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RUTGERS MAGAZINE

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Brain POWER

Paula Tallal's mind games click with kids

African Adventure ◆ Still Lives ◆ Carousel Keepers

"Can you help my child?"

At a speech-therapy clinic in Short Hills, two young girls, ages 12 and 10, are seated in front of computer monitors, headphones snug against their ears. On one screen an animated cow rides a spaceship floating above a farm. On the other, colorful shapes appear and disappear. The girls, who have problems learning language, each use a mouse to respond to instructions. Correct answers are rewarded with the sound of bells, the flash of lights, and the accumulation of points. Incorrect answers bring on a hollow clunk. For nearly two hours, the girls sit hypnotized by a series of computer games—an indulgence that most parents would discourage. But when six weeks of these weekday sessions with a CD-ROM called Fast ForWord are completed, it's likely the girls will have achieved the level of improvement in language processing and comprehension that takes as many as three years with traditional one-on-one therapy.

"What you're seeing shouldn't be mistaken for just computer games. These are mental exercises for language, reading, and auditory-processing disorders," says Nancy Polow, the program director at the clinic, Suburban Speech Center. Polow, a speech pathologist who was one of 35 therapists throughout the country who field-tested Fast For-

Paula Tallal spent two decades pinpointing the cause of childhood language disorders—a timing glitch in the brain. For parents, it wasn't enough.

by Bill Glovin

Illustration by Gina R. Binkley


Firmness
Veneration
Benevolence
Hope
Conscientiousness
Self-Esteem
Spirituality
Imitation
Approbativeness
Sublimity
Cautiousness
Friendship or Adhesiveness
Inhabitiveness
Parental Love
Combativeness
Destructiveness
Secretiveness
Acquisitiveness
Constructiveness
Alimentiveness
Mirthfulness
Tune
Time
Color
Order
Calculation
Causality
Comparison
Ideality
SUCCESS

Word, has put 250 children through the software-based training program. "This is the only product that provides clinicians with an objective, testable measure of performance. It's the most important innovation for processing problems that I've seen in 30 years as a therapist."

The product earning this off-the-charts endorsement is the brainchild of Paula Tallal, a professor of neuroscience at the Center for Molecular and Behavioral Neuroscience (CMBN) at Rutgers–Newark, and Michael Merzenich, a neurophysiologist at the University of California at San Francisco (UCSF). A portion of the research and the clinical trials that led to this breakthrough in the treatment of children with language-based impairments were conducted by Tallal. Two other colleagues, Steven Miller at CMBN and William Jenkins at UCSF, are named on the technology's patent.

Studies show that language-based learning problems may affect as many as 20 percent of school-age children. So it's not surprising that each year in the United States $7.5 billion is spent on therapy and special-education programs and products, most of which promise more than they deliver. But skeptics should consider that Tallal and Merzenich's computer programs proved so effective in clinical trials that millions of dollars in venture capital were generated, and, within a year, the scientists launched their own company, Scientific Learning Corporation, to market Fast ForWord. In its first year, the privately held company trained 2,000 professionals in the United States and Canada to administer the program, moved from a home office in San Francisco to spacious headquarters in Berkeley, and increased its payroll to 100 employees.

Tallal, who says she knew "nothing about business before this venture," is a company founder, the chair of the board, and an executive vice president. After taking a sabbatical last year to concentrate on the company's development, she returned to Rutgers this past fall to resume her role as co-director of CMBN and work on other research projects. Miller, a research professor, left CMBN to become the company's vice president of outcomes research. Carlton Holstrom (GSM'62), a former chair of Rutgers' Board of Governors and a retired senior executive at Bear Sterns, became the company's first chief financial officer.

The scientists might never have mastered the steps necessary to start a business if they hadn't been helped by Rutgers and UCSF experts in technology transfer, the process of moving university research from the laboratory to the marketplace. (See sidebar on page 21.) Scientific Learning Corporation, which expects to more than double its revenues this year, has the potential to become an important revenue stream for Rutgers and UCSF, which will share royalties. "Without the technology transfer office and other key individuals at Rutgers who helped us, I doubt we would have been able to bring Fast ForWord to the marketplace," says Tallal. "And even if we had somehow managed to do it on our own, I'm sure it would have taken much longer."

