Brain-scans Research Delivers Lessons on How Kids Learn

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SEATTLE—On a recent afternoon, a 10-year-old girl with long, blond, curly hair, gave University of Washington researchers a peek inside her brain.

Lying flat on her back inside a machine that looks like a big doughnut, Shelter Gimbel-Sherr read individual letters presented on a video screen and then wrote the one that would come next in the alphabet on a special pad.

All the while a scanner generated images of her neural tissue.

UW Washington researchers Virginia Berninger, an educational psychologist, and radiologist Todd Richards, watched on a computer screen from a control room.

"There we go," Richards said. "She wrote something! That's a good W."

They are at the forefront of brain research that's illuminating what happens inside the brain as young children learn to speak, listen, read and write—and how to help those who struggle with those skills, like Shelter.

That's because our brains aren't naturally wired for reading and writing (or multiplying and dividing). Infants aren't born with neural pathways needed for those skills.

In early childhood, a complex blending of genetics and early experiences—good and bad—wires the brain's cells and regions together, forming increasingly sophisticated networks that, over time, either support or hinder future learning and happiness.

The brain's extraordinary flexibility during children's first five years primes them for learning about their world, but it also makes them vulnerable if they don't get many opportunities to learn about spoken and written language at home.

Our capacity for learning lasts throughout our lifetime, so it's not as if a window of opportunity slams shut on a child's fifth birthday.

But we don't learn all things equally well at all ages, and that brain circuitry becomes harder to change as children get older. So it's better to get it right the first time, when efforts to strengthen weak connections stand their best chance for success.

Berninger and Patricia Kuhl, who codirects the university's Institute for Learning and Brain Sciences, are two of the prominent researchers at UW exploring how children's brains develop for literacy.

Their discoveries already are helping parents—schools and preschools—strengthen children's neural connections in ways that can prevent or at least blunt learning problems later.

In Berninger's lab, she and Richards are working on helping older children who struggle with reading, investigating whether specialized instruction developed at UW can help them.

They are building on other studies showing that teaching 4 and 5 year olds to write and name the letters of the alphabet improves their reading later on.

The basic idea is this: Naming the letters and physically making them stroke by stroke in preschool helps children notice and remember their differences.

Berninger and Richards give children tests and brain scans before and after the specialized instruction, which they receive via computer, so researchers can figure out if anything has changed in their brains.

Shelter was back in the lab for her follow-up scan.

She loves math and studies hard, but she struggled so much with reading and spelling that she broke down in tears one day toward the end of second grade.

Her mother, Sarah Gimbel, also a UW professor, knew that Shelter was a bright kid, but dyslexia runs in her family, so she signed up her daughter for Berninger's study.

As Shelter wrote letters, Richards scanned her brain using magnetic resonance imaging, which analyzes signals that the brain's soft tissues emit when radio waves wash over them in a strong but harmless magnetic field.

Using sophisticated computer software, he can generate images of the brain's structure and map which areas consume more energy during a particular task. He can also develop images showing the nerve fiber tracts that connect those areas.

Researchers believe that those spaghetti-like bundles help form complex and partially overlapping circuits that connect the brain's systems for vision, spoken language and movement, all of which are used when we read.

Those circuits become more efficient and automatic over time, which makes reading and writing a seamless experience.

When children with language-learning disabilities read and write, those tasks activate specific locations of their brains differently from those in their typically developing peers.

Berninger and Richards' prior research showed that after dyslexic children received specialized reading and writing instruction, those brain differences often disappeared and their reading and writing improved.

Now they want to explore those changes in more detail to see if computerized reading and writing instruction can "normalize" not only the activity of different parts of the brain, but the connections between them.

In a nearby lab, Kuhl, one of the world's leading experts on speech development, focuses on infants and

toddlers—specifically how the connections in their brains change as they learn language.

An adult brain has an estimated 86 billion neurons, which can each have as many as 1,000 to 10,000 connections with other neurons.

Kuhl studies how genetics combine with early experiences to forge efficient circuits through those thickets of connections the way that a path emerges in the woods from constant use.

For example, she has found, in work that is not yet published, that the ability of 6-month-olds to tune in to the sounds of their native language—like the subtle difference between "pat" and "bat"—predicts a skill at age 5 that corresponds strongly with reading success.

Academics call that skill "phonological awareness," which is the ability to think about the different sounds in a word and how they are ordered.

Kuhl discovered to her surprise that it wasn't some raw biological talent for discriminating sounds that predicted later speech and reading success.

Rather, what mattered was the babies' ability to focus on sounds that were relevant to learning their native language while also ignoring irrelevant sounds.

Those two dimensions of attention—locking in on what's important while ignoring distractions—predicted both how well they would speak at 2 ½ as well as their phonological awareness at age 5.

Parents direct their babies' attention to what's important with lots of warm, loving, fact-to-face talk using that kind of singsong voice that dips and rises and stretches out vowel sounds.

And parents strengthen those connections as their children grow by reading aloud to them, asking open-ended questions, and practicing serve-and-return conversations that build vocabulary and basic knowledge about the world around them.

Children who have even one adult spending time with them like that can form those connections, regardless of family wealth and education, Kuhl said.

"It's not a fancy toy or a television set; it's you and your time," Kuhl said. "Your kid's brain is not a turnkey system; it really does require you to talk and play and challenge cognitively."

Putting research to use Parents and teachers can use the insights from Berninger and Kuhl's research to help children build stronger foundations for future learning and even prevent some problems before kindergarten.

For example, to strengthen phonological awareness, kids in preschool might play rhyming games and clap out the syllables of a silly song.

But teachers should stay away from drilling phonics, a more fine-tuned ability to match letters and sounds, Berninger says.

Children's brains generally aren't mature enough for phonics until kindergarten, which is why simply shoving the kindergarten curriculum down to preschool isn't likely to be effective, she said.