EDUCATION WEEK
Published Online: June 4, 2012
Published in Print: June 6, 2012, as **Neuroscientists Find Learning Is Not 'Hard-Wired'**

FOCUS ON Complete Coverage ▸

FOCUS ON: BRAIN SCIENCE

# Scientists Find Learning Is Not 'Hard-Wired'

**By Sarah D. Sparks**

Back to Story



Neuroscience exploded into the education conversation more than 20 years ago, in step with the evolution of personal computers and the rise of the Internet, and policymakers hoped medical discoveries could likewise help doctors and teachers understand the "hard wiring" of the brain.

That conception of how the brain works, exacerbated by the difficulty in translating research from lab to classroom, spawned a generation of neuro-myths and snake-oil pitches—from programs to improve **cross-hemisphere brain communication** to teaching practices aimed at **"auditory" or "visual" learners**.

Today, as educational neuroscience has started to find its niche within interdisciplinary "mind-brain-education" study, the field's most powerful findings show how little about learning is hard-wired, after all.

"What we find is people really do change their brain functions in response to experience," said Kurt W. Fischer, the director of Harvard University's Mind, Brain, and Education Program. "It's just amazing how flexible the brain is. That plasticity has been a huge surprise to a whole lot of people."

In contrast to the popular conception of the brain as a computer hard-wired with programs that run different types of tasks, said Dr. Jay N. Giedd, a neuroscientist at the National Institute of Mental Health, brain activity has turned out to operate **more like a language**.

Different parts of the brain act like the letters of the alphabet, he said, and by the time a child is 8 months old, the letters are there—the basic connections have formed in the hippocampus or the prefrontal cortex, say—but then through experience, those neural letters activate in patterns to form words, sentences, and paragraphs of thought.

That analogy offers a whole different idea of how the brain develops, both normally and abnormally.

"When I first started, we made the mistake of talking about, 'Oh, the hippocampus is memory; the prefrontal does decisionmaking, impulse control'—and it's sort of a half-truth,'" Dr. Giedd said at a recent Learning and the Brain Society talk.

"I was looking for letters—a hole in this part of the brain, damage in that part of the brain," he said. Researchers do find predictable problems, he said, "but it's not because of everything that lies in that spot; it's because it's part of a word or sentence or paragraph that uses that letter a lot. ... The cells that fire together are wired together—and grow together."

Moreover, Mr. Fischer and other mind-brain-education researchers said, helping teachers and students understand how the brain changes in response to experience may be the best way to link neuroscience findings to classroom experience.

**Rocky Start**

Education watchers have had great hopes for dramatic, instruction-changing findings since the early days of educational neuroscience. President George H.W. Bush **declared** the 1990s "the decade of the brain," but by the end of it, the promise of the research—most of it done with animals—had not translated into clear guidelines for instructional practice.

In 1997, the cognitive scientist and philosopher John T. Bruer of the James S. McDonnell Foundation, in St. Louis, declared in a **landmark essay** in the American Educational Research Association's journal *Educational Researcher* that directly connecting neuroscience to classroom instruction was "a bridge too far." He urged collaboration among cognitive psychologists, neuroscientists, and educators.

Miles Murdough plays the piano while wired to a brain-scanning device at the Society for Psychology in the Performing Arts in Dublin, Calif. The scans show how his brain reacts to music.
—Manny Crisostomo for Education Week

"All of our outcome measures, the things we are hoping to see, are not neurological changes; they are behavioral changes," explained Daniel T. Willingham, a psychology professor at the University of Virginia, in Charlottesville. "We don't measure how are your dendritic connections, we measure how well you can read.

"Trying to leverage behavioral science [for education] is complicated enough," he said. "For neuroscience to get into the mix, we have **translation problems**. The more distant you get from the level of the classroom, the less likely [the research] is to make a difference in the classroom."

Dr. Kenneth S. Kosik, a neuroscience professor at the University of California, Santa Barbara, and co-director of the Neuroscience Research Institute, helped found the Needham, Mass-based **Learning and the Brain Society** in 1999 to bring together experts from those different fields. But he acknowledged that, 15 years after Mr. Bruer's critique, "we still have a paucity of real, concrete findings in neuroscience that we can say will change what goes on in the classroom."