On a four-hour drive to Ithaca, New York, to speak at a neurological conference, Tallal lets herself drift back 25 years to some of the defining moments on her path to becoming a leading neuroscientist. As an undergraduate at New York University, she was undecided between a career in medicine or psychology. Her aunt, Lisa Tallal, a medical doctor and a primary role model for her as a female scientist, helped her find internships at Rockefeller University and Kings County Medical School, where she was first exposed to neurological research and stroke survivors who had lost their ability to speak.

The internships swung her career pendulum towards experimental psychology. After college, Tallal spent a year working at a research lab at Cambridge University in England, then approached the chair of the psychology department about graduate study. Before he would consider taking her into the department, he told her, he needed to know the subject of her graduate thesis. "That was on a Friday afternoon," Tallal recalls. "He made it clear that if I wanted to do graduate work, I needed to make up my mind by Monday."

Tallal went to the library and pored over articles and papers until a pioneering study on developmental dysphasia in children caught her eye. "I had always loved working with children, and I had pretty much decided early on that no matter what my career path was, children would be in the equation," she recalls. After reading the paper, Tallal made her decision: "I went back to the chair and told him that pinpointing the cause of language-based learning problems in children was my research interest. And that has not changed to this day."

"I had

After receiving her doctoral degree from Cambridge, Tallal returned to the United States four years later to do postdoctoral work at Johns Hopkins University. Within six months, she received an enormous break when the National Institutes of Health awarded her a four-year grant that allowed her to set up her own research lab. Here, she developed her theory that the cause of language-based learning problems in children is a timing glitch in the brain. Colleagues scoffed: The accepted school of thought held that language functioned independently of other processes in the brain, and thus there could be no correlation between timing and language comprehension.

Tallal spent the next 20 years investigating her hypothesis. She discovered that children with language-learning problems process auditory information too slowly. This slower processing rate interferes with their ability to hear the rapid acoustic changes

that allow the brain to differentiate among sounds. "You can feel the difference between the sound of 'ba' and 'pa' by putting your finger to your throat," Tallal explains. "The brain has to pick up and decide in a millisecond what all the subtle changes that occur between syllables are." Using computers, she was able to slow down these almost-imperceptible acoustic changes. In clinical trials, children with language-learning problems comprehended these changes much better when they listened to Tallal's computer-modified speech as compared with regular speech.

The real challenge was to find a way to apply the research in a therapy that could actually help children. "It was one thing to use a computer to modify the acoustics within a single syllable, but quite another to do that with sound as it is really spoken," she says. "The technology needed to catch up with the theory. There were also many other practical problems that had to be addressed, such as, how could we use acoustically modified speech to train children to process normal speech?"

The breakthrough occurred in 1992, when Tallal visited the Santa Fe Institute, a think tank that encourages collaborations among scientists. There she met Merzenich, whose experiments on animals and humans showed that an individual continues to learn throughout a lifetime because the physiology of the brain changes with experience. Merzenich and Jenkins had also found evidence that specialized training could improve the brain's response to sensory information.

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Tallal and Merzenich knew almost instantly that her research into the neural basis of language-learning disabilities and his work on brain plasticity were a perfect fit. The pair believed that, once children had mastered acoustic differentiation through computer-modified speech exercises, their brains could be progressively trained to process speech normally. Says Tallal: "If we could alter the way children's brains processed information, we could see if they could be 'trained out' of their slow processing mode and into better speech processing."

The effort to develop the computer-learning exercises that evolved into Fast ForWord was led by Jenkins; Miller guided the team that developed the technology to track the user's responses to the auditory processing and language exercises. The exercises require that spoken commands be followed; correct responses are tracked and rewarded with bells and whistles, points that are converted to prizes, and ever-increasing levels of difficulty based on each child's response pattern. Once the user achieves normal levels, the program gradually weans them off the exercises. "The computer-modified speech that is incorporated into Fast ForWord's seven exercises cannot be replicated by human speech," says Tallal. "Furthermore, these exercises would be incredibly repetitious and tedious if delivered in traditional therapy. But in a computer-game format, it's fun."

