young children to work for adults. "If you're 18 and you're about to graduate and you don't have phonemic awareness, that may not be your top priority," says Chris Schnieders, director of teacher training at the Frostig Center in Pasadena, Calif. "It's a little bit late to start 'Buh is for baby' at that point."

Technology can play a supporting role. Some dyslexics supplement their reading with books on tape. (Indeed, in 1995, the Recording for the Blind organization changed its name to Recording for the Blind and Dyslexic in recognition of that fact.) Because their condition affects the ability to write as well as read, a growing number of dyslexics are turning to voice-recognition software for help in preparing term papers, memos and reports. A couple of small studies have shown that the software can also bolster the ability to read. "We found improvement in word recognition, in reading comprehension and spelling," says Marshall Raskind, director of research at the Frostig Center. He suspects that the ability to say, hear and see words almost simultaneously provides good training for the brain.

There are, alas, no quick fixes. Dyslexic students often have to put many more hours into their course work than naturally skilled readers do. But the results are worth it. In the seventh grade, Sean Slattery was barely reading on a first-grade level. Now, after four years at the Frostig Center, he has nearly caught up to where he should be. In May, on his third try, Slattery passed California's high school exit exam.

That's another thing about dyslexics: they learn to persevere. Now Slattery has his eye on a career as an underwater welder. "There's a lot of reading involved" between the course work and the instruction manuals, he says. "But I'm looking forward to it, actually." The written word is not going to hold him back anymore.

—Reported by Paul Cuadros/ Chapel Hill, Greg Land/Atlanta, Sean Scully/ Los Angeles and Sora Song/New York