Interdisciplinary turf wars are partly to blame for slowing the development of mind-brain-education science, said Dr. Janet N. Zadina, a former high school teacher turned adjunct assistant professor in neurology at Tulane University, in New Orleans, and the winner of the Society for Neuroscience's 2011 science educator award.

"At first, it was defensiveness; cognitive psychology wanted to claim it, neuroscience wanted to claim it, educators wanted to claim it, and because the fields have been separate, they were all reinventing the wheel," she recalled.

**Bridging the Disciplines**

In the absence of cohesive collaboration among the disciplines, Dr. Zadina said, teachers, policymakers, and education companies were often left to draw their own conclusions from the research, and they often came to overly simplistic or outright wrong conclusions.

One 2011 Arizona State University **study** asked 267 preservice and active teachers to review one of three versions of a fake journal article reporting inaccurate information: One version contained only text, the second contained a graph, and the third had a picture of a brain scan. Teachers were more likely to consider the article containing the brain scan credible, even though it was unrelated to the text.

"There's a reductionism [in which] finding a difference [on a brain scan] is equated with explaining the difference," said Carol A. Tavris, a psychologist and the author of the 2010 Prentice Hall book *Psychobabble and Biobunk: Using Psychological Science to Think Critically About Popular Psychology*. "It is easy for the public to infer that a snapshot out of context is not a snapshot, but a timeless, unchanging blueprint."

Because most members of the public, including many teachers and researchers, don't understand how brain-imaging equipment works, they often develop "technomyopia—the sense that the technology knows more than I do," Ms. Tavris said in a keynote address to the Association for Psychological Science last month.

Yet technology used in brain imaging, including functional magnetic-resonance imaging, or fMRI, and magnetoencephalography, can be thrown off by movement, she said, and readings are easily misinterpreted.

"Neuroscientists love their brain scans," Dr. Kosik agreed. "They can be interpreted in all kinds of ways, as though they're Tarot cards, when you are talking to a teacher, ... then you go home and say, 'That was a beautiful picture with lots of brain stuff, but, OK, what does it mean, what do I do next?' "

For example, early brain-imaging studies on dyslexia pointed to differences between dyslexic and typical readers in the back left of the brain—a region associated with sound processing. That led some educators to consider dyslexia a hard-wired physical problem in the brain and therefore harder to treat with educational interventions. Yet emerging research on language development shows that a person processes both letter sounds and the direct meanings

**Toolbox**

Researchers use a variety of new technologies to take measurements on the brain, including:

• Electroencephalography (EEG) measures changes in electrical voltage in neurons by using sensors placed on the scalp.

• Magnetoencephalography (MEG) uses arrays of highly sensitive magnetometers to measure the electrical currents produced by brain activity.

• Functional magneticresonance imaging (FMRI) measures changes in blood flow during brain activity.

of words, and uses different neural connections to comprehend a language like English, in which the same letters can have multiple sounds, than for Finnish, which has more stable phonemes, the sounds that make up spoken words. Later studies have shown various subtypes of dyslexia respond differently to interventions, and in some cases, those with the disorder can have an edge in types of pattern recognition like the kind astronomers use.

"We got very excited about that" finding, Mr. Fischer said, "because it shows we need to stop thinking about simple disabilities; we need to think about patterns of understanding, patterns of processing. Different kids learn differently."

Ms. Tavris told *Education Week* she sees little potential in the near future for neuroscience to do more than reinforce findings from psychology and behavioral sciences.

Yet Mr. Fischer argued that methods for measuring brain growth and activity have all been developed in the past 10 to 15 years, and "it takes a while when you have a new tool to figure out how to use it effectively."

Moreover, he added, laboratory-based psychological studies can be just as difficult to translate into classroom practice.

"In cognitive science," he said, "you flash a word on the screen for a 10th of a second—that's not what happens in a classroom."

Dr. Kosik, Mr. Fischer, and others in mind-brain-education research agree that the neuroscience evidence in their field has been sketchy so far, but they argue that criticizing the field for replicating educational findings from psychology misses the point of mind, brain, and education.