The results of the first study were so positive that even the scientists were startled: In only four weeks, children exposed to the exercises not only demonstrated much greater improvement in language than did those in the control group, the levels for many children even moved into the normal range. On average, the children demonstrated advances in auditory processing, speech processing, and language skills that would normally take a year and a half with traditional therapy. And, when the children were tested six months later, they had retained their new skills.

In January 1996, the two research teams published their findings in the journal *Science*, generating international media attention. At the time, recalls Miller, the scientists believed it would take at least 10 years for the research to be applicable in therapy. But urgency to move the research from intellectual prop-

Photograph by Dennis Connors

erty to marketable product heightened considerably when both Rutgers and UCSF received thousands of phone calls and letters from anxious parents. "They had read or heard about the training program and wanted access to it for their kids," says Miller. "We knew we had to do something."

For Tallal, "doing something" meant putting her other research interests on hold to concentrate on what seemed like a dream: turning these newly discovered scientific learning principles into a product that could benefit millions of children throughout the world. Although Fast ForWord, in just two years, has already helped 10,000 children improve their language skills, its potential has been merely scratched. Tallal finds herself spending a great deal of time spreading the word at events like the annual convention of the New Jersey Chapter of the International Dyslexia Association, held this past October at Princeton's Forrestal Village.

The teaching side of the professor surfaces as Tallal addresses a morning workshop. Clearly comfortable in front of an audience, she doesn't miss a beat as she talks about the evolution of the research, explains data indicating that Fast ForWord has a 90 percent success rate, and demonstrates some of the training exercises that are disguised as computer video games.

The data presented by Tallal make Fast ForWord seem almost too good to be true, and some members of the audience are unconvinced. "Do we know exactly why Fast ForWord works?" Tallal asks, repeating a question from a listener. "The answer is, not entirely. We don't know exactly how aspirin works either, but we use it all the time. Don't take my word for it: Talk to the professionals who use it. Evaluate the data yourself. See how it works for the children you serve. That's the best way to measure its effectiveness."

When the session ends, Tallal grabs a box lunch and heads for the elevator. The spacious room where she is scheduled to lead a noontime discussion is already packed with educators and clinicians eager to hear about "the miracle breakthrough." "Oh well," she says, glancing with resignation at her lunch, "I guess I'll eat later."

Fast ForWord, she tells the group, has proved especially effective as a therapy for children with developmental language problems—including dyslexia, which is notoriously difficult to treat. The software package also works with other groups: children with attention deficit disorders, autistic children who can work with computers, and children who have central auditory processing disorder, or CAPD, a difficulty in organizing sounds correctly. "To be considered candidates for Fast ForWord, children should be at least one standard deviation below the mean in auditory processing, phonics, or language for their age," she says.

Clinicians, teachers, and even a parent offer moving testimonials about their successful experiences with Fast ForWord. But a man in the second row challenges Tallal: "How can we expect you to be objective? After all, aren't you and your collaborators hoping to make a lot of money from this?" Tallal, without losing her composure, patiently explains that, first and foremost, she is a scientist and a professor at Rutgers University; she has no plans to abandon her research or to leave academia for business. She considers herself blessed to see a lifetime of research make a real difference in the lives of so many children and their families.

And second, "Fast ForWord is not magic; it's a new scientific tool," she explains. "As educators and clinicians, you've always had to figure out how to marry the best procedures to each child. They're not the same procedures for every child. The bottom line is, professionals are talking to professionals, parents are talking to each other, success stories appear daily on the Web site, and more and more people are looking at the data and saying, 'I want to try this.' "

What Tallal calls "the cost issue" is raised at every speaking engagement, and today's meeting is no exception. The price for the CD-ROM and the company's support services is $850, but private clinicians are free to set their own fees for additional clinical services. The company also requires that clinicians and teachers go through a $995 two-day training program in which they learn to use the software, to screen and monitor candidates, and to track their students' performance on the company's Web site. This Internet support service eliminates grading and testing and allows teachers and clinicians to evaluate a child's performance on a particular exercise or the entire program on a daily basis.

"When measured against the hiring of teachers, the redistribution of resources, and other costs associated with compliance with the Individual Disability Education Act, we anticipate that—even if only one quarter of our kids benefit—Fast ForWord will be a huge cost savings," says Gerald Cohen, superintendent of schools for Vineland, which will put 500 of its 10,000 students through Fast ForWord this year. For school districts that purchase the program in bulk, the company will arrange discount packages that include on-site training for teachers and reductions in the cost of the CD-ROM and the training.

Cohen is among the educators, therapists, and parents who agree that Fast ForWord is a bargain when one considers the cost of traditional therapy and the difference the product has made in many youngsters' lives. Roxanna Sheikh, a Bernardsville mother of three, was unwilling to accept that her 7-year-old son, Kayvan, had a learning problem, despite the fact that she herself holds a master's

degree in learning disabilities. She preferred to believe that he had fallen behind in school because of her divorce, his shyness, and the chronic ear infections he suffered as an infant and toddler.

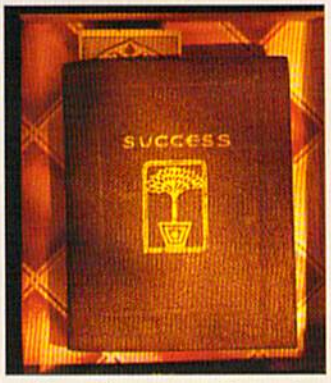
But when Kayvan's brother, younger by 18 months, began catching on to learning concepts more quickly, she knew he needed to be tested. Kayvan was diagnosed with CAPD, which Sheikh describes as "analogous to hearing bits and pieces of information and placing them in the wrong filing cabinet." She brought Kayvan for traditional therapy once a week, but improvements were minimal.

When Suburban Speech Center became a test site for Fast ForWord, Kayvan—a second grader at a pri-

big ideas

Everybody profits when university research moves from the laboratory to the marketplace.

When the four scientists who share the patent for Fast ForWord launched Scientific Learning Corporation, each had a personal and professional decision to make: Should they remain in academia or work for the company? "It was very difficult," says Paula Tallal. "In deciding to remain at Rutgers, I considered that my goals were never business-oriented—I'm more interested in knowledge for knowledge's sake, rather than for profit's sake. Plus, I enjoy my role as codirector of a neuroscience center that has more than 100 researchers interested in a wide range of activities."



But two of her three colleagues decided to trade academia's open discourse and free exchange of ideas for industry's restricted discourse and corporate secrecy. One of them, Steve Miller, a former Rutgers research professor, sees it another way: "After working for so many years on projects with potential at some indefinite point in the future, I felt it would be rewarding to focus on a product that could have a direct impact on people."

More and more university researchers are asking "Should I stay or should I go?" That's because the federal Technology Transfer Acts of 1980 and 1984 changed the rules regarding government-funded university research to allow faculty inventors and their institutions to gain financially from products arising from their work.

"Before the legislation, the federal government was spending billions of dollars on university research grants, but there was no real incentive to move research from the ivory tower to a place where the public would benefit," says William Adams, director of Rutgers' Office of Corporate Liaison and Technology Transfer. "The acts delivered everything they promised. Products and technology with university patents account for almost $1 billion a year in royalties that benefit universities. Companies, jobs, and new and better products for people—some of which reduce suffering and save lives—have also been created. Those kinds of benefits can't be measured in dollars."

Rutgers' best-known patented product, streptomycin, saved countless lives when it provided a cure for tuberculosis in 1944. Besides bringing its codiscoverer, Selman Waksman, a Nobel Prize, the antibiotic also produced royalties that helped fund Rutgers' Waksman Institute of Microbiology. About 80 percent of patents spring from biomedical research, but Rutgers scientists have also created breakthrough technology in agriculture (turf grass), ceramics (nanomaterials), engineering (plastic lumber), and computers (voice-recognition software). About half the research disclosed at Rutgers results in a patent.

Rutgers is one of about 100 colleges and universities in the United States that now have technology transfer offices. The Rutgers office, founded in 1988 as a two-person operation, now has 12 employees at the Busch campus. The office evaluates, protects, and licenses patents and copyrights; negotiates contracts; conducts patent searches; and arranges meetings between industry partners and university researchers.

The Association of University Technology Managers ranks the University among the top five in achieving effective, practical results from its research dollars, and among the top 15 in revenues from royalties. In 1997 alone, Rutgers' technology transfer office filed 55 patent applications, received $15 million in corporate contracts, and banked $6.5 million in royalties.—*BG*

vate school—was among the first participants. He was even featured on "CBS Morning News." It wasn't easy for the family to go through six weeks of the daily program, says Sheikh. "After school, I had to drive Kayvan to the clinic, an hour each way, with my two younger kids in tow. We then had to kill two hours waiting for Kayvan to finish. There were also financial considerations, since my HMO wasn't about to pay for it."

Before Kayvan had even completed the program, his mother was startled by his sudden inclination to express himself. He also seemed more confident. "I found myself asking, 'Is this actually Kayvan?' " remembers Sheikh. "He's not completely over his learning problems yet, but he's in the fourth grade now and keeps up with his peers. When my friend in California was going through a similar problem with her son, I recommended Fast ForWord to her. She had the same result and couldn't stop thanking me."

Tallal, although proud of such testimonials, is careful of misimpressions. "Fast ForWord does not cure anything," she warns. "If you give a child who can't see a pair of glasses, he still needs to be taught to read. Fast ForWord helps kids take important steps, and Fast ForWord Two—an advanced version that builds letter–sound correspondence for reading—helps them go a little further. Education is a lifelong process. What we do is simply provide the building blocks so kids can reach their learning potential."

It was considered a coup for Rutgers when Tallal and her husband, Ian Creese—two of the leading neuroscientists in the country—accepted the 1988 offer of Rutgers–Newark provost Norman Samuels to codirect a new neuroscience center that the Aidekman family had agreed to support. At the time, both scientists ran separate labs at the University of California at San Diego. "We saw the center as an opportunity to merge our two fields, the behavioral side of neuroscience and the molecular side," says Tallal. "CMBN has been the model for numerous neuroscience centers that have since come into existence."

Six years after the center had been established and recognized as one of the premier facilities of its kind, Samuels invited Tallal to talk about CMBN and her research before Rutgers' Board of Governors. During her presentation, she mentioned the difficulty she had finding toddlers to participate in research and clinical trials. Afterwards, board member Carl Holstrom approached her with a proposition: He would bring his two-year-old son to her lab if she would examine his five-year-old grandson who had suffered with neurological problems since birth. "Paula gave us some very helpful suggestions, and I never forgot it," recalls Holstrom.

In 1995, Holstrom's service on the board came to a statutory conclusion, and he was invited by the Graduate School of Management at Rutgers–Newark to join the faculty as a distinguished member-in-residence. During his first day on the job, he ran into Tallal in the faculty–staff dining room. Tallal told him that her collaborative research project had attracted considerable attention and that the research teams were close to developing what might be a breakthrough product to help children with language problems.

But Tallal and her colleagues faced the daunting obstacle of trying to launch a new product while fulfilling their academic obligations. After disclosing their research, as required, to the technology transfer offices at Rutgers and UCSF, the parties agreed that UCSF's office would take the lead in filing for the patent and working out a licensing agreement with an established company. "But UCSF didn't find a large company chomping at the bit," says William Adams, director of Rutgers' Office of Corporate Liaison and Technology Transfer. "In most cases, there's an awful lot of development work that needs to be done on university research, and I'm sure that was the perception in this case."

Without a corporate partner, the scientists were left with one option: starting their own company. "It's certainly more difficult," says Adams, "but the advantages are that you have more control over development and the rewards can be greater." Holstrom, remembering Tallal's work with his grandson and impressed with the possibility of helping millions of children with similar problems, volunteered to answer questions and offer advice. After struggling to create a viable business plan, Tallal and Merzenich asked Holstrom for a deeper commitment. "My role as someone they could consult evolved into a hands-on creator of a company," he says.

Holstrom spent portions of 1995 and 1996 flying to California at his own expense every other weekend. UCSF agreed to pay for the patent-application fees, and Holstrom and the four neuroscientists named on the patent—Tallal, Merzenich, Jenkins, and Miller—were able to raise about $2 million from family members and friends. They set up temporary offices in the spare bedroom of Merzenich's house in San Francisco in February 1996. "Silicon Valley had a talent pool of computer programmers who are willing to work with a start-up company," says Miller.

It wasn't long before the newly incorporated company needed considerably more capital to hire professionals who could make the CD-ROM user-friendly and set up a marketing and distribution network. In October 1996, E.M. Warburg, Pincus & Co., Inc., in New York, one of the largest venture capital firms in the country, agreed to invest $8 million over two years, and UCSF granted the company an exclusive worldwide license. That November, Scientific Learning Corporation hired a chief executive officer and began to bring in experts in linguistics, psychology, art and animation, advanced computer technology, and marketing. Jenkins left UCSF to lead the

company's Internet and multimedia development. With the company up and running, Holstrom stepped down as CFO and joined the board of directors.

In March 1997, less than four years after Tallal and Merzenich had met, Fast ForWord was available to certified speech, language, and learning professionals. Over the past year, the company introduced Fast ForWord Two and began marketing the programs to U.S. public schools. Cherry Hill and Vineland were the first New Jersey school districts to purchase Fast ForWord for their remedial education programs. "Educational materials for school curricula are always closely evaluated by boards of education on the state level, on district levels, and by teachers and administrators," Holstrom points out. "It's a long, difficult, and expensive process." Still, company executives, clinicians, and investors believe the program could revolutionize remedial education in public schools.

Somewhat ironically, the success of the company means that Tallal can return to her first love: university research. Her current NIH-funded project, the exploration of the role that genetics plays in speech and reading disorders, is monitored by a university committee to ensure that her business and research interests don't conflict. Which is not to say that her experiences won't inform the work she does in the future. "People always seem so shocked that all of it happened so fast," she says. "But Fast ForWord is the culmination of a lifetime of work for each of the scientists involved. The lesson is that you have to understand the nature of a problem before you can find the solution. In our case, we approached the problem of language and speech processing from a whole new angle—and we found the answer." ❑

Bill Glovin is the senior editor of Rutgers Magazine.

success stories

These eight patented products and technologies, invented or coinvented by Rutgers researchers, brought in royalties of $400,000 or more in fiscal year 1997.

Turfgrasses

Rutgers Researcher: C. Reed Funk (GSNB'61), professor of plant science, Cook College

Description: More than 50 new varieties of premium turfgrasses

Chloroplast transformation

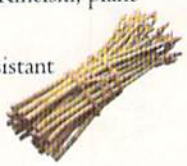
Rutgers Researchers: Pal Maliga, professor of microbiology, and Zora Maliga, research associate, Waksman Institute of Microbiology

Description: Process to manipulate plant traits through gene insertion

Asparagus

Rutgers Researchers: J. Howard Ellison, professor emeritus of plant science, and John Kinelski, plant science technician, Cook College

Description: High-yield, disease-resistant male asparagus hybrids



Fast ForWord

Rutgers Researcher: Paula Tallal, professor of neuroscience, Rutgers–Newark

Description: Remedial computer software for children with language-learning problems

Plastic lumber

Rutgers Researchers: Richard Renfree and Thomas Nosker, adjunct professors of packaging engineering, College of Engineering

Description: Building materials recycled from plastics

Voice-recognition technology

Rutgers Researcher: Richard Mammone, professor of electrical engineering, College of Engineering

Description: Software system for computer response to spoken commands

PEG technology

Rutgers Researcher: Theodoreus Van Es, professor of biochemistry and microbiology, Cook College

Description: Water-soluble polypeptides that do not cause immune responses when used in medical applications

Laser-based isotope analysis

Rutgers Researcher: Daniel Murnick, professor of physics, Rutgers–Newark

Description: System for diagnosis of disease by breath testing

Data from Rutgers' Office of Corporate Liaison and Technology Transfer