"What we're trying to do is cover the discipline [of learning] more broadly," Mr. Fischer said. "We need to figure out how to do more practical research. We need to have research in school settings and learning environments to become a norm."

"We do it in medicine for just about everything," he said. "We need to do it in education."

Mind-brain-education experts have also called for the creation of more laboratory schools, similar to teaching hospitals in medicine, in which teachers can test the implications of emerging research. Doing so could take translations of mind-brain-education research beyond "just a talk on the brain," Dr. Zadina said, to "an overhaul of practice, the basis of what we do."

Broad changes in perspective will be more important to shifting teacher practice than fMRI results of a particular intervention, according to Marc Schwartz, the director of the Southwest Center for Mind, Brain, and Education at the University of Texas at Arlington. "I tell [teachers] right from the beginning that silver bullets don't exist," Mr. Schwartz said, but argued that doesn't mean neuroscience findings, such as those on brain plasticity, can't be relevant to education.

"Variability is often overlooked as a gift rather than a nemesis; teachers think, 'these students are so different, they can't adapt to what I'm teaching,' " he said. "Mind-brain-education [study] has given us a more flexible view of children, and to the extent teachers accept that, they become more powerful teachers."

The 300-student **Jacob Shapiro Brain Based Instruction Laboratory School** in Oshkosh, Wis., does not look promising from the outside: A hulking, windowless concrete throwback to the 1970s open-concept school design, it has virtually no interior classroom walls.

Yet for the past six years, the charter school—with a 2011-12 enrollment in which 45 percent of students are living in poverty and 30 percent require special education services—has been building just the sort of teaching environment that could help translate brain research into classroom practice throughout the district.

**Learning Laboratory**

The 50-odd teachers are on monthly listservs for new research and discuss the findings during regular lunch discussions. "If it's been studied, we'll probably talk about it: neuroscience, cognitive psychology, behaviorism," Principal B. Lynn Brown said.

"A student's brain physically changes every day, and the way we teach either enhances or impairs it," she said, noting that she and her teachers hold summer seminars for other district staff on the brain's flexibility and response to instruction. "We have to ask ourselves as educators, what does our practice say about what we believe? We are explicitly teaching thinking skills."

As a laboratory school, the Jacob Shapiro school regularly provides training seminars for teachers and administrators from other schools and districts and plays host to observing researchers; the children have learned to ignore visitors moving in and out of the classrooms.

During one such visit last fall, the 2nd grade science class was learning about butterflies. The students took a lot of breaks, all of them active; students started out with wild wriggles and moved to smaller and slower movements, quieting. Students with difficulty regulating their emotions learn about executive function in the prefrontal cortex of the brain, and how, like lifting weights to build a muscle, they can practice self-control and attention, according to Kristine Hutchinson, the school's music teacher, who also helps implement Jacob Shapiro's discipline program.

Students who became stressed or frustrated during class could seek one of the school's many "safe spots," quiet nooks with soft seating and pictures reminding them of those lessons in calming themselves down, such as taking deep breaths, squeezing a compression ball, or writing out their anxieties. "It's not a time-out spot; it's a place kids voluntarily go," said Ms. Hutchinson. "We check in with them, but we're teaching them to self-regulate."

Three times a week, students also take a 30-minute class in metacognitive skills, learning about how their brains work and how to think about their own learning and problem-solving.

In one session, thinking-skills teacher Shirley Rose set out a spatial-logic problem for the 3rd graders to teach directions. She drew out the image of a man standing in the center of a group of objects, and the children talked through ways to figure out which direction the man was facing and which objects he could see at any one time.

"When I first started this, sometimes you are driven to just finish this sheet and make sure all the answers are correct, and really that's not the point," said Ms. Rose. "The point is to get them to understand their own thinking and strategies."

Even young children can understand the basic concepts of brain plasticity—for example, that their brains are malleable and will change as they practice something—and she said "it becomes a very powerful thing for them, that just because they have an error, it's not this terrible, dreadful thing."

*Coverage of "deeper learning" that will prepare students with the skills and knowledge needed to succeed in a rapidly changing world is supported in part by a grant from the William and Flora Hewlett Foundation, at* ***www.hewlett.org****.*

Vol. 31, Issue 33, Pages 1,16